

Gries, T.; Redlin, M.

Article — Published Version

Trade and economic development: global causality and development- and openness-related heterogeneity

International Economics and Economic Policy

Provided in Cooperation with:

Springer Nature

Suggested Citation: Gries, T.; Redlin, M. (2020) : Trade and economic development: global causality and development- and openness-related heterogeneity, International Economics and Economic Policy, ISSN 1612-4812, Springer, Berlin, Heidelberg, Vol. 17, Iss. 4, pp. 923-944, <https://doi.org/10.1007/s10368-020-00467-1>

This Version is available at:

<https://hdl.handle.net/10419/288474>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.


If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by/4.0/>



Trade and economic development: global causality and development- and openness-related heterogeneity

T. Gries¹ · M. Redlin¹ 

Published online: 2 June 2020
© The Author(s) 2020

Abstract

This paper reconsiders the classic relationship between trade and economic development. We examine the short-term and long-run dynamics between trade and income for 167 countries over the period 1970–2011 and assume that the effect is not homogenous for all countries but rather varies according to the development stage and the degree of trade openness. We apply panel cointegration, Granger causality and panel error correction in combination with Dynamic Ordinary Least Squares and General Method of Moments estimation to explore the causal relationship between these two variables. The results suggest a statistically significant positive short-run and long-run global relationship between trade and income. However, when splitting the panel into different income and trade openness groups, a long-run relationship is observed only for high-income countries and countries with a relatively high degree of trade openness.

Keywords Trade · Openness · Development · Panel cointegration · Causality · Error correction

JEL classification F10 · F15 · F43 · O10

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s10368-020-00467-1>) contains supplementary material, which is available to authorized users.

✉ M. Redlin
margarete.redlin@notes.upb.de

T. Gries
thomas.gries@notes.upb.de

¹ Economics Department, Paderborn University, Warburger Strasse 100, 33098 Paderborn, Germany

1 Introduction

The relationship between international integration and economic development has long been a subject of interest and even controversy.¹ With regard to the theoretical relationship between trade and development, most studies support the proposition that openness to international trade positively affects income. Romer (1993), Grossman and Helpman (1990, 1991), and Barro and Sala-i-Martin (1995), among others, argue that countries that are more open to trade are better able to catch up to the leading technologies. International trade promotes the efficient allocation of resources through comparative advantages and allows the dissemination of knowledge and technological progress through high-tech imports (Chang et al., 2009; Baldwin et al., 2005). Additionally, trade openness encourages competition in domestic and international markets and allows to better reap the potential benefits of increasing returns to scale and economies of specialization by increasing the market size (Melitz and Ottaviano, 2008; Alesina et al., 2005).

However, the empirical evidence on the relationship between trade and income varies a lot, depending on the econometric technique used, the sample studied, and the exact definition of the variables used.² Further, recent developments suggest that trade openness is not always beneficial to economic growth and that the relationship between trade and development may vary with the level of development and trade.

First, due to technological or financial constraints, a lack of human capital, brain drain and weak institutions, less developed countries may fall behind in adopting and using new technologies and thus not be able to fully benefit in the advantages of trade. Due to this limitation in technology and knowledge transfer the countries stay on a technology and income trap where they continue to produce basic goods and services that do not encourage innovation and enable structural transformation and growth. Empirical evidence suggests that the relationship between trade and growth may vary with economic development. Analyzing the relationship between trade and development Kim and Lin (2009) and Kim et al. (2011) identify an income threshold above which greater trade openness has beneficial effects on economic growth and below which heightened trade has harmful consequences. In line with this, Sakyi et al. (2011) and Herzer (2013) find that the effect of trade on income tends to be greater in countries with higher income levels. Thus, the growth effect of trade may differ according to the level of economic development.

Second, theoretic models also claim that higher trade openness may be detrimental to economic development (Lucas, 1988; Young, 1991). Opening up to international trade and specialization in sectors with comparative disadvantages or production of low-quality products might actually reduce international competitiveness and economic growth (Grossman and Helpman, 1990, 1991). Thus, the benefits of trade may differ according to the level of trade openness. Zahonogo (2016) investigates the relationship between trade and growth depending on the degree of openness and identifies an

¹ For a comprehensive survey on the relationship between trade and development, see Singh (2010).

² See e.g. Edwards (1998), Frankel and Romer (1999), Rodríguez and Rodrik (2001), Irwin and Tervio (2002), Yanikkaya (2003), Dollar and Kraay (2003, 2004), Felbermayr (2005), Nogue and Siscart (2005), Wacziarg and Welch (2008), Feyrer (2019), and for causality based studies e.g. Bahmani-Oskooee et al. (1991), Islam (1998), Xu (1996), Awukuse (2007), Herzer (2013), Sakyi et al., (2015).

openness threshold below which increasing trade has beneficial effects on economic growth and above which the trade effect on growth declines.

In our study we reexamine the relationship between trade and development and contribute to the literature by empirically analyzing if the relationship differs between countries depending on both, their level of income and their degree of trade openness. This fragmented examination adds to the existing literature as it enables us to identify differentiated development- and openness related heterogeneity in the relationship based on a wide range of countries and a long time dimension. Specifically, we shed light on whether benefits are contingent upon the development and openness level. Further, our empirical evidence is based on short-term and long-run causality methods that allow the identification of and differentiation between long-term causality and short-term adjustment. In particular, we apply panel based cointegration tests, error correction and Granger causality models using data for 167 countries over the period 1970–2011 and employ Dynamic Ordinary Least Squares and General Method of Moments estimation techniques, which are appropriate in the presence of endogeneity concerns.

We identify a positive long-run relationship between trade and development, however, our findings support the view that the relation between trade globalization and economic growth is heterogeneous for different stages of development and openness.

The paper proceeds as follows. The next section presents the empirical investigation including the data, the methodology, and the results of the panel unit root tests, the panel cointegration tests, the error correction model and the Granger causality tests for the global relationship and the income- and trade share-related subpanels. Section three concludes.

2 Empirical analysis

This section aims at empirically investigating the causal relationship between trade and economic development. However, a loop of causality between these variables can lead to endogeneity problems. Endogeneity bias can lead to inconsistent estimates and incorrect inferences. Current literature has identified this problem and suggests two common solutions. One solution to address the endogeneity problem is to use instrumental variables (IV) techniques. For example, several studies use geographic attributes as instruments to identify the effects of trade on income.³ However, there is also criticism that geography-based instruments are too weak to identify the true effect and are invalid, since they are correlated with other geographic variables that affect income through non-trade channels and so reflect only the geography effect on income. Further, their use can lead to multicollinearity problems between geographical controls, institutional proxies, and the trade instruments, which yields statistically insignificant results (Rodríguez and Rodrik, 2001; Herzer, 2013).

Another solution to address the problem of endogeneity is the use of an appropriate estimation technique. Here the Dynamic Ordinary Least Squares (DOLS) estimation accounts for possible serial correlation and endogeneity of the regressors and thus

³ See e.g. Frankel and Romer (1999), Irvin and Terviö (2002), Douglas and Terviö (2002), and Noguer and Siscart (2005).

yields unbiased estimates of the long-run relationship.⁴ Further, Generalized Method of Moments (GMM) techniques developed by Arellano and Bond (1991) and Blundell and Bond (1998) use an internally generated set of instruments to alleviate endogeneity concerns and control for the dynamic nature of the relationship.⁵ Since the availability of time-varying trade instruments on panel level is limited and weak, and invalid instruments lead to spurious results, we abstract from instrumentalization and approach the problem of endogeneity by focusing on DOLS and GMM estimation techniques.

2.1 Data

We use a balanced panel data set containing 167 countries over the period 1970–2011. The bivariate analysis is based on two variables, GDP per capita and trade share in GDP.

GDP per capita corresponds to real GDP per person. It is calculated as real GDP at constant 2005 US\$ divided by population. Both, the GDP and the population data are drawn from the Penn World Table 8.0 as provided by Feenstra et al. (2013).

In the literature, trade volume measures and trade restriction measures are used to examine the effect of trade openness and development. Since our research question is aimed at investigating whether additional trade encourages additional development we use trade share as the most common measure of the class of trade volume measures. Trade share is measured by the sum of exports and imports as a percentage of GDP at 2005 constant prices and corresponds to the trade openness variable extracted from the Penn World Tables 8.0.

In addition to the overall panel, we segment the data set into eight subpanels; four according to per-capita income and four according to trade share. For the income classification, we use the World Bank country classification and distinguish between low-income (LI) economies (\$1045 or less), lower-middle-income (LMI) economies (\$1046 to \$4125), upper-middle-income (UMI) economies (\$4126 to \$12745) and high-income (HI) economies (\$12,746 or more). Further, we classify the list of countries into countries with low trade openness (LTO), lower-middle trade openness (LMTO), upper-middle trade openness (UMTO) and high trade openness (HTO) by computing the quartiles of the trade share variable. The limits for the quartiles are <0.44 for the first quartile, 0.44–0.66 for the second quartile, 0.67–0.99 for the third quartile and >0.99 for the fourth quartile.

Table 1 shows the descriptive statistics for the global sample and the income- and trade-related subpanels. The descriptive statistics show that from a diversified perspective there is no clear evidence of a positive relationship between trade and development, rather the causality should be assumed to be heterogeneous. First, for the income

⁴ DOLS are usually preferred to the OLS estimator because they take care of small sample bias and endogeneity bias by taking the leads and lags of the first-differenced regressors.

⁵ Dynamic panel data models include lagged levels of the dependent variable as regressors. This violates strict exogeneity, because the lagged dependent variable is necessarily correlated with the idiosyncratic error. When the strict exogeneity assumption is violated, commonly used static panel data techniques are inconsistent, because these estimators require strict exogeneity. The System-GMM estimator uses lags of the dependent variable as instruments for differenced lags of the dependent variable (which are endogenous) to solve the endogeneity, heteroscedasticity and serial correlation problems.

subpanels the trade share increases with income, but hardly differs in the groups of UMI and HI. Second, the trade share subpanels show that income does not increase simultaneously with the trade share. Here the UMT0 group shows the highest average income; the other groups almost do not differ from each other. The descriptive statistics thus show that a causal analysis of the relationship should consider development and openness related differences.

2.2 Global causality between trade and economic development

2.3 General methodology

To explore the short-run and long-run dynamics between GDP p.c. and openness we perform panel unit root and panel cointegration tests. The cointegration test shows us whether there is a long-term relationship or not. Therefore, depending on the result of the cointegration test we perform long-run DOLS estimation and panel vector error correction (for the case of cointegration) or short-term Granger-causality tests (for the case of no cointegration). More specifically, our point of departure is a bivariate autoregressive-distributed lag (ADL) model

$$y_{i,t} = \alpha_0 + \sum_{j=1}^p \alpha_j y_{i,t-j} + \sum_{j=1}^p \delta_j x_{i,t-j} + f_i + u_{i,t} \quad (1)$$

$$x_{i,t} = \beta_0 + \sum_{j=1}^p \beta_j x_{i,t-j} + \sum_{j=1}^p \gamma_j y_{i,t-j} + \eta_i + v_{i,t} \quad (2)$$

where index $i = 1 \dots N$ refers to the country and $t = 1 \dots T$ to the period. Following Granger (1969) there is Granger causality from x to y if past values of x improve the prediction of y given the past values of y .⁶ With respect to the model x Granger causes y if not all δ_j are zero. By the same token Granger causality from y to x occurs if not all γ_j are equal to zero. However, Engle and Granger (1987) have shown that, if the series x and y are cointegrated, the standard Granger causality test is misspecified. In this case an error correction model should be used instead. Therefore, in a first step we apply unit root and cointegration tests. Based on the results we determine whether to use the Granger causality framework or an error correction technique to test causality.⁷

⁶ Note that model selection criteria, such as the Bayesian Information Criterion (BIC, (Schwarz, 1978)) or the Akaike Information Criterion (AIC, (Akaike, 1974)), can be used to determine the appropriate model order p .

⁷ Causality in the sense of Granger implies the ability to predict the behavior of a variable using lagged values of another variable. Granger models can only identify short-term relationships.

In contrast error correction models belongs to a category of multiple time series models most commonly used for data where the underlying variables are cointegrated and thus have a long-run stochastic trend. ECMs are a theoretically-driven approach useful for estimating both short-term and long-term effects of one time series on another. The term error-correction relates to the fact that last-period's deviation from a long-run equilibrium, the error, influences its short-run dynamics. Thus, ECMs directly estimate the speed at which a dependent variable returns to equilibrium after a change in other variables.

Table 1 Descriptive statistics

panel	World	LI	LMI	UMI	HI	LTO	LMT0	UMTO	HTO
Countries.	167	28	38	46	55	33	45	49	40
Observations	6515	1136	1457	1772	2150	1366	1811	1898	1440
GDP p.c.									
mean	10,070.74	989.76	2225.41	6138.81	23,510.56	8957.54	8867.99	12,496.01	9458.16
std. dev.	13,887.17	784.58	1171.69	3051.58	17,259.29	9928.97	11,511.21	19,478.43	10,139.60
trade									
mean	0.770	0.542	0.723	0.850	0.858	0.319	0.552	0.833	1.391
std. dev.	0.495	0.294	0.381	0.468	0.613	0.162	0.193	0.256	0.553

2.4 Panel unit root test

The Granger causality test requires the variables to be stationary. We check their stationarity using a battery of panel unit root tests. We apply the IPS test by Im et al. (2003) and the Fisher-type unit root test developed by Maddala and Wu (1999) and Choi (2001) which allow for heterogeneous unit root processes among cross sections but assume that the cross sections are independent. However, for macroeconomic variables like GDP per capita and trade cross-sectional dependence is most likely, e.g., through regional linkages, local spillover effects between countries or globally common shocks. The results for the cross-sectional independence test developed by Pesaran (2004) reveal that the hypothesis of cross-sectional independence is rejected at the 1% significance level for both variables.⁸ Therefore, we apply also a second-generation unit root test developed by Pesaran (2007) allowing for cross-sectional dependence. The results (presented in Table 10 in the appendix) indicate that the null hypothesis of a unit root cannot be rejected for the levels, however the differences are stationary.

2.5 Panel cointegration test

Since the panel unit root tests indicate that the variables are integrated of order one $I(1)$, we test for cointegration using the panel cointegration tests developed by Pedroni (2004) as well as Westerlund (2007) and Persyn and Westerlund (2008). The former test allows for heterogeneity in the panel by permitting unit-specific short-run dynamics, heterogeneous trend and slope parameters, fixed effects, and individual specific deterministic trends, while the later additionally allows for cross-sectional dependence. Table 2 presents the results and shows that predominantly the null of no cointegration is rejected for both directions of the cointegration relation, indicating that the variables exhibit a cointegration relationship, regardless of the direction of the cointegration equation.

2.6 Error correction model

Engle and Granger (1987) have shown that when the series x and y are cointegrated, a standard Granger causality test as presented in the eqs. (1) and (2) is misspecified, because it does not allow for the distinction between the short-run and the long-run effect. Following Stock and Watson (1993) and Pedroni (2001) the long-run relationship between the cointegrated variables can be estimated using the dynamic OLS estimator for heterogeneous cointegrated panels. The estimator accounts for the endogeneity bias, heteroscedasticity and autocorrelation problems that typically occur when estimating dynamic relationships using the traditional OLS estimator and thus provides consistent and efficient estimates. Considering the short-run dynamics, we additionally estimate error correction models (ECM). These are linear transformations of the above ADL models and provide a link between the short-run and the long-run effect.

⁸ The test results are presented in Table 9 in the appendix.

Table 2 Panel cointegration test

test	$\ln GDP\ p.c. - trade$	$trade - \ln GDP\ p.c.$
Pedroni (2004)		
Panel ν -test	-0.549	2.470**
Panel ρ -test	3.767***	-4.031***
Panel pp-test	2.130**	-6.879***
Panel adf-test	2.373**	-4.026***
Group ρ -test	5.437***	-1.187
Group pp-test	1.865*	-7.423***
Group adf-test	1.305	-5.540***
Westerlund (2007) and Persyn & Westerlund (2008)		
Gt	-3.482***	-2.946***
Ga	-8.063	-7.415
Pt	-33.501***	-28.944**
Pa	-9.833**	-8.646

Note: The Akaike information criterion (AIC) is used to determine the optimal lag length. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

$$\Delta y_{i,t} = \alpha_0 + \sum_{j=1}^p \alpha_j \Delta y_{i,t-j} + \sum_{j=1}^p \delta_j \Delta x_{i,t-j} + \lambda ECT_{y,t-1} + f_i + u_{i,t} \quad (3)$$

$$\Delta x_{i,t} = \beta_0 + \sum_{j=1}^p \beta_j \Delta x_{i,t-j} + \sum_{j=1}^p \gamma_j \Delta y_{i,t-j} + \kappa ECT_{x,t-1} + \eta_i + v_{i,t} \quad (4)$$

The standard error correction procedure is a two-step method where first the error correction terms ECT_y and ECT_x are obtained by saving residuals of separate estimation of the long-run equilibrium of $y_{i,t}$ on $x_{i,t}$ and $x_{i,t}$ on $y_{i,t}$. In a second step the ECM with the included error correction term can be estimated. While the coefficients α_j and δ_j as well as β_j and γ_j capture the short-run effects, the coefficients λ and κ of the error correction terms give the adjustment rates at which short-run dynamics converge to the long-run equilibrium relationship. If λ and κ are negative and significant a relationship between x and y exist in the long run.

Table 3 shows the results of the long-run relationships presenting the Pedroni (2001) DOLS estimator. The results reveal that all coefficients have a positive sign and are statistically significant at the 1% level. We find a positive causal relationship between GDP per capita and trade for both directions for the global panel.

In order to infer the causal short-run relationship between GDP per capita and trade openness a panel vector error correction model is specified. The results of the corresponding error correction regressions are summarized in Table 4. They include the summation of the short-run coefficients with the corresponding F-statistic and the ECT coefficient with the corresponding t-statistic. Since the results of the short-run relationship are sensible to the lag length, the Akaike information criterion (AIC) is used to determine the optimal lag length. The first column explores the dynamics of trade on

Table 3 Pedroni panel DOLS long-run estimates

model	Dependent Variables	
	$\ln GDP p.c.$	<i>trade</i>
$\ln GDP p.c.$		0.351*** (0.014)
<i>trade</i>	0.571*** (0.025)	
Observations	5680	5680

Note: Standard errors are reported in parentheses. The Akaike information criterion (AIC) is used to determine the optimal lag length. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

GDP per capita and contains the results with reference to eq. (3), while the second column investigates the other direction of causality and is consequently based on eq. (4).

To avoid the problem of biased estimates through possible endogeneity caused by a simultaneity of GDP per capita and trade, we use the System-GMM estimator developed by Blundell and Bond (1998). This estimator effectively deals with the problem caused by endogenous explanatory variables by using their lagged levels as instruments for the difference equation and lagged differences as instruments for the level

Table 4 System-GMM panel causality test results

model	Dependent Variables	
	$\Delta \ln GDP p.c.$	$\Delta trade$
Short-run		
$\Delta \ln GDP p.c.$	0.286 [0.66]	0.745*** [6.91]
$\Delta trade$	0.025** [4.56]	0.002 [0.00]
Long-run		
ECT	-0.049* (0.071)	-0.481** (0.244)
AR2	0.858	0.087
Hansen test	0.080	0.066
Instruments	41	41
Countries	167	167
Observations	6181	6181

Note: The Akaike information criterion (AIC) is used to determine the optimal lag length. The short-run effect presents the summation of the short-run coefficients; the corresponding F-statistics is presented in squared parentheses. The long-run effect presents the coefficient for the error correction term with the corresponding standard errors in round parentheses. AR2 presents the p value of the Arelano-Bond (1991) test for autocorrelation of second order. Hansen test presents the p value of the J-test for overidentifying restrictions.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

equations. Therefore, we report several test statistics to evaluate instrument validity. In line with Roodman (2009), we also keep the number of used instruments always below the number of cross-sections by, collapsing the instrument matrix, to avoid the problem of instrument proliferation, which may render GMM estimates invalid.

With regard to the first error correction model presented in the first columns, we can identify both, a significant long-run and short-run effect of trade on income. The coefficient of the error correction term gives the adjustment rate at which short-run dynamics converge to the long-run equilibrium relationship. With respect to our specifications, this is the adjustment rate at which the gap between trade share and GDP per capita is closed. Furthermore, the significant error correction coefficient provides evidence of the already tested cointegration relationship between the variables and implies that short-run adjustments in trade will re-establish the long-run equilibrium when there are deviations from long-run equilibrium. The absolute value of the term provides the speed of the short-run adjustment process, indicating that about 5 % (-0.049) of the discrepancy is corrected in each period. Aside of the speed of adjustment, the results indicate the magnitude of the short-run effect. It is measured by the sum of the included lags of the independent variable and tested via an F-test. The coefficient indicates a positive significant causal effect running from trade to GDP per capita.

As for the other direction of the causal relationship presented in the second column of Table 4, the results also reveal a significant short-run and long-run effect running from GDP per capita to trade. Again, the error correction term is negative and significant. This intensifies the long-run relationship with a short-run adjustment to equilibrium that we already found in the first model. At about 48% (-0.481) the speed of adjustment is higher than in the reversed model. The short-run effect of income on trade is also positive, however at a higher level as the effect of the other direction, indicating that the short-run openness response to a temporary income shock is of a higher magnitude as the income response of a temporary openness shock.

In summary, the short-run and long-run results reveal a positive causality between trade and income, confirming the findings of previous causality studies (e.g. Bahmani-Oskooee et al., 1991; Islam, 1998; Xu, 1996; Awokuse, 2007; Herzer, 2013; Sakyi et al., 2015). From a global perspective, free trade policies prove beneficial to productivity and income levels, which is consistent with recent studies that suggest that openness to trade promotes economic development through various channels, such as technological progress (e.g., Fagerberg, 2000; Keller, 2000; Saggi, 2002) increasing key markets (e.g., Baldwin and Gu, 2004; Melitz and Ottaviano, 2008), and rising competition (e.g., Porter, 2000; Badinger, 2007).

2.7 Income- and trade-related differences

The question arises whether this globally identified positive connection applies to all countries, regardless of their development stage and their openness to international trade. Following the argument that least developed countries have a lower adoption capability of global know-how and technical knowledge due to e.g. weak institutions, a lack of investment in human capital and of a well-functioning financial system, developing countries may struggle to employ technologies with the same degree of intensity and versatility as developed countries and thus may not be able to benefit

equally from opening up to international trade. In this context Blalock and Gertler (2009) find that firms with investments in research and development and such with highly educated employees adopt more technology from foreign entrants than others and Levchenko (2007) argues that development differences captured by differences in institutional quality imply, among other things, that less developed countries may not gain from trade.

Further, following the reasoning that the relationship between trade and economic development may differ according to the level of trade openness, e.g. due to specialization patterns (Hausmann et al., 2007), different trade structures (Madsen, 2007; Saggi, 2002) and diversification patterns (Hesse, 2006; Naudé and Rossouw, 2011; Herzer and Nowak-Lehmann, 2006), more open countries may benefit to a different extent from the advantages of trade than less open countries. The empirical evidence also points at a possible asymmetry in the effect and shows that below a specific openness threshold greater trade openness has beneficial effects on economic growth and above the trade effect on growth declines (Zahonogo, 2016).

Hence, the literature suggests heterogeneity in the relationship between trade and development with regard to both, the stage of development and the degree of openness. To account for these possible development- and openness-related effects, we subdivide the global panel into income- and openness-related subpanels and carry out the cointegration and causality analysis for each panel individually.

The results for the unit root tests for the income subpanels are presented in Tables 11 and 12 in the appendix. Predominantly, the statistics indicate that - consistent with the results of the global panel - the variables are non-stationary in levels (Table 11), while the differenced data shows stationarity (Table 12). Since the variables are integrated of order one, in a next step we test for cointegration within the subpanels.

Table 5 shows the results for the cointegration tests. It becomes apparent that the subpanel results are not homogeneous and differ according to the income level and the degree of openness. Starting with the difference according to the stage of development, first, high-income countries exhibit a cointegration relationship. These groups of countries seem to have a long-run relationship between per-capita income and trade share for both directions of the cointegration equation. Second, the vast majority of the test statistics for the lower income subpanels (low-income, lower-middle income and upper-middle income) do not show a significant cointegration relation, with the exception of the trade-to-income direction for the low-middle income subpanel.

Considering the differences according to the degree of openness the picture is similar. We can identify a cointegration relationship for countries with a high degree of openness, while the test statistics (especially when cross-sectional dependence is taken into consideration) are insignificant for the lower quartiles.

Depending on the result of the cointegration test we now apply DOLS estimation and ECM for those subpanels that show a cointegration relationship and Granger causality test for those subpanels without a long-run relationship. The DOLS estimator allows to account for the magnitude and sign of the long-run relationship. The results are presented in Table 6. The coefficients indicate a highly significant long-run relationship running from trade to GDP p.c. and vice

Table 5 Panel cointegration test for income- and trade-related subpanels

Test	lnGDP p.c. – trade							
Panel	LI	LMI	UMI	HI	LTO	LMTO	UMTO	HTO
Pedroni (2004)								
Panel v-test	-0.670	0.500	0.710	-1.603	0.122	-0.247	-0.136	-0.112
Panel ρ -test	1.137	0.497	0.683	3.198***	1.389	1.443	2.224**	2.116**
Panel pp-test	0.147	-1.296	-0.415	2.355**	0.385	0.625	0.660	1.995**
Panel adf-test	0.113	-0.692	-0.557	3.204***	0.468	0.296	1.353	2.403**
Group ρ -test	1.649*	1.873*	2.551**	3.969***	2.743***	2.529**	2.752***	3.843***
Group pp-test	0.094	-0.986	0.216	1.835*	0.956	1.142	-0.1777	2.742***
Group adf-test	0.314	-1.046	-1.111	1.990**	1.171	0.635	-0.472	2.175**
Westerlund (2007) and Persyn & Westerlund (2008)								
Gt	-2.131	-4.352***	-4.739***	-2.519*	-2.216***	-2.311	-4.635***	-4.434***
Ga	-7.791	-8.489	-7.831	-8.109	-7.721	-8.211	-8.903	-7.093
Pt	-12.810**	-15.146***	-23.402***	-12.778	-11.492	-17.715***	-17.564***	-14.899**
Pa	-9.023	-9.253	-15.734***	-5.097	-7.029	-10.542**	-9.548	-8.041
Test	trade – lnGDP p.c.							
Panel	LI	LMI	UMI	HI	LTO	LMTO	UMTO	HTO
Pedroni (2004)								
Panel v-test	-0.303	1.292	-0.186	1.454	-0.219	2.013**	0.958	2.278**
Panel ρ -test	-1.174	-2.885***	-1.172	-1.957*	0.866	-2.269***	-2.567**	-2.566**
Panel pp-test	-2.196**	-3.822***	-2.963***	-4.403***	-0.008	-3.369***	-3.860***	-4.868***

Table 5 (continued)

Test	trade – lnGDP p.c.							
Panel	LI	LMI	UMI	HI	LTO	LMTO	UMTO	HTO
Panel adf-test	-1.776*	-2.086*	-2.449**	-2.807***	0.402	-2.459**	-1.942*	-3.146***
Group ρ -test	0.355	-1.169	0.157	-0.613	1.629	-0.399	-1.204	-0.374
Group pp-test	-1.473	-3.817***	-3.307***	-4.856***	0.255	-2.692***	-4.320***	-5.485***
Group adf-test	-1.414	-2.749***	-3.342***	-3.309***	0.629	-2.083**	-2.924***	-4.380***
Westerlund (2007) and Persyn & Westerlund (2008)								
Gt	-4.141***	-2.606**	-3.238***	-2.329**	-3.858***	-2.419	-3.056***	-2.653**
Ga	-7.531	-8.886	-7.314	-6.441***	-6.126	-6.491	-9.338	-7.266
Pt	-10.641	-14.085	-14.969	-17.014***	-11.025	-14.417	-13.231	-14.702*
Pa	-8.098	-10.900**	-8.145	-6.589***	-6.344	-9.030	-7.551	-8.101

Note: The Akaike information criterion (AIC) is used to determine the optimal lag length. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

versa for all subpanels where we could identify a cointegration relationship. Further, the beneficial effect of trade on income is much higher for high-income countries than for highly open countries. This is also the case for the positive effect of development on trade, where we again can identify the highest effect for the group of high-income countries. In comparison, the effect for lower-middle income countries is only about half as large. For the openness subpanels the effects are relatively close, but the countries with the highest openness benefit less than those in the upper-middle openness group.

The results of the short-run dynamics are presented in Table 7 for the effect of trade on GDP p.c. and in Table 8 for the opposite direction. Here the short-run effects are calculated within error correction models for the case of a cointegration relationship, and within Granger causality models for the case of no cointegration. Both model classes also control for the inclusion of a lagged dependent variable. The negative significant error correction terms confirm the previously identified long-run relationship. As for short-run effects, only the countries with low levels of income and a lower-middle degree of trade openness show a positive significant short-run effect of trade on income. The group of low-income countries also shows a significant short-run effect for the direction from income to trade where also the coefficient of the upper-middle trade openness panel is significant.

In summary, the long- and short-run results suggest that the relationship between trade and income is not that straightforward. We can identify heterogeneity in the relationship depending on both, the stage of development and the degree of openness.

While trade does not seem to drive economic development for the low- and middle-income countries, where only short-run benefits can be identified, high-income countries seem to gain income advantages in the long run. The beneficial effects of opening up to international trade thus seem to increase as economies develop, confirming the arguments about the adaptation capabilities of a country in determining technology transfer and knowledge diffusion (Kim and Lin, 2009). This result is consistent with existing empirical evidence, which shows considerable differences in the effects of trade on income across countries (Herzer, 2013)

Table 6 Pedroni panel DOLS long-run estimates for income- and trade-related subpanels

	LI	LMI	UMI	HI	LTO	LMTO	UMTO	HTO
model	Dependent Variables $\ln GDP$ p.c.							
trade.	–	–	–	0.363*** (0.024)	–	–	–	0.133*** (0.033)
model	Dependent Variables <i>trade</i>							
$\ln GDP$ p.c.	–	0.180*** (0.036)	–	0.373*** (0.029)	–	–	0.282*** (0.016)	0.228*** (0.029)
Observations	–	1267	–	1875	–	–	1517	1036

Note: Standard errors are reported in parentheses. The Akaike information criterion (AIC) is used to determine the optimal lag length. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7 Panel causality test results: Short-run and lung-run effect of trade on GDP p.c. for income- and trade-related subpanels

model	Dependent Variables $\Delta \ln GDP$ p.c.							
	LI	LMI	UMI	HI	LTO	LMTO	UMTO	HTO
Short-run								
$\Delta \ln GDP$ p.c.	-0.052 [0.04]	-0.285 [0.32]	-0.049 [0.12]	0.181 [1.19]	0.115 [0.30]	-0.018 [0.15]	0.324*** [0.12]	0.026 [0.12]
$\Delta trade$	0.301*** [14.22]	-0.048 [0.45]	0.101 [1.36]	0.042 [0.19]	-0.034 [0.075]	0.165** [0.07]	-0.044 [0.05]	0.084 [0.08]
Long-run								
ECT	— —	— —	— —	-0.072* (0.040)	— —	— —	— —	0.011* (0.006)
AR2	0.295	0.721	0.144	0.141	0.231	0.094	0.986	0.262
Hansen test	0.901	0.721	0.404	0.133	0.731	0.454	0.594	0.402
Instruments	40	40	40	40	40	45	40	40
Countries	28	387	46	55	33	40	49	40
Observations	1080	1343	1680	2040	1300	1721	1800	1360

Notes: The Akaike information criterion (AIC) is used to determine the optimal lag length. The short-run effect presents the summation of the short-run coefficients and the corresponding F-statistics in squared parentheses. The long-run effect presents the coefficient for the error correction term with the corresponding standard errors in round parentheses. AR2 presents the p value of the Arelano-Bond (1991) test for autocorrelation of second order. Hansen test presents the p value of the J-test for overidentifying restrictions * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

and higher trade benefits for developed countries (Kim and Lin, 2009; Kim, 2011).

Further, the link between trade and income also appears to be dependent on the degree of trade openness. Countries that are only open to international trade on a medium and small scale are unable to tap into the trade advantages in the form of economies of scale, specialization or technology adoption. The effect heterogeneity may reflect the development- and openness-related trade structure characteristics of countries at different stages of development and global integration (Hausmann et al., 2007; Rodrik, 2006). Contrary to the result of Zahanogo (2016), who identifies higher benefits below a certain threshold of openness, our result suggests that a certain degree of openness is required to reap the benefits. The differences in the results may appear due to the fact that his analysis is based on Sub Saharan African countries only, representing different conditions in terms of development and trade.

3 Conclusion

In this contribution we reconsider the link between openness and development and examine the causal relationship between trade and income for 167 countries over the period 1970–2011. After reviewing recent research regarding the link between trade and income, we apply panel cointegration, Granger causality and panel error correction

Table 8 Panel causality test results: Short-run and long-run effect of GDP p.c. on trade for income- and trade-related subpanels

model	Dependent Variables $\Delta trade$							
	LI	LMI	UMI	HI	LTO	LMTO	UMTO	HTO
Short-run								
$\Delta \ln GDP\ p.c.$	0.454*	0.310	-0.043	-0.189	-0.324	0.226	0.627***	0.334
	[2.77]	[4.65]	[0.01]	[3.81]	[0.36]	[0.26]	[0.17]	[0.29]
$\Delta trade$	-0.029	0.015	-0.073***	0.218	0.012	-0.048	-0.087	-0.017
	[0.20]	[5.19]	[12.72]	[5.75]	[0.035]	[0.07]	[0.06]	[0.03]
Long-run								
ECT	-	-0.226*	-	-0.124**	-	-	-0.265**	-0.345**
	-	(0.127)	-	(0.052)	-	-	(0.114)	(0.179)
AR2	0.942	0.874	0.212	0.936	0.135	0.162	0.592	0.128
Hansen test	0.989	0.432	0.404	0.049	0.774	0.265	0.244	0.353
Instruments	41	41	41	40	41	41	41	41
Countries	28	387	46	55	33	45	49	40
Observations	1080	1305	1680	1930	1300	1721	1800	1360

Notes: The Akaike information criterion (AIC) is used to determine the optimal lag length. The short-run effect presents the summation of the short-run coefficients and the corresponding F-statistics in squared parentheses. The long-run effect presents the coefficient for the error correction term with the corresponding standard errors in round parentheses. AR2 presents the p value of the Arelano-Bond (1991) test for autocorrelation of second order. Hansen test presents the p value of the J-test for overidentifying restrictions

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

in combination with Dynamic Ordinary Least Squares and General Method of Moments estimation to explore the causal relationship between these two variables. Besides a global analysis, we account for potential development- and openness-related effect differences by subdividing the global panel into subpanels and examining causality differences with regard to different stages of development and different degrees of openness.

In line with recent literature, the global analysis reveals a statistically significant positive short-run and long-run relationship between trade and income. The subpanel analysis, however, shows that the identified relationship is not universally valid, it is rather heterogeneous and varies according to development and openness levels. A bidirectional positive long-run relationship is evident only for high-income and highly open countries, while countries with a low level of income or a low degree of openness are not able to benefit.

The heterogeneity of the results indicates that the opening process plays an important role. Countries at a low stage of development and a low degree of global integration where the opening process has so far been insufficient do not participate in the benefits of trade. From a certain development and openness stage - which is accompanied by a link to leading technologies and the transfer of knowledge - trade and economic development show a positive causal relationship.

Acknowledgments We thank the anonymous reviewer whose comments have greatly improved this manuscript.

Funding information Open Access funding provided by Projekt DEAL.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Appendix

Appendix 1

The countries included in the analysis are.

Low-income economies (\$1045 or less GDP per capita):

Bangladesh, Benin, Burkina Faso, Burundi, Cambodia, Central African Republic, Chad, Comoros, Congo, Dem. Rep., Ethiopia, Gambia, Guinea, Guinea-Bissau, Kenya, Liberia, Madagascar, Malawi, Mali, Mozambique, Nepal, Niger, Rwanda, Sierra Leone, Tajikistan, Tanzania, Togo, Uganda, Zimbabwe.

Lower-middle-income economies (\$1046 to \$4125 GDP per capita):

Armenia, Bhutan, Bolivia, Cameroon, Cape Verde, Republic of Congo, Cote d'Ivoire, Djibouti, Egypt, El Salvador, Georgia, Ghana, Guatemala, Honduras, India, Indonesia, Kyrgyzstan, Laos, Lesotho, Mauritania, Moldova, Mongolia, Morocco, Nigeria, Pakistan, Paraguay, Philippines, Sao Tome and Principe, Senegal, Sri Lanka, Sudan, Swaziland, Syria, Ukraine, Uzbekistan, Vietnam, Yemen, Zambia.

Upper-middle-income economies (\$4126 to \$12,745 GDP per capita):

Albania, Angola, Argentina, Azerbaijan, Belarus, Belize, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, China, Colombia, Costa Rica, Dominica, Dominican Republic, Ecuador, Fiji, Gabon, Grenada, Hungary, Iran, Iraq, Jamaica, Jordan, Kazakhstan, Lebanon, Macedonia, Malaysia, Maldives, Mauritius, Mexico, Montenegro, Namibia, Panama, Peru, Romania, Serbia, South Africa, St. Lucia, St. Vincent & Grenadines, Suriname, Thailand, Tunisia, Turkey, Turkmenistan, Venezuela.

High-income economies (\$12,746 or more GDP per capita):

Antigua and Barbuda, Australia, Austria, Bahamas, Bahrain, Barbados, Belgium, Bermuda, Brunei, Canada, Chile, Croatia, Cyprus, Czech Republic, Denmark, Equatorial Guinea, Estonia, Finland, France, Germany, Greece, Hong Kong, Iceland, Ireland, Israel, Italy, Japan, Republic of Korea, Kuwait, Latvia, Lithuania, Luxembourg, Macao, Malta, Netherlands, New Zealand, Norway, Oman, Poland, Portugal, Qatar, Russia, Saudi Arabia, Singapore, Slovak Republic, Slovenia, Spain, St. Kitts & Nevis, Sweden, Switzerland, Taiwan, Trinidad & Tobago, United Kingdom, United States, Uruguay.

Table 9 Pesaran cross-sectional independence test

	<i>ln GDP p.c.</i>	<i>trade</i>
avg ρ	0.436	0.232
avg ρ	0.647	0.502
CD	298.59	164.54
p value	0.000	0.000

Note: Under the null hypothesis of cross-section independence $CD \sim N(0,1)$. ρ refers to the correlation coefficients between the time-series for each panel member

Table 10 Panel unit root test

Test	<i>ln GDP p.c.</i>	<i>trade</i>	$\Delta \ln GDP p.c.$	$\Delta trade$
Im et al. (2003)				
Z_t	6.96	8.52	-19.75***	-22.25***
Maddala & Wu (1999) and Choi (2001)				
P	247.62	251.05	1158.88***	1331.45***
Z	6.85	8.42	-21.50***	-24.23***
L^*	6.97	9.12	-23.61***	-27.67***
Pm	-3.34	-3.21	31.92***	38.59***
Pesaron (2007)				
Z_t	4.03	-1.56*	-9.83***	-15.03***

Note: The Akaike information criterion (AIC) is used to determine the optimal lag length. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11 Panel unit root test for income- and trade-related subpanels - level data

Test	$\ln GDP_{p.c.}$				trade											
	LI	LMI	UMI	HI	LTO	LMTO	UMTO	HTO	LI	LMI	UMI	HI	LTO	LMTO	UMTO	HTO
Im et al. (2003)																
Z_t	4.26	4.47	3.89	1.81	7.73	4.78	1.28	1.08	2.78	0.93	3.62	8.77	10.16	5.73	1.78	0.35
Maddala & Wu (1999) and Choi (2001)																
P	31.26	60.18	62.03	94.16	29.75	41.89	104.65	71.34	41.04	82.28	77.13	50.60	12.85	50.12	98.49	89.59
Z	3.03	3.867	3.87	2.54	5.39	5.40	1.68	1.59	2.91	1.09	3.79	8.25	9.86	5.23	1.86	0.64
L^*	3.18	4.244	4.24	2.26	5.75	5.55	1.49	1.59	3.19	1.13	4.17	8.92	10.74	5.58	2.05	0.74
Pm	-2.34	-1.28	-1.28	-1.07	-3.16	-3.59	0.47	-0.68	-1.41	0.51	-1.10	-4.01	-4.63	-2.97	0.04	0.76
Pesaron (2007)																
Z_t	3.97	-2.32***	-0.06	2.15	4.40	2.78	-0.09	-0.83	-1.74*	-2.28**	-1.06	0.63	-0.30	-0.43	0.27	1.82

Note: The Akaike information criterion (AIC) is used to determine the optimal lag length. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12 Panel unit root test for income- and trade-related subpanels - differenced data

Test	$\Delta \ln GDP$ <i>p.c.</i>							
	LI	LMI	UMI	HI	LTO	LMTO	UMTO	HTO
Im et al. (2003)								
Z_t	-7.72***	-8.49***	-11.45***	-11.34***	-6.92***	-10.82***	-11.27***	-10.09***
Maddala & Wu (1999) and Choi (2001)								
P	182.30***	246.62***	341.30***	388.66***	185.06***	317.72***	362.94***	293.16***
Z	-8.37***	-9.17***	-12.60***	-12.35***	-7.40***	-11.81***	-12.28***	-11.09***
L^*	-8.97***	-10.33***	-13.64***	-13.74***	-7.89***	-12.71***	-13.79***	-12.40***
Pm	-11.94***	13.84***	18.38***	18.79***	10.36***	16.97***	18.92***	16.85***
Pesaron (2007)								
Z_t	-6.26***	-5.94***	-7.93***	-4.56***	-4.16***	-6.69***	-7.42***	-4.40***
Test	$\Delta trade$							
	LI	LMI	UMI	HI	LTO	LMTO	UMTO	HTO
Im et al. (2003)								
Z_t	-8.99***	-10.66***	-12.93***	-11.36***	-7.95***	-11.58***	-11.98***	-12.65***
Maddala & Wu (1999) and Choi (2001)								
P	236.02***	299.23***	422.81***	388.66***	199.99***	364.83***	374.07***	392.55***
Z	-9.61***	-11.69***	-14.07***	-12.35***	-8.58***	-12.51***	-13.46***	-13.89***
L^*	-11.89***	-13.01***	-16.93***	-13.74***	-9.12***	-14.61***	-14.41***	-16.92***
Pm	17-01***	18.11***	24.39***	18.79***	11.66***	20.48***	19.72***	24.71***
Pesaron (2007)								
Z_t	-6.19***	-7.13***	-6.51	-4.563***	-6.25***	-7.92***	-8.48***	-7.36***

Note: The Akaike information criterion (AIC) is used to determine the optimal lag length. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Akaike H (1974) A new look at the statistical model identification, automatic control. *IEEE Transactions on* 19(6):716–723
- A. Alesina, E. Spolaore, R. Wacziarg (2005). Trade, growth and the size of countries. In *handbook of economic growth*, 1, 1499–1542. Elsevier
- Arellano M, Bond S (1991) Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Rev Econ Stud* 58(2):277–297
- Awokuse TO (2007) Causality between exports, imports, and economic growth: evidence from transition economies. *Econ Lett* 94(3):389–395
- Badinger H (2007) Market size, trade, competition and productivity: evidence from OECD manufacturing industries. *Appl Econ* 39(17):2143–2157
- Bahmani-Oskooee M, Mohtadi H, Shabsigh G (1991) Exports, growth and causality in LDCs: a re-examination. *J Dev Econ* 36(2):405–415
- Baldwin JR, Braconier H, Forslid R (2005) Multinationals, endogenous growth, and technological spillovers: theory and evidence. *Rev Int Econ* 13(5):945–963
- Baldwin JR, Gu W (2004) Trade liberalization: export-market participation, productivity growth, and innovation. *Oxf Rev Econ Policy* 20(3):372–392
- Barro RJ, Sala-i-Martin X (1995) *Economic growth*. McGraw-Hill, Cambridge, MA
- Blundell B, Bond S (1998) Initial conditions and moment restrictions in dynamic panel data models. *J Econ* 87(1):115–143
- Chang R, Kaltani L, Loayza N (2009) Openness is good for growth: the role of policy complementarities. *J Dev Econ* 90:33–49
- Choi I (2001) Unit root tests for panel data. *J Int Money Financ* 20(2):249–272
- Dollar D, Kraay A (2003) Institutions, trade, and growth. *J Monet Econ* 50(1):133–162
- Dollar D, Kraay A (2004) Trade, growth, and poverty. *Economic Journal* 114(493):22–49
- Douglas AI, Tervio M (2002) Does trade raise income? Evidence from the twentieth century. *J Int Econ* 58(1):1–18
- Edwards S (1998) Openness, productivity, and growth: what do we really know? *Economic Journal* 108(447):383–398
- Engle RF, Granger CWJ (1987) Co-integration and error correction: representation, estimation, and testing. *Econometrica* 55(2):251–276
- Fagerberg J (2000) Technological progress, structural change and productivity growth: a comparative study. *Struct Chang Econ Dyn* 11(4):393–411
- Felbermayr GJ (2005) Dynamic panel data evidence on the trade income relation. *Rev World Econ* 141(4):583–611
- R.C. Feenstra, R. Inklaar, M Timmer. (2013). The next generation of the Penn world table (no. w19255), National Bureau of Economic Research
- Feyrer J (2019) Trade and income - exploiting time series in geography. *Am Econ J Appl Econ* 11(4):1–35
- Frankel JA, Romer DH (1999) Does trade cause growth? *Am Econ Rev* 89(3):379–399
- Granger CWJ (1969) Investigating causal relations by econometric models and cross-spectral methods. *Econometrica* 37(3):424–438
- Grossman GM, Helpman E (1990) Comparative advantage and long-run growth. *Am Econ Rev* 80:796–815
- Grossman GM, Helpman E (1991) *Innovation and growth in the global economy*. MIT Press, Cambridge, MA
- Hausmann R, Hwang J, Rodrik D (2007) What you export matters. *J Econ Growth* 12(1):1–25
- Herzer D (2013) Cross-country heterogeneity and the trade-income relationship. *World Dev* 44:194–211
- Herzer D, Nowak-Lehmann DF (2006) What does export diversification do for growth? An econometric analysis. *Appl Econ* 38(15):1825–1838
- Hesse H (2006) *Export diversification and economic growth*. World Bank, Washington, DC
- Im KS, Pesaran MH, Shin Y (2003) Testing for unit roots in heterogeneous panels. *J Econ* 115(1):53–74
- Irwin DA, Tervio M (2002) Does trade raise income? Evidence from the twentieth century. *J Int Econ* 58(1):1–18

- Islam MN (1998) Export expansion and economic growth: testing for cointegration and causality. *Appl Econ* 30(3):415–425
- Keller W (2000) Do trade patterns and technology flows affect productivity growth? *World Bank Econ Rev* 14(1):17–47
- Kim DH, Lin SC (2009) Trade and growth at different stages of economic development. *J Dev Stud* 45(8): 1211–1224
- Kim DH, Lin SC, Suen YB (2011) Nonlinearity between trade openness and economic development. *Rev Dev Econ* 15(2):279–292
- Levchenko AA (2007) Institutional quality and international trade. *Rev Econ Stud* 74(3):791–819
- Lucas RE (1988) On the mechanic of economic development. *J Monet Econ* 22:3–42
- Maddala GS, Wu S (1999) A comparative study of unit root tests with panel data and a new simple test. *Oxf Bull Econ Stat* 61(1):631–652
- Madsen JB (2007) Technology spillover through trade and TFP convergence: 135 years of evidence for the OECD countries. *J Int Econ* 72(2):464–480
- Melitz MJ, Ottaviano GI (2008) Market size, trade, and productivity. *Rev Econ Stud* 75(1):295–316
- Naudé W, Rossouw R (2011) Export diversification and economic performance: evidence from Brazil, China, India and South Africa. *Econ Chang Restruct* 44(1–2):99–134
- Noguer M, Siscart M (2005) Trade raises income: a precise and robust result. *J Int Econ* 65(2):447–460
- Pedroni P (2001) Fully modified OLS for heterogenous cointegrated panels. In: Baltagi, B., ed. *nonstationary panels, panel Cointegration, and dynamic panels, advances in econometrics*. Amsterdam: JAI Press 15:93–130
- Pedroni P (2004) Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. *Econometric Theory* 20(3):597–625
- Persyn D, Westerlund J (2008) Error-correction-based cointegration tests for panel data. *Stata J* 8(2):232–241
- Pesaran, M.H. (2004). General diagnostic tests for cross section dependence in panels, CESifo working paper series no. 1229; IZA discussion paper no. 1240
- Pesaran MH (2007) A simple panel unit root test in the presence of cross-section dependence. *J Appl Econ* 22(2):265–312
- Porter ME (2000) Location, competition, and economic development: local clusters in a global economy. *Econ Dev Q* 14(1):15–34
- Rodríguez F, Rodrik D (2001) Trade policy and economic growth: a skeptics guide to the cross-national evidence, in B. Bernanke and K. Rogoff (eds.), *NBER macroeconomics annual 2000*. MIT Press 15:261–325
- P Romer. (1993). Two strategies for economic development: Using ideas and producing ideas, proceedings of the World Bank annual conference on development economics, 1992, ed. Summers, L.H; Shah, S., Washington, D.C.: World Bank, 63–91
- Roodman D (2009) A note on the theme of too many instruments. *Oxf Bull Econ Stat* 71(1):135–158
- Saggi K (2002) Trade, foreign direct investment, and international technology transfer: a survey. *World Bank Res Obs* 17(2):191–235
- Sakya D, Villaverde J, Maza A (2015) Trade openness, income levels, and economic growth: the case of developing countries, 1970–2009. *The Journal of International Trade & Economic Development* 24(6):860–882
- Schwarz G (1978) Estimating the dimension of a model. *Ann Stat* 6(2):461–464
- Singh T (2010) Does international trade cause economic growth? A survey. *World Econ* 33(11):1517–1564
- Stock JH, Watson MW (1993) A simple estimator of cointegrating vectors in higher order integrated systems. *Econometrica* 61(4):783–820
- Wacziarg R, Welch KH (2008) Trade liberalization and growth: new evidence. *World Bank Econ Rev* 22(2):187–231
- Westerlund J (2007) Testing for error correction in panel data. *Oxf Bull Econ Stat* 69(6):709–748
- Xu Z (1996) On the causality between export growth and GDP growth: an empirical reinvestigation. *Rev Int Econ* 4(2):172–184
- Yanikkaya H (2003) Trade openness and economic growth: a crosscountry empirical investigation. *J Dev Econ* 72(1):57–89
- Young A (1991) Learning by doing and the dynamic effects of international trade. *Q J Econ* 106(2):369–405
- Zahonogo P (2016) Trade and economic growth in developing countries: evidence from sub-Saharan Africa. *Journal of African Trade* 3(1–2):41–56