

Colombia's potential for trade with the European Union and other major global markets

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Abstract

This paper identifies potential for trade between Colombia and the European Union following the implementation of a free trade agreement as from 2013. Predictions of potential are based on estimates produced by the Poisson pseudo maximum likelihood estimator applied to a gravity model, controlling for unobserved omitted variable bias with exporter and importer time-varying fixed effects on a sample of 153 countries, from 1980 to 2012. Untapped potential is found in both directions of trade flows. The results could increase the effectiveness of trade policy and define companies' expansion plans in international markets.

Keywords

Free trade, economic agreements, market potential, measurement, stochastic models, Colombia, European Union

JEL classification

F14, F15, F53

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I. Introduction

Colombia was left behind by Chile and Mexico with their prolific trade policies in the last thirty years, and suffered from a competitive disadvantage in the Latin American and Caribbean region. This, along with relatively weak opposition to the liberal ideas promoted by ruling administrations, gave rise to a wave of trade liberalization negotiations that concluded with important trade agreements with Canada, Central American and European Free Trade Association (EFTA) countries and the United States. In March 2010, Colombia and Peru formally concluded negotiations to liberalize trade and investment with the European Union. This agreement (European Union, 2012) entered into force on 1 March 2013 (WTO, 2015) for Peru and on 1 August for Colombia.

The aim of free trade agreements is to increase trade among signatory countries (Kohl, 2014). However, is there really a gap between observed and potential trade between Colombia and the European Union? Or, on the contrary, does trade between Colombia and the European Union already exceed what should be considered normal? The aim of this paper is to determine the existence of untapped trade potential between Colombia and European Union countries in both directions: exports from Colombia to European Union countries and exports from European Union countries to Colombia.

To determine the existence of potential for trade between European Union countries and Colombia, we must know what a “normal” bilateral trade relationship constitutes. The gravity model establishes a theoretical framework to tackle this question empirically. We then produce estimates using up-to-date methodologies, mainly the Poisson pseudo maximum likelihood (PPML) estimator.

This paper will provide evidence of overtrading or undertrading in Colombia’s bilateral trade flows to European Union countries and a group of interesting markets, as well as in flows from these markets to Colombia.

Predictions indicating a weaker trade pattern than the one observed can be interpreted in many ways: they could stem from short-term deviations, structural restrictions or even model specification problems. However, an analysis of trade potential, combined with the study of the development and particularities of bilateral relationships, could point to undertrading as a potential gap to be filled by the exporting country.

Trade potential could be a valuable input to focus trade policy on areas where it would be most effective and help define expansion plans in international markets for businesses. We also hope to pave the way for future research on the ex post impact of the agreement.

Records were reviewed for 2013–2015 bilateral trade data on flows between Colombia and the European Union. We found that flows with higher potential grew at a faster rate than those reflecting an overtrading position or with low potential. Exports from Sweden to Colombia —which decreased by 31% on average— were a clear exception. Other cases such as exports from Colombia to France and Poland, which also decreased, reflected an overtrading position or only slim potential based on some specifications.

Considering Colombian exports to the European Union under the time-varying fixed effects specification with PPML, the model successfully predicted the dynamics of 83% of the analysed countries. For European Union exports to Colombia, this rate was 72%.

Section II presents a literature review on trade potential, and is followed by an explanation of the data and methodology used in section III, a presentation of results in section IV, a sensitivity analysis of trade potential in section V, and a summary of conclusions in section VI.

II. Literature review

Some of the pioneering articles on trade potential have focused on Central and Eastern European countries (CEECs). These countries presented a distorted pattern of trade that was supposed to find its natural equilibrium in a more open environment. Working with data for 76 countries from 1984–1986, Wang and Winters (1992) predicted a reconfiguration of cross-border transactions concerning these economies. They found a relative overtrading pattern with Western Europe and projected a rise in exports to Japan and the United States. Using the same sample, Hamilton and Winters (1992) estimated that trade between countries of the former Soviet Union and Eastern Europe and market economies fell dramatically short of potential and that trade, mainly with Germany, the United Kingdom and the United States, had to increase.

Baldwin (1994) found that “even at 1989 CEEC income levels, EFTA-CEEC trade should have been four times greater”, and there were variations across countries. For example, observed trade between Bulgaria and the European Union was five times lower than the potential level, while observed trade for Hungary was closer to equilibrium owing to anticipated trade liberalization programmes.

Grosa and Andrzej (1996) used Baldwin (1994) as a benchmark and focused their attention on the most advanced transition economies, namely Czechia, Hungary, Poland and Slovakia, as data for 1992 found that the potential for trade from CEECs to European Union markets was relatively exhausted, meaning that trade flows had already been redirected. Bullhart and Kelly (1999) focused on Ireland’s trading potential with CEECs. The application of out-of-sample ordinary least square (OLS) estimates to 1994 cross-sectional data for 24 countries determined that trade between the top five CEECs and Ireland was below half the potential level, while Ireland’s bilateral flows with all other countries in the sample were around the normal level.

Christie (2002) applied another gravity model to trade potential for countries in South-Eastern Europe, and estimated pooled cross sections with OLS for 1996–1999. Observed and predicted bilateral flows reflected large deviations, particularly among Balkan countries, in what could be considered unnatural trade relationships deriving from the war.

A review of the integration of countries in Central and South-Eastern Europe into the euro area (Bussière, Fidrmuc and Schnatz, 2008) based on a panel of 61 countries for 1980–2003 and estimates with OLS fixed effects showed that the potential for trade between the new European Union members and the euro area was relatively limited, while there was still considerable potential for Albania, Bosnia and Herzegovina, Croatia and the former Yugoslav Republic of Macedonia, according to the out-of-sample trade potential indicator.

Martínez and Nowak (2003) analysed European Union-MERCOSUR trade potential using panel data. They applied an OLS fixed-effects gravity model to a sample of 20 countries over a 1988–1996 time span. They found that in 1996, MERCOSUR traded below its potential with every single country of the European Union.

On the basis of a 1967–2001 panel of 45 countries, Antonucci and Manzocchi (2006) explored the trade potential between Turkey and European Union countries, and found that bilateral trade flows between them were around the normal rule prediction of the OLS fixed-effects gravity model estimations.

In one of the most recent studies, Péridy (2012) applied an out-of-sample methodology and found that Mediterranean partners have exhausted their trade potential with the European Union. He opted for the Hausman and Taylor estimator, which is a two-stage least squares (2SLS) random effect model, to estimate a gravity equation for 67 countries for 2000–2009. Péridy (2006) also found that

although many of the old adherents of the European Neighbourhood Policy or early liberalizers had exhausted their potential, new members such as countries from the South Caucasus and the Balkans still harboured potential for trade. Péridy (2005) revealed limited trade potential among the signatory countries of the Agadir Agreement based on a dynamic Arellano, Bond and Bover (ABB) gravity model, in spite of the fact that only a tiny fraction of total trade took place within this free trade area.

With a view to evaluating African regional integration schemes, Rojid (2006) estimated a gravity model using a Tobit specification on a 1980–2001 panel data set for 147 countries. According to his results, flows between countries belonging to the Common Market for Eastern and Southern Africa (COMESA) reflected overtrading, and the only countries still harbouring potential for trade were Angola and Uganda.

China's integration into global trade has been achieved, as confirmed by Bussière and Schnatz (2007) through their OLS fixed-effects estimations of a gravity model across 61 countries from 1980 to 2003. To avoid omitted variable bias, they adjusted residuals with a new empirical indicator of trade integration that took into account country-average trade links or trade intensity. They detected potential for trade between China and India, Luxembourg and Portugal.

Armstrong, Drysdale and Kalirajan (2008) focused on Asia, and compared potential for trade between East Asian and South Asian countries. The authors applied OLS regressions to four cross-sections with average values between 1993 and 2004 for a list of 68 trading economies. Their findings suggest that East Asian trade exceeded the global average, while countries in South Asia harboured substantial unrealized trade potential, even within the region.

The potential for trade between Pakistan and Bangladesh, Japan, Malaysia, New Zealand, Norway, the Philippines and Sri Lanka is considerable, as Gul and Yasin (2011) found by using an out-of-sample technique based on a gravity model with fixed effects across 42 countries for 1981–2005.

India's global trade potential was documented by Batra (2006). He applied OLS to a gravity equation using a sample of 146 countries with cross-sectional data for the year 2000. Trade potential was detected mainly in the Asia-Pacific region, the Commonwealth of Independent States (CIS) and Western Europe. Trade for Georgia, Turkmenistan and Uzbekistan was more than ten times lower than the potential level. Much of the predicted expansion in trade was expected to involve China, France, Italy and the United Kingdom.

Masudur Rahman and Arjuman Ara (2010) used OLS random and fixed-effects models to estimate a gravity equation for a 1995–2007 panel using a sample of 81 countries. Their results indicate “that a large part of Bangladesh's potential trade has remained unrealized”. Based on these findings, they claim that that country's trade policy should focus on partner diversification strategies. Masudur Rahman (2010) also explored the global trade potential of Australia. He used OLS to estimate a regression for a 50-country cross-section based on a gravity equation and data from 2001 and 2005. His results for 2005 revealed substantial potential for trade with Argentina, Chile, Greece, Portugal, the Philippines and the Russian Federation. Trade with these countries reflected potential for an increase of at least three times the actual level, based on the predicted values of the gravity model.

Using a 1990–2004 pooled cross-section OLS estimation of a gravity model for 88 countries, Boughanmi (2008) concluded that Gulf Cooperation Council (GCC) intra-bloc trade had already attained its potential. Unexpectedly, trade with the countries of the Maghreb was below the potential level after ten years of the Greater Arab Free Trade Area (GAFTA) agreement.

The Russian Federation officially joined the WTO in 2012, and the prospect of its forthcoming commitment to international trade rules generated big expectations. In order to explore this subject Babetskaia-Kukharchuk and Maurel (2004) estimated a gravity equation using the Hausman-Taylor estimator, controlling for individual effects on a 1994–2001 data panel for 42 countries. They found

that trade between CIS and non-CIS countries in the sample reflected considerable potential. A sharp increase in trade was expected after the Russian Federation's accession to the WTO owing to institutional improvements.

In the case of the Republic of Korea, Sohn (2005) determined that there was unrealized potential for trade with China and Japan, and suggested further negotiations to conclude a free trade agreement between these nations. Sohn worked with 1995 data on a sample of bilateral exports for 31 countries and 23 desegregated sectors.

The out-of-sample and in-sample computation of trade potential was criticized by Egger (2002) who estimated a gravity model with OLS for a sample of OECD countries and 10 Central and Eastern European countries over the period 1986–1997. He believed that many of the biggest gaps between predicted and observed flows derived from a misspecification of the model. In a previous work (Breuss and Egger, 1999), Egger had also analysed the reliability of CEEC trade potential estimations and concluded that large forecast interval spans around the predicted values for cross-sectional estimations were common; therefore, predictions of a rise in exports in absolute terms were questionable based on predicted versus observed bilateral export ratios.

Other questions concerning sample choice and multilateral resistance bias were raised by Fontagné, Pajot, and Pasteels (2002), who worked with a sample of 74 countries and 1995–1996 average data. They also suggested that some corrections to obtain a closer adjustment between fitted and observed trade could be needed to achieve a better interpretation of trade potential.

In the same vein, Luca De Benedictis and Claudio Vicarelli (2005), working with a panel of 11 European and 31 OECD countries, estimated a gravity model with OLS and found that results were sensitive to country heterogeneity and dynamics. These authors suggested that the sign of a country's potential yearly average had to be considered with caution to determine the existence or non-existence of unrealized trade potential.

Cárdenas and García (2004) published one of the most influential papers applying quantitative methods to explain Colombia's international trade relationships. They estimated a gravity equation with OLS for 178 countries for the period 1948–1999. They found a negative fixed effect for Colombia that they interpreted as a general undertrading position relative to all other countries. As their objective was to determine the expected impact of a free trade agreement between Colombia and the United States, they did not try to identify the countries that offered Colombia untapped potential to increase exports or imports. They predicted a 40% increase in trade between Colombia and the United States after discounting the Generalized System of Preferences (GSP) effect from the regional trade agreement (RTA) effect they found.

In an analysis of the impact of the European Union's GSP on Colombia's exports, Correia (2008) found that this system of preferences did little to promote Colombian exports to the European Union. The results were derived from OLS gravity model estimations including country fixed effects for 167 countries from 1991 to 2005.

Umaña (2011) reiterated the need to better explore Colombia's international trade. He predicted a positive expected impact of the free trade agreements between Colombia and the United States and between Colombia and the European Union by combining a Computable General Equilibrium model for 45 countries with 2009 data based on results from a gravity equation applied to 208 countries and 1948–2006 data estimated with PPML and fixed effects. Nevertheless, this study does not provide information on trade potential for Colombia.

We are confident that the application of a PPML estimator and the possibility to control for country heterogeneity and multilateral resistance with panel data on a reasonably large group of countries over many years will produce reliable trade potential results.

III. Data and methodology

1. Model specification

The gravity model explains bilateral international trade flows X_{ijt} from country i to country j , for a given year t , as a function of the size of both economies y_{it} and y_{jt} and transaction cost t_{ijt} . Global nominal income is represented by YW and θ_i and θ_j are shares of global income. The term σ is the elasticity of substitution between all goods. Distance is considered one of the most important transaction costs. There are also other geographical, cultural and institutional factors to consider, such as the presence of a common border, the use of a common language, the sharing of historical colonial links, legal systems and free trade agreements.

The following is a theoretical gravity model proposed by Anderson and Van Wincoop (2003):

$$x_{ij} = \frac{y_i y_j}{y_w} \left(\frac{t_{ijt}}{P_i \Pi_j} \right)^{1-\sigma} \quad (1)$$

where

$$\Pi_i = \left(\sum_j \left(\frac{t_{ij}}{P_j} \right)^{1-\sigma} \theta_j \right)^{\frac{1}{1-\sigma}} \quad (2)$$

and

$$P_j = \left(\sum_i \left(\frac{t_{ij}}{\Pi_i} \right)^{1-\sigma} \theta_i \right)^{\frac{1}{1-\sigma}} \quad (3)$$

The terms P_i and Π_j are non-observable variables representing multilateral resistance. To avoid endogeneity problems owing to unobservable heterogeneity the introduction of time-invariant fixed effects from importer and exporter countries has become customary. In this paper we also introduce exporter and importer time-varying fixed effects to control for omitted variables derived from multilateral resistance and any other source of non-constant unobserved variation across countries over time.

We estimate our models with the Santos Silva and Tenreyro (2006, 2011) PPML estimator. Another estimator we use is the Simcoe (2008) fixed-effects PPML estimator (XTPQML). This estimator allows us to control for observed and unobserved heterogeneity at the country-pair level that is constant over time.

Our first model (model 1) consists of a PPML specification controlling for a set of dyadic variables, time-varying fixed effects for exporters and importers, time-invariant fixed effects for exporters and importers and year fixed effects.

$$X_{ijt} = \exp\left(\beta_0 + \varphi_g Z_{ijt} + \alpha_t + \alpha_i + \alpha_j + \alpha_{it} + \alpha_{jt}\right) u_{ijt} \quad (4)$$

where our dependent variable X_{ijt} represents bilateral FOB export values in millions of current dollars from country i to country j ; α_t stands for time fixed effects, α_i and α_j are exporter and importer time-invariant fixed effects; α_{it} and α_{jt} are time-varying exporter fixed effects and time-varying importer fixed effects respectively; and u_{ijt} is an idiosyncratic error term. Likewise, Z_{ijt} is a vector of dyadic variables

that help to minimize possible biases. It consists of RTA_{ijt} , $contg_{ijt}$, $comlang_{ijt}$, $col45_{ijt}$ and $Indist_{ijt}$; and ϕ_h is a vector of coefficients to be estimated in relation to these dyadic variables where the subscript g indicates the variables. The idiosyncratic error term can be expressed as follows: $u_{ijt} = \exp\left((1-\sigma)\varepsilon_{ijt}\right)$.

More precisely, $Indist_{ijt}$ represents the natural logarithm of the weighted distance between countries i and j ; $contg_{ijt}$ takes on 1 if there is a common land border between i and j , and 0 otherwise; $comlang_{ijt}$ takes on 1 if at least 9% of the pair population share the same language, and 0 otherwise; $col45_{ijt}$ takes on 1 if both countries had colonial ties before 1945, and 0 otherwise; and RTA_{ijt} takes on 1 if both countries share a free trade agreement, and 0 otherwise.

Our second model in Eq(5) (model 2) is a PPML specification controlling for a set of dyadic and non-dyadic variables. This model does not include time-varying fixed effects while maintaining time-invariant country fixed effects for exporters and importers and year fixed effects.

$$X_{ijt} = \exp\left(\beta_0 + \varphi_g Z_{ijt} + \psi_h S_{it} + \phi_h M_{jt} + \alpha_t + \alpha_i + \alpha_j\right) u_{ijt} \quad (5)$$

Where S_{it} and M_{jt} are vectors of time-varying monadic controls for exporters and importers respectively composed of h variables: $\ln GDP_{it}$, $\ln pop_{it}$, $OECD_{it}$ and $GATT_{it}$, as well as $\ln GDP_{jt}$, $\ln pop_{jt}$, $OECD_{jt}$ and $GATT_{jt}$.

In this model, ψ and ϕ are vectors of coefficients to be estimated with respect to the above control variables and the subscript h indicates variables.

Variables $\ln GDP_{it}$ and $\ln GDP_{jt}$ are the natural logarithms for current dollar GDP of countries i and j ; $\ln pop_{it}$, $\ln pop_{jt}$ are the natural logarithms for the population of countries i and j . Respectively, $GATT_{it}$ and $GATT_{jt}$ take on 1 if countries i and j are GATT signatories or WTO members. $OECD_{it}$ and $OECD_{jt}$ take on 1 if countries i and j belong to the OECD. We define model 3 and model 4 as the versions of model 1 and model 2, respectively, adjusted by Eq(9).

Our fifth model in Eq(6) (model 5) is a fixed-effects PPML specification controlling for a set of time-varying non-dyadic variables, country-pair fixed effects and year fixed effects.

$$X_{ijt} = \exp\left(\beta_0 + \psi_h S_{it} + \phi_h M_{jt} + \alpha_{ij} + \alpha_t\right) u_{ijt} \quad (6)$$

In Eq(6) α_{ij} defines country-pair fixed effects. All time-invariant variables have been eliminated from the equation owing to multicollinearity.

2. Variable sources for the gravity model

- Bilateral export FOB values in millions of current dollars. (X_{ijt}): International Monetary Fund (IMF), Direction of Trade Statistics (DOTS) database (2013).
- GDP in millions of current dollars, population in number of inhabitants and urban participation in percentages ($\ln GDP_{it}$; $\ln GDP_{jt}$; $\ln pop_{it}$; $\ln pop_{jt}$): World Development Indicators (WDI) database, World Bank (2013).
- Weighted distance in km, common land border and colonial ties ($Indist_{ijt}$; $contg_{ijt}$; $comlang_{ijt}$; $col45_{ijt}$): Head, Mayer and Ries (2010), gravity dataset.
- Regional Trade Agreements (RTA_{ijt}): prepared by the author, based on the Regional Trade Agreements Information System (RTA-IS), WTO (n/d). Also de Sousa, J. (2012).

- GATT membership ($GATT_{it}$; $GATT_{jt}$): prepared by the author based on WTO (n/d).
- OECD membership ($OECD_{it}$; $OECD_{jt}$): prepared by the author based on information from the OECD.

3. Trade potential: methodological issues

An out-of-sample approach was needed to estimate trade potential for transition economies because no suitable counterfactual was discernible from the data available at the time. A sample of 153 countries over 33 years facilitates a within-sample approach for Colombia as this country has remained relatively well integrated in cross-border exchanges, and similar countries are also present in the sample; sufficient country heterogeneity guarantees a good counterfactual in a gravity model. The countries covered by the sample represent more than 96% of Colombian exports and imports.

An intuitive and direct form of presenting trade potential is the ratio between bilateral export fitted values and the respective observed values.

$$\text{Trade Potential Indicator} = \left[\frac{\hat{x}_{ijt}}{x_{ijt}} \right] \quad (7)$$

where x_{ijt} represents the observed bilateral exports from country i to country j for each year t , and \hat{x}_{ijt} represents bilateral export fitted values.

Results above one reflect undertrading while those below one indicate overtrading. Nevertheless, comparisons of this indicator are slightly difficult. For example, some countries that are 40% above the normal trade pattern will show a reading of 1.400 while some 40% below will show 0.714.

Another way to present trade potential is to calculate a relative residuals ratio and then multiply that by 100. The following formula proposed by Pasteels (2006) summarizes this indicator:

$$\text{Trade Potential Relative Residuals Indicator} = \left[\frac{\hat{x}_{ijt} - x_{ijt}}{x_{ijt} + \hat{x}_{ijt}} \right] * 100 \quad (8)$$

The within-sample trade potential indicator based on gravity equation residuals, expressed in relative terms, ranges from -100% to +100%. Positive (negative) values of this ratio indicate that country i exports to country j are below (above) the reasonable level predicted by the model.

If the indicator is close to 0%, predicted trade is close to current trade. Negative values imply an overtrading position and positive values indicate undertrading. Some kind of threshold could be useful to reflect bilateral trade positions better. Pasteels (2006) suggests that if the indicator is above 30%, untapped trade potential clearly exists, and if below 30%, current trade is already strong.

Pasteels' suggestion of a 30% threshold for relative residuals is preferable to the sign of the trade potential statistic as the only criterion to define the existence of potential, because values close to zero should not be easily taken as overtrading or undertrading flows. However, we would relax the 30% threshold as it could be too conservative, in particular when the three-year average and the 2012 relative residuals indicate the same conclusion.

(a) Periods and panel balance

Our 1980–2012 panel based on DOTS is unbalanced, owing mainly to new countries emerging and old countries ceasing to exist, but also because of statistical collection restrictions, for example in the cases of Belgium, Luxembourg and South Africa. As time goes by, more countries are reporting a

larger number of trading partners; this means a more balanced panel data structure. At the same time, the proportion of flows declared at zero is diminishing.

Given that a balanced panel configuration would be a preferable approach to making predictions, we also compute statistics for a 2000–2012 panel. This narrower timeframe, although not yet completely balanced, guarantees the inclusion of observations for all the countries in the sample at the same time and a more balanced structure of country-pair relationships. Thus, relative residual trade potential statistics for a 2000–2012 panel will be presented in tables alongside 1980–2012 trade potential. This involves a trade-off, as switching from the wider panel to the narrower one to obtain a more balanced structure results in the loss of historical data.

(b) Averaged vs. snapshot prediction

Another issue to consider is the fact that relative residual comparisons for a single-year snapshot—in this case 2012, which is the last year in our sample—could be affected by exogenous transitory shocks. Developing countries are prone to this kind of event as their export base is less diversified, and thus vulnerable to shocks. Hence, we compute an average of relative residual trade potential for the last three years of our sample (2010, 2011 and 2012) to account for sensitivity to this kind of one-off fluctuation. The assumption here is that if trade potential is detected in a three-year average measure, as well as in the 2012 snapshot, it would be less attributable to transitory short-term shocks or measurement errors. We present these results for both periods of analysis (1980–2012 and 2000–2012).

(c) Econometric methods

Equations (4) to (6) summarize the three main models we use to compute relative residuals in the detection of trade potential. Given that Eq(6) or the country-pair fixed-effect specification estimated by the XTPQML command in Stata, also known as the Poisson country-pair fixed-effects method (Simcoe, 2008),¹ generates fitted values that are not suitable to compute trade potential, Santos-Silva and Tenreyro suggest an adjustment parameter to obtain zero mean residuals. This parameter θ_{ij} is the ratio between the mean of observed exports by cluster of bilateral exports or pairs and the mean of the respective fitted values. Each fitted value is then adjusted for the respective θ which is a constant for all observations within its cluster. This is comparable to a pair fixed effect.

$$\text{Adjustment factor: } \theta_{ijt} = \frac{\frac{1}{t} \sum_{t=1}^t X_{ijt}}{\frac{1}{t} \sum_{t=1}^t \hat{X}_{ijt}} \text{ for each cluster of bilateral exports.} \quad (9)$$

We also apply this adjustment factor to PPML fitted values to review sensitivity. Nevertheless, PPML adjusted models do not necessarily need to be considered the correct specification to follow. One of the noteworthy consequences of these adjustments concerns zero flows. PPML non-transformed models will predict a positive flow in historical zero flow bilateral relationships that will generate a 100% relative residual or absolute trade potential. Conversely, adjusted PPML models will predict a zero when the historical bilateral relationship is always zero; in these circumstances they will predict no trade potential at all.

We think that PPML with time-varying fixed effects without adjustment is a better benchmark because this specification fully controls for unobserved variable bias and its residuals are zero mean, but it is useful to know its adjusted transformation for comparison purposes.

¹ <http://people.bu.edu/tsimcoe/data.html>.

(d) Putting Colombia-European Union trade potential into context

To put the potential for trade between Colombia and European Union countries into context, we also present results for 12 other interesting markets, namely Australia, Brazil, Canada, China, India, Japan, Mexico, the Republic of Korea, the Russian Federation, Switzerland, Turkey and the United States. They were selected mainly on the basis of the size of their economies.

To make our tables more comprehensible we have opted to show only statistics for the biggest markets, as the economic value of their possible potential is of greater interest. However, small European Union markets such as Bulgaria, Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, Slovakia and Slovenia are included in the calculation of European Union average relative residuals. Croatia was not an official member of the European Union in 2012.

Five specifications are then calculated to evaluate trade potential relative residuals. The first one stems from Eq(4) and is estimated with PPML and country time-varying fixed effects (TVFE); the second is the specification in Eq(5) which contains country time-invariant fixed effects (TIFE), but not TVFE. Specifications 3 and 4 are adjusted with θ_{ijt} versions of relative residuals. Finally, specification 5 is derived from Eq(6) which is estimated with XTPQML country-pair fixed effects and is adjusted with θ_{ijt} .

IV. Results

We present regression results for the three different specifications that we selected to compute trade potential (see table 1). Next, four figures show the trade position of bilateral relationships in five categories that reflect the intensity of the gap between predicted and observed bilateral exports.

Because a combined analysis of trade potential and export trends can provide better insight on the strength of this potential, a graphic analysis showing the trends in bilateral trade and projected flows complements the relative residuals or trade potential analysis.

Table 1
PPML and XTPQML regressions for 153 countries for 1980-2012 and 2000-2012

	1980-2012			2000-2012		
	PPML (1) X_{ijt}	PPML (2) X_{ijt}	XTPQML (3) X_{ijt}	PPML (4) X_{ijt}	PPML (5) X_{ijt}	XTPQML (6) X_{ijt}
RTA_{ijt}	0.397*** (0.018)	0.407*** (0.017)	0.140*** (0.037)	0.365*** (0.021)	0.371*** (0.021)	0.078*** (0.029)
$GATT_{it}$		0.280*** (0.039)	0.307*** (0.051)		0.188*** (0.069)	0.224*** (0.040)
$GATT_{jt}$		0.175*** (0.033)	0.196*** (0.054)		0.116* (0.060)	0.158*** (0.043)
$\ln GDP_{it}$		0.729*** (0.024)	0.744*** (0.034)		0.624*** (0.040)	0.632*** (0.027)
$\ln GDP_{jt}$		0.644*** (0.022)	0.670*** (0.035)		0.641*** (0.037)	0.653*** (0.041)
$\ln dist_{ijt}$	-0.770*** (0.009)	-0.761*** (0.009)		-0.792*** (0.012)	-0.789*** (0.012)	
$Contig_{ijt}$	0.471*** (0.016)	0.488*** (0.016)		0.452*** (0.021)	0.459*** (0.020)	
$Comlang_{ijt}$	0.261*** (0.016)	0.258*** (0.016)		0.228*** (0.021)	0.226*** (0.021)	

Table 1 (concluded)

	1980-2012			2000-2012		
	PPML (1) X_{ijt}	PPML (2) X_{ijt}	XTPQML (3) X_{ijt}	PPML (4) X_{ijt}	PPML (5) X_{ijt}	XTPQML (6) X_{ijt}
Col45ijt	0.251*** (0.039)	0.244*** (0.041)		0.243*** (0.054)	0.246*** (0.054)	
OECDit		0.240*** (0.043)	0.258*** (0.096)		0.026 (0.106)	0.014 (0.035)
OECDjt		0.157*** (0.039)	0.209*** (0.057)		0.064 (0.050)	0.064 (0.056)
Lnpopit		-0.193** (0.077)	-0.082 (0.101)		0.113 (0.181)	0.213* (0.116)
Lnpopjt		-0.376*** (0.064)	-0.215*** (0.105)		-0.241 (0.150)	-0.058 (0.128)
Constant	13.144*** (0.125)	9.121*** (1.640)		14.937*** (0.143)	2.210 (4.061)	
Observations	606 710	588 262	339 724	281 016	277 483	146 297
R2	0.906	0.899		0.901	0.900	
Exporter time-invariant fixed effects	Yes	Yes	No	Yes	Yes	No
Importer time-invariant fixed effects	Yes	Yes	No	Yes	Yes	No
Time-varying exporter fixed effects	Yes	No	No	Yes	No	No
Time-varying importer fixed effects	Yes	No	No	Yes	No	No
Country-pair fixed effects	No	No	Yes	No	No	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Source: Prepared by the author.

Note: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Results from the gravity model estimations summarized in table 1 are theoretically sound for columns (1) and (2) corresponding to the PPML estimator and the longer period of analysis. There are some important differences between the PPML and XTPQML estimations: RTA estimates are underestimated in columns (3) and (6). The impact of population size and OECD membership are non-significant in columns (5) and (6) corresponding to models computed in the 2000–2012 sample. Dyadic variable estimates from PPML are robust to the change in time span. PPML deals better than XTPQML with zero registered flows including more observations in the analysis. Fitted values from the regressions summarized in table 1 are used to calculate trade potential.

1. Potential of Colombian exports to a group of European Union countries

Trade potential is calculated using Eq(8) for relative residuals where results can take on values from -100% to +100%. Positive values imply undertrading.

Colombia's average relative residuals for the last three years of our panel reveal untapped export potential with Austria, Czechia, Finland, France, Germany, Greece, Hungary, Poland, Romania and Sweden (see table 2). These results also suggest that Colombia is overtrading with Belgium, the Netherlands, Portugal and Spain. The United Kingdom and to a lesser extent Ireland are around the normal rule of trade while Italy could harbour some potential.

Switching from the 1980–2012 panel to a more balanced 2000–2012 panel does not change our main findings. The same can be said when considering only 2012 results instead of the average of the last three years.

Relative residual results from Poisson country-pair fixed effects on the average of the last three years for the period 1980–2012 show export potential with Austria, Czechia, Finland, France, Germany, Hungary and Sweden. When only 2012 is analysed, Poland and France become more attractive. These results remain valid but are revised downward (except in the cases of Austria and Czechia) when we shift to the 2000–2012 period. Trade potential with Hungary is eliminated, reflecting the fact that there have been no exports from Colombia to this market in the last thirteen years.

Table 2
Relative residuals (-100% to +100%)
Consolidated results from Colombia's exports to European Union countries

Panel	PPML TVFE		PPML TIFE		PPML adjusted TVFE		PPML adjusted TIFE		XTPQML country-pair fixed effects	
	1980-2012		1980-2012		1980-2012		1980-2012		1980-2012	
	3-yr avg.	2012	3-yr avg.	2012	3-yr avg.	2012	3-yr avg.	2012	3-yr avg.	2012
Snapshot										
Austria	100	100	100	100	100	100	100	100	100	100
Belgium	-27	-24	-35	-31	16	20	8	13	8	14
Czechia	100	100	100	100	100	100	100	100	100	100
Denmark	-30	-27	-33	-29	13	19	9	16	10	18
Finland	25	32	22	32	41	48	38	47	39	48
France	35	43	29	40	21	31	14	27	15	28
Germany	56	51	50	47	65	61	60	58	61	58
Greece	51	63	55	67	-19	-2	-15	3	-14	4
Hungary	100	100	100	100	100	100	100	100	100	100
Ireland	-16	-25	-11	-18	-9	-19	-6	-13	-4	-11
Italy	10	16	4	16	11	16	5	16	6	17
Netherlands	-58	-60	-66	-69	-10	-14	-22	-27	-21	-26
Poland	70	84	63	80	40	64	23	53	24	54
Portugal	-22	-39	-22	-34	-6	-24	-7	-20	-6	-19
Romania	73	80	70	78	24	36	-7	6	-7	7
Spain	-27	-59	-31	-60	-15	-50	-19	-50	-18	-49
Sweden	62	62	60	62	60	59	57	59	58	60
United Kingdom	-5	-11	-9	-14	-8	-14	-13	-18	-12	-17

Source: Prepared by the author.

Note: TVFE: time-varying fixed effects; TIFE: time-invariant fixed effects.

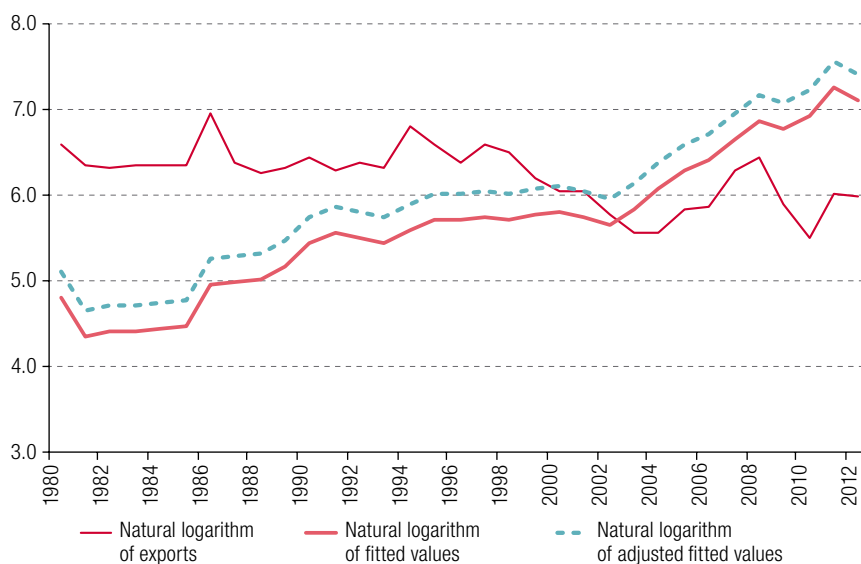
Strong potential.
Some potential.
Around the rule.

While most of Colombia's exports to European Union countries reflect an increasing trend, which is particularly strong for Ireland, Italy, the Netherlands, Portugal, Spain and the United Kingdom, exports to Germany and France have experienced a slight decline and a weak advance, respectively, over the last three decades.

Special attention should also be paid to Finland and Sweden, as exports to these countries reflect a similar trend to that seen in exports to Germany, so the potential for the gap to be filled seems promising.

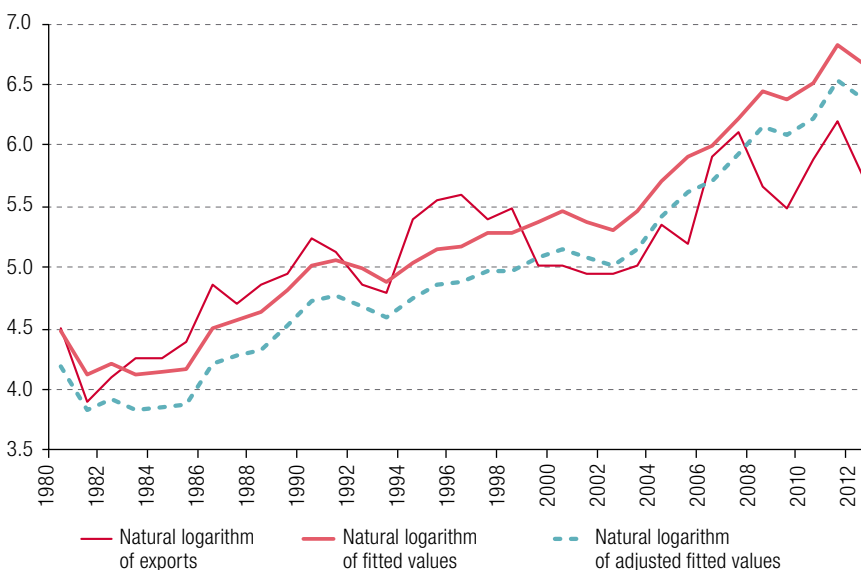
Exports to Spain skyrocketed during the last three years, exhausting trade potential. Potential relating to markets such as Czechia, Greece, Hungary, Poland and Romania is harder to evaluate owing to the lack of a clear trend and the absence of trade flows. Combining the analysis of trade potential with the graphic perspective offered in figures 1 to 4 at least confirms how attractive the largest European Union economies are to Colombia.

Figure 1
Colombia-Germany
Exports, PPML time-varying fixed effects fitted and adjusted fitted values, 1980–2012
(Logarithms)



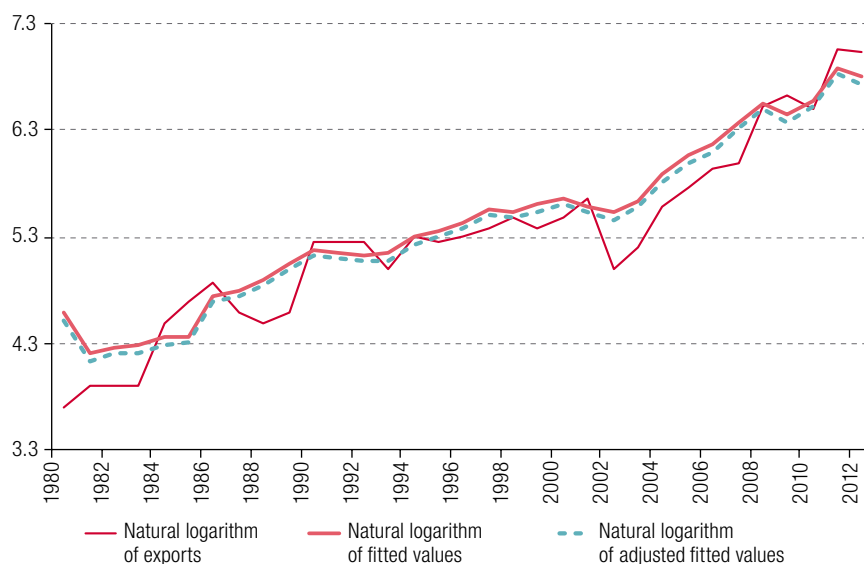
Source: Prepared by the author, on the basis of information from International Monetary Fund (IMF), "Direction of Trade Statistics (DOTS)".

Figure 2
Colombia-France
Exports, PPML time-varying fixed effects fitted and adjusted fitted values, 1980–2012
(Logarithms)



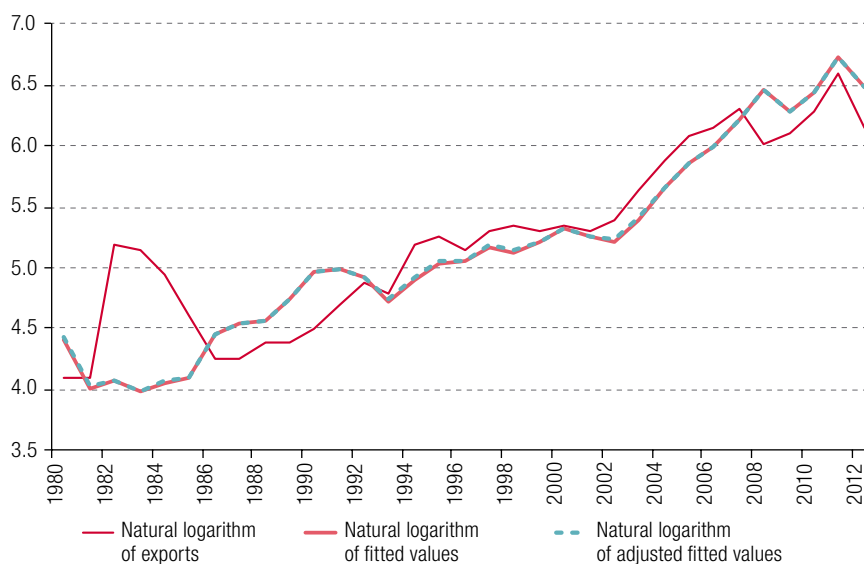
Source: Prepared by the author, on the basis of information from International Monetary Fund (IMF), "Direction of Trade Statistics (DOTS)".

Figure 3
Colombia-United Kingdom
Exports, PPML time-varying fixed effects fitted and adjusted fitted values, 1980–2012
(Logarithms)



Source: Prepared by the author, on the basis of information from International Monetary Fund (IMF), "Direction of Trade Statistics (DOTS)".

Figure 4
Colombia-Italy
Exports, PPML time-varying fixed effects fitted and adjusted fitted values, 1980–2012
(Logarithms)



Source: Prepared by the author, on the basis of information from International Monetary Fund (IMF), "Direction of Trade Statistics (DOTS)".

2. Potential of Colombia's exports to a group of interesting markets

It is worth noting the potential of Colombia's exports to a group of other interesting markets. Table 3 shows potential to increase exports to Australia, Brazil, Canada, the European Union, Japan, Mexico and the Russian Federation. The Republic of Korea is also appealing, to a lesser extent. Conversely, Colombia seems to be overtrading with China, India, Switzerland, Turkey and the United States. These results remain stable if either the panel or snapshot time frame is used to observe potential.

Table 3
Relative residuals (-100% to +100%)
Consolidated results from Colombia's exports to major global markets

Panel	PPML TVFE		PPML TIFE		PPML adjusted TVFE		PPML adjusted TIFE		XTPQML Country-pair fixed effects	
	1980–2012		1980–2012		1980–2012		1980–2012		1980–2012	
	3-yr avg.	2012	3-yr avg.	2012	3-yr avg.	2012	3-yr avg.	2012	3-yr avg.	2012
Australia	86	87	86	87	3	4	2	4	4	6
Brazil	48	48	41	40	-7	-7	-15	-15	-17	-18
Canada	38	57	37	57	2	24	0	24	-1	15
China	-8	-21	-17	-26	-19	-31	-25	-34	-23	-32
European Union	50	48	48	48	43	42	39	40	41	39
India	-18	-45	-35	-59	-21	-47	-35	-59	-34	-57
Japan	45	57	44	57	20	36	19	34	20	35
Mexico	49	47	39	36	11	9	1	-3	1	-2
Switzerland	-55	-41	-60	-43	-3	17	-10	15	-11	5
Republic of Korea	16	16	7	9	-12	-13	-21	-19	-19	-17
Russian Federation	62	63	63	67	16	17	17	23	18	25
Turkey	-22	-44	-31	-51	-18	-41	-27	-48	-26	-46
United States	-10	1	-12	1	-6	4	-8	5	-10	-5

Source: Prepared by the author.

Note: TVFE: time-varying fixed effects; TIFE: time-invariant fixed effects.

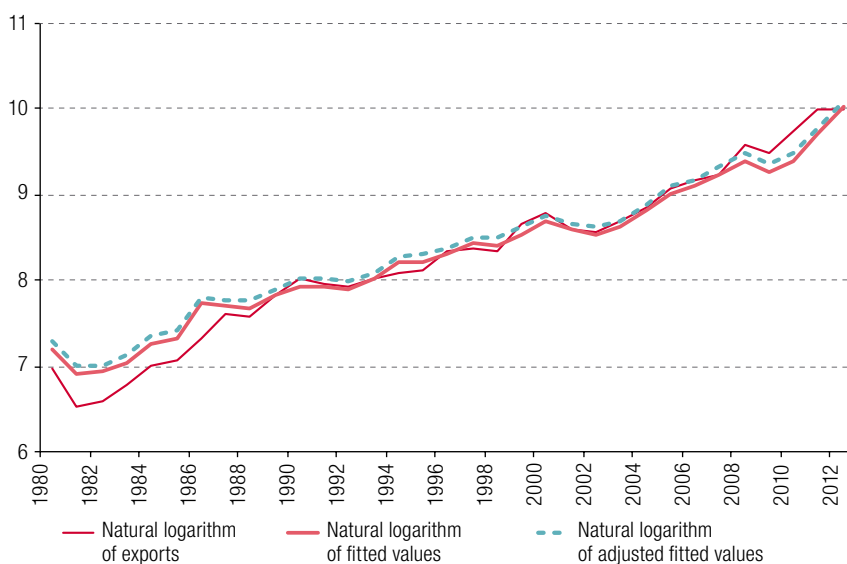
Strong potential.
Some potential.
Around the rule.

Relative residuals based on Poisson country-pair fixed effects show that a number of interesting countries could already be buying Colombia's products around reasonable levels. There is unexhausted trade potential with the European Union, Japan and the Russian Federation. These results also reinforce the finding that there is no potential with China, India or Turkey, and cast doubt on the potential for trade with Brazil and the Republic of Korea.

Additional analysis of the trends in Colombia's exports to Australia, Japan and the Russian Federation over the last three decades shows weak growth. The gap between current export levels and predicted values is increasing over time for these markets. The combined analysis of trade potential (see table 3) with export trends points to substantial trade potential with Japan and the Russian Federation.

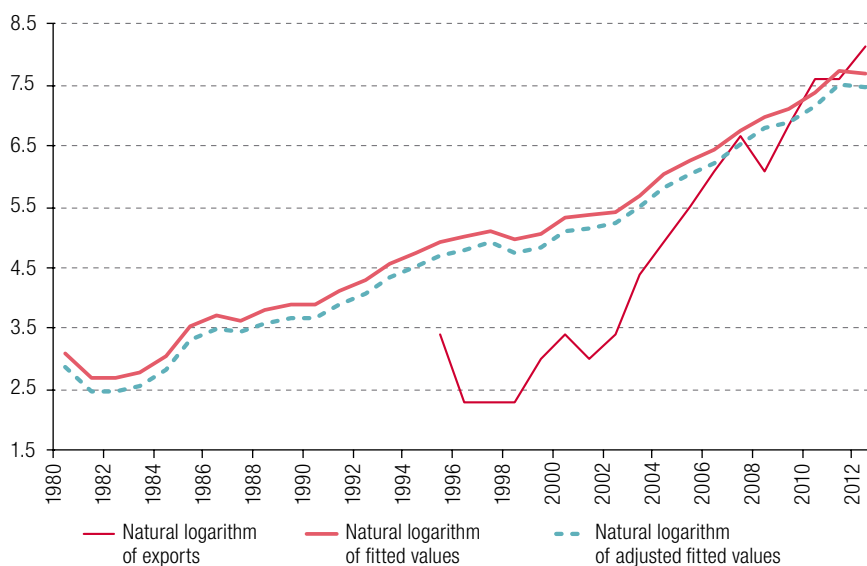
Colombia has sharply increased its exports to China and the United States (see figures 5 and 6). Exports to India and Turkey ballooned from 2008 and 2010, respectively. Exports to Canada, the Republic of Korea and Switzerland were also ramped up, but have experienced trend corrections recently. Potential for trade with these markets appears to have been exhausted.

Figure 5
Colombia-United States
Exports, PPML time-varying fixed effects fitted and adjusted fitted values, 1980–2012
(Logarithms)



Source: Prepared by the author, on the basis of data from International Monetary Fund (IMF), "Direction of Trade Statistics (DOTS)".

Figure 6
Colombia-China
Exports, PPML time-varying fixed effects fitted and adjusted fitted values, 1980–2012
(Logarithms)



Source: Prepared by the author, on the basis of data from International Monetary Fund (IMF), "Direction of Trade Statistics (DOTS)".

3. Potential of European Union exports to Colombia

A review of export potential from a group of European Union countries to Colombia points to a very stable result under the PPML time-varying country fixed-effects specification of relative trade residuals. The traditional big European Union economies seem to have exhausted their potential for trade with Colombia, but a large group of countries —most of them medium or small in size— view the Colombian consumer market as promising. These countries are Czechia, Greece, Hungary, Ireland, Poland, Portugal and Sweden. Trade potential is stable when using a database with a shorter time frame or when taking into account only the last year of the sample instead of the average of the last three years. Of the largest European Union markets, the United Kingdom and to a lesser extent the Netherlands exhibit some room to increase exports to Colombia (see table 4).

Table 4
Relative residuals (-100% to +100%)
Consolidated results for exports from European Union countries to Colombia

Panel	PPML TVFE		PPML TIFE		PPML adjusted TVFE		PPML adjusted TIFE		XTPQML country-pair fixed effects	
	1980–2012		1980–2012		1980–2012		1980–2012		1980–2012	
	3-yr avg.	2012	3-yr avg.	2012	3-yr avg.	2012	3-yr avg.	2012	3-yr avg.	2012
Snapshot										
Austria	2	-4	-1	-6	-9	-15	-13	-18	-11	-16
Belgium	-5	-13	-5	-12	-6	-14	-8	-14	-7	-13
Czechia	67	59	61	51	22	8	13	-2	14	-1
Denmark	17	1	20	5	-4	-20	-1	-17	0	-15
Finland	12	3	19	14	15	6	21	16	22	17
France	-24	-26	-22	-23	-6	-7	-5	-5	-3	-3
Germany	-7	-14	-11	-16	5	-2	1	-4	2	-3
Greece	87	62	85	55	44	-69	42	-74	42	-73
Hungary	80	70	76	66	-8	-30	-18	-38	-16	-37
Ireland	66	66	67	68	22	20	22	24	23	26
Italy	-7	-10	-8	-11	-2	-5	-3	-6	-1	-4
Netherlands	18	18	7	7	9	9	-2	-2	0	0
Poland	69	67	64	61	38	34	15	10	16	11
Portugal	57	47	54	42	-17	-31	-21	-36	-20	-34
Romania	-16	-41	-24	-47	2	-24	-5	-30	-4	-29
Spain	-5	-11	-11	-17	12	7	6	0	8	2
Sweden	30	31	33	38	27	29	30	35	31	36
United Kingdom	25	19	31	28	8	2	13	10	15	12

Source: Prepared by the author.

Note: TVFE: time-varying fixed effects; TIFE: time-invariant fixed effects.

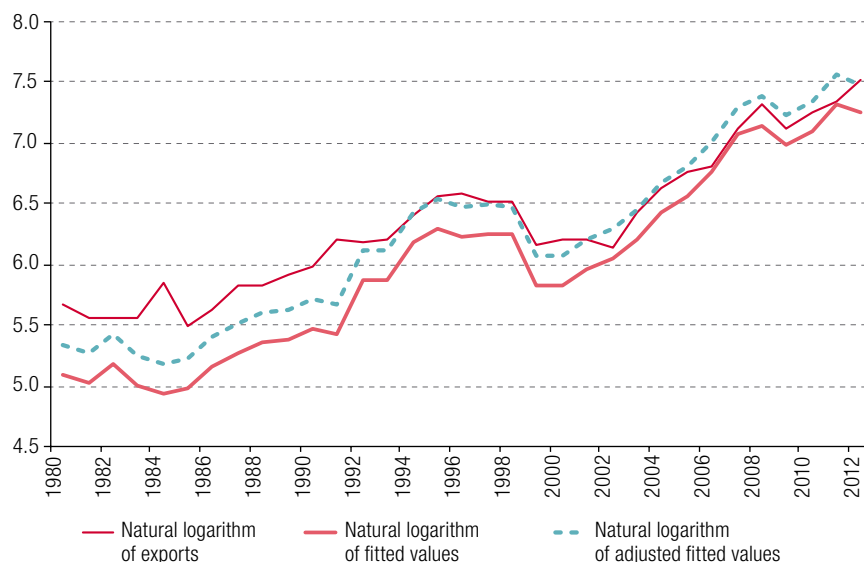
Strong potential.
Some potential.
Around the rule.

On the basis of Poisson country-pair fixed effects, most European Union countries have no potential for trade with Colombia, regardless of the period or snapshot used. Sweden has significant potential, but only over the longer period. Colombia's appeal diminishes with the shorter time frame database. Finland and Ireland have an interesting margin and could consider Colombia a potential market to conquer under this specification. In both databases, Greece only has potential based on a three-year average measure, as it reflects strong overtrading when only 2012 is considered.

Big market economies in the European Union, along with Austria, Denmark and Romania, have experienced exponential growth in their sales to Colombia (see figures 7 to 10). A notable exception

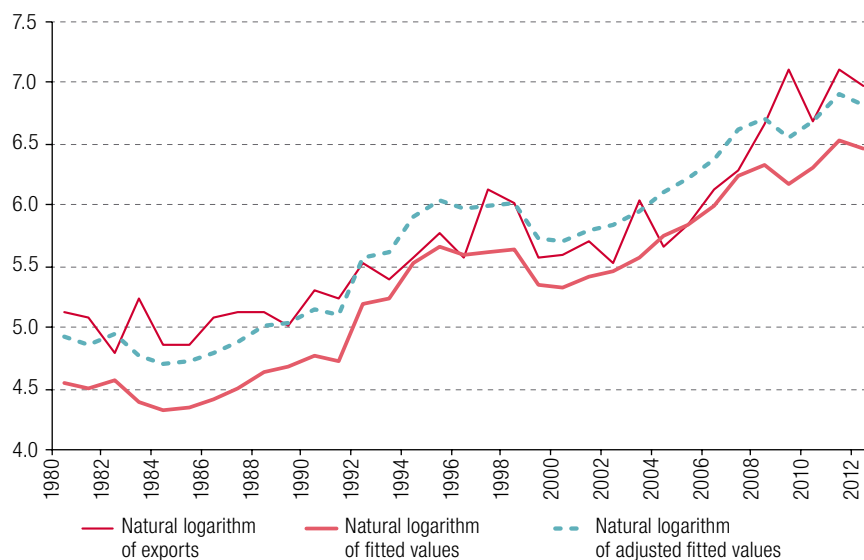
is the United Kingdom and possibly the Netherlands. These trends mirror the abovementioned trade potential, as among major European Union economies, only the Netherlands and the United Kingdom appear to have room to increase exports to Colombia.

Figure 7
Germany-Colombia
Exports, PPML time-varying fixed effects fitted and adjusted fitted values, 1980–2012
(Logarithms)



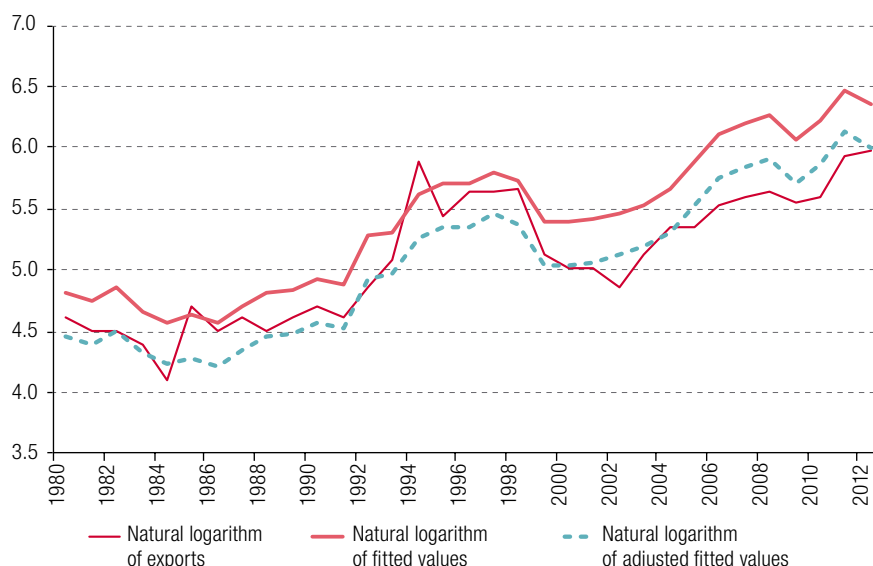
Source: Prepared by the author, on the basis of data from International Monetary Fund (IMF), “Direction of Trade Statistics (DOTS)”.

Figure 8
France-Colombia
Exports, PPML time-varying fixed effects fitted and adjusted fitted values, 1980–2012
(Logarithms)



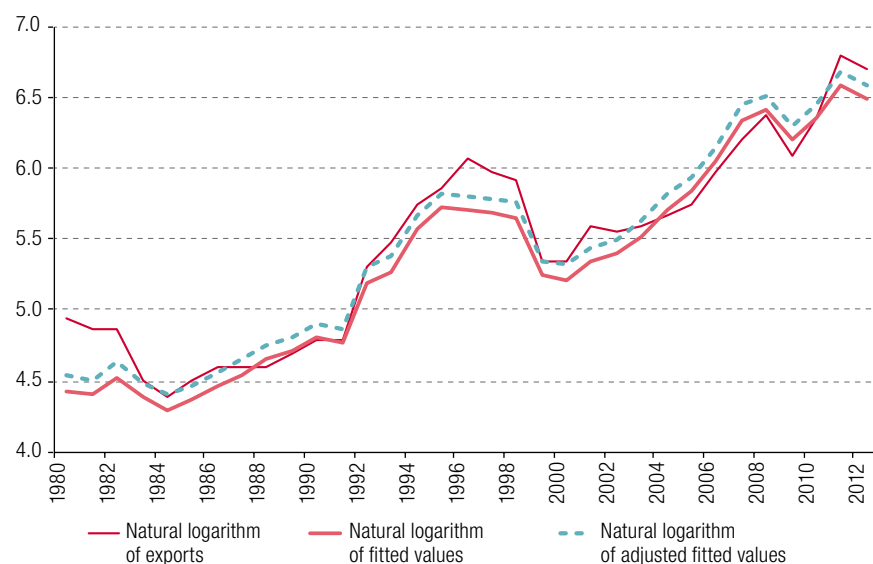
Source: Prepared by the author, on the basis of data from International Monetary Fund (IMF), “Direction of Trade Statistics (DOTS)”.

Figure 9
United Kingdom-Colombia
Exports, PPML time-varying fixed effects fitted and adjusted fitted values, 1980–2012
(Logarithms)



Source: Prepared by the author, on the basis of data from International Monetary Fund (IMF), "Direction of Trade Statistics (DOTS)".

Figure 10
Italy-Colombia
Exports, PPML time-varying fixed effects fitted and adjusted fitted values, 1980–2012
(Logarithms)



Source: Prepared by the author, on the basis of data from International Monetary Fund (IMF), "Direction of Trade Statistics (DOTS)".

Smaller European Union countries' exports to Colombia were not dynamic and continue to reflect a flat trend. Portugal has managed to rebound in the last four years. There are interesting gaps for Ireland, Finland, Poland and Sweden, which are compatible with the relative residual indicator. Colombia could be an interesting commercial opportunity for these markets.

4. Potential for trade from a group of interesting countries to Colombia

When PPML relative residuals are examined using the model 1 specification, we detect some potential for trade from Australia, Canada, the European Union and the Russian Federation to Colombia. Conversely, Mexico and the Republic of Korea are clearly overtrading. Again, results are robust to the use of the panel or the snapshot time frame to determine potential with this specification.

The relative residuals analysis based on Poisson country-pair fixed-effects reveals almost none of the potential detected using the PPML relative residuals analysis. The Colombian market only appears to harbour considerable potential for Australia. For most countries analysed, product sales to Colombia already seem to be around the reasonable level predicted by the model. If we relax our threshold to determine potential under this specification, Brazil, Canada, the European Union and even Japan could see some room for stronger exports to Colombia (see table 5).

Table 5
Relative residuals (-100% to +100%)
Consolidated results for exports from major global markets to Colombia

Panel	PPML TVFE		PPML TIFE		PPML Adjusted TVFE		PPML Adjusted TIFE		XTPQML country-pair fixed effects	
	1980–2012		1980–2012		1980–2012		1980–2012		1980–2012	
	3-yr avg.	2012	3-yr avg.	2012	3-yr avg.	2012	3-yr avg.	2012	3-yr avg.	2012
Australia	90	91	88	91	36	41	30	41	32	43
Brazil	19	15	17	13	14	10	12	8	9	6
Canada	19	28	21	32	10	19	12	24	11	15
China	-29	-34	-30	-31	-13	-18	-14	-15	-13	-14
European Union	46	43	45	42	14	8	11	6	7	12
India	-32	-41	-43	-50	0	-10	-12	-21	-10	-19
Japan	3	-2	10	10	5	0	12	12	13	14
Mexico	-41	-44	-50	-52	-12	-14	-22	-24	-21	-23
Republic of Korea	-44	-45	-47	-43	-9	-11	-14	-9	-12	-8
Russian Federation	61	48	66	61	-8	-27	-2	-10	-1	-8
Switzerland	-29	-22	-32	-24	16	22	12	20	11	11
Turkey	36	21	28	10	-5	-21	-12	-31	-10	-29
United States	-8	0	-10	0	-3	5	-5	5	-6	-4

Source: Prepared by the author.

Note: TVFE: time-varying fixed effects; TIFE: time-invariant fixed effects.

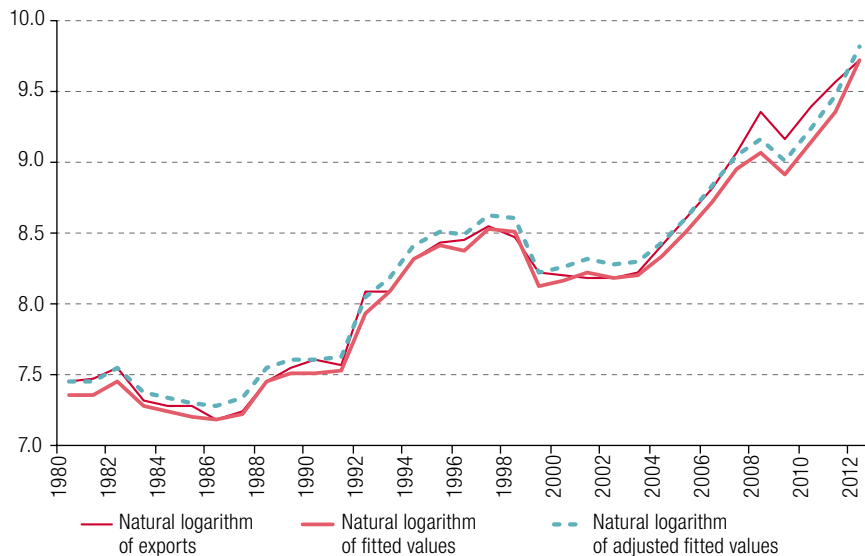
Strong potential.
Some potential.
Around the rule.

Exports to Colombia from the United States and China show a steady increase over time (see figures 11 and 12). This is also valid for India, Mexico, the Republic of Korea and Turkey. Exports from the Russian Federation and Switzerland to Colombia have not grown as sharply, but the positive trend also appears to be steady.

The 2009 global economic crisis halted trade expansion temporarily. Exports from Brazil, Canada and Japan to Colombia appear to have lost momentum, thus creating room for recovery.

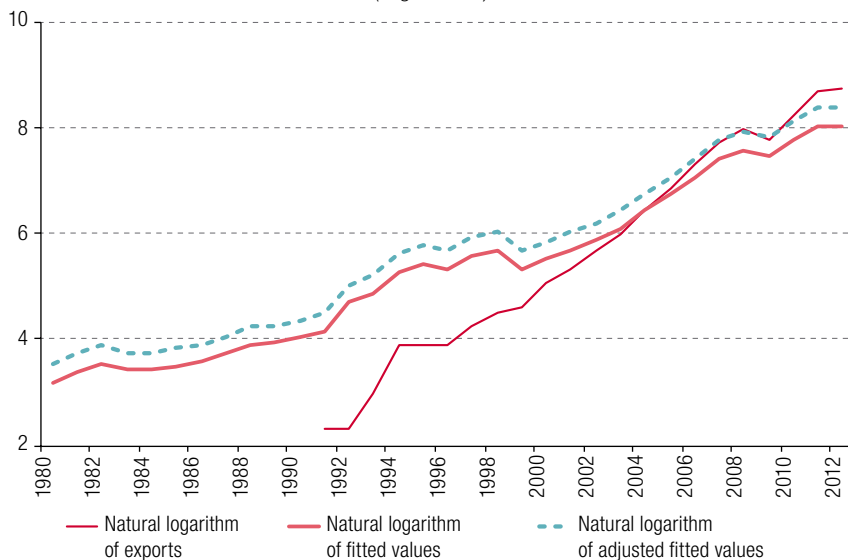
Exports from Australia are particularly sluggish. The gap between current trade and predicted trade has clearly widened over time. Table 5 indicates considerable potential for trade from Australia to Colombia. Infrastructure and trade policy interventions could help to stimulate trade in both directions.

Figure 11
United States-Colombia
Exports, PPML time-varying fixed effects fitted and adjusted fitted values, 1980–2012
(Logarithms)



Source: Prepared by the author, on the basis of data from International Monetary Fund (IMF), “Direction of Trade Statistics (DOTS)”.

Figure 12
China-Colombia
Exports, PPML time-varying fixed effects fitted and adjusted fitted values, 1980–2012
(Logarithms)



Source: Prepared by the author, on the basis of data from International Monetary Fund (IMF), “Direction of Trade Statistics (DOTS)”.

It is not always easy to understand why some cases reveal overtrading while others point to trade potential. Overtrading in the case of Belgium and the Netherlands could be associated with their positions as international logistic hubs. Most Central and Eastern European countries erected strong barriers to trade with Colombia as they focused on the Soviet Union. Potential for trade with France could be influenced by the country’s special relationship with its former colonies. Nevertheless, this study tries hard to control for all these factors through the incorporation of fixed effects into the analysis.

V. Trade potential sensitivity analysis

This subsection examines the impact on results analysis of changes in the fixed-effects specification, the snapshot and the database time span used, and the inclusion of an adjustment factor for fitted values.

(a) Time-varying fixed effects, time-invariant fixed effects or country-pair fixed effects

In the Colombia case study, adding time-varying fixed effects (model 1) to the time-invariant fixed-effect specification (model 2) does not significantly change the final conclusion on trade potential based on the relative residuals analysis. However, results from the country-pair fixed-effects specification (model 5) produce bigger variations. This shift can affect conclusions about the existence of untapped trade potential in some cases.

(b) Snapshot: average potential for 2010–2012 versus 2012

The use of the average 2010–2012 measure of trade potential versus the 2012 measure produces different results, but although the difference can be considerable in some cases, the overall picture remains the same in most cases. This is consistent with volatility, which can cause flows to diverge from their current trend.

(c) Changing the database time span from 1980–2012 to 2000–2012

To verify the sensitivity of results, estimations were made for 2000–2012. Although this period is shorter, the panel is more balanced, mainly because of the emergence of some countries during the 1990s.

The change in the period of analysis had small impacts on relative residual values. Nevertheless, this variation does not affect the final judgment on the existence of trade potential in most cases in this study. One exception is the potential for exports to Hungary. In the end, results are robust to this change in panel structure and are available on demand.

On the basis of PPML results with no adjustments to the Eq(9) procedure, export potential is robust to the change in the period of analysis. The same is true across adjusted models.

(d) The adjustment factor

The country-pair PPML model (XTPQML) needs to be adjusted to produce zero mean residuals. This is not the case for the PPML estimator. Nevertheless, we adjust PPML results for comparison. The adjustment factor, which is equivalent to a country-pair fixed effect, is a coefficient of the observed bilateral export average and its respective average fitted values clustered by country pairs over time.

The application of the adjustment factor to PPML reveals the sensitivity of export potential. This sensitivity is amplified when the period of analysis is changed from 1980–2012 to 2000–2012 on the basis of the adjusted results. However, conclusions about trade potential are less sensitive to changes depending on the adjusted model (see results for models 3 to 5 in figures 1 to 4).

For example, when determining potential for trade from Colombia to European Union countries, shifting from PPML relative residuals to adjusted PPML relative residuals reduces or even eliminates trade potential for some countries. It also diminishes potential for trade from the analysed countries to Colombia.

VI. Conclusions

Our analysis of PPML relative residuals shows untapped potential for exports from Colombia to some European Union countries and vice versa.

We believe that Colombia can take advantage of its new trade agreement with the European Union to increase its exports to the following markets: Austria, Czechia, Finland, France, Germany, Greece, Hungary, Poland, Romania and Sweden.

Trade potential variations between the PPML time-varying fixed effects method and the PPML time-invariant fixed effects method are relatively insignificant. Yet this type of potential is sensitive to the adjustment factor. Once adjusted, trade potential is not overly sensitive to changes from one adjusted method (PPML adjusted) to the next (XTPQML adjusted).

Shifting from PPML to adjusted PPML relative residuals is less sensitive for 1980–2012 than for 2000–2012. Trade potential is eliminated with Greece and to a lesser extent with Romania under the more cautious scenario of the adjusted models.

Changes in the database periods from 1980–2012 to 2000–2012 under the same method of relative residual calculations are not as sensitive in models 1 and 2 as they are in the adjusted models. Hungary is sensitive to this test. The impact from considering the average of the last three years instead of the relative residual for the single year 2012 is generally insignificant across specifications. Bearing in mind Colombia's potential for trade with the European Union, the impact is minimal, after reasonable thresholds of caution are considered.

Potential for trade with Colombia is less promising for other countries. Most European Union countries are already trading near the normal rule predicted by the models, or even overtrading. This is particularly evident in the case of bigger countries. Yet, there is still some room for the United Kingdom to increase trade with Colombia.

The picture is more encouraging in the cases of Finland, Ireland, Poland and Sweden, which have unrealized potential for trade with Colombia. On the basis of only model 1 and model 2 specifications, Czechia, Greece, Hungary and Portugal also have potential for trade with Colombia.

Our analysis of major global markets excluding the European Union indicates steady potential across models for trade from Colombia to Japan and the Russian Federation. Under the relative residual analysis for models computed with PPML, and no adjustment factor for the entire 1980–2012 period, there is also potential for trade from Colombia to Australia, Canada and Mexico.

As regards flows to Colombia, only Australia presents steady potential for trade with Colombia across all models, followed by Brazil, Canada and the European Union. On the basis of only model 1 and model 2 specifications, there is also potential for trade from the Russian Federation and Turkey to Colombia.

Future research on the ex post effect of the European Union-Colombia free trade agreement would be of interest to determine whether this agreement successfully bridged the gap of unrealised trade potential.

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Annex 1

List of Countries Included in the Gravity Model Data Set

Albania, Algeria, Angola, Argentina, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bermuda, Bolivarian Republic of Venezuela, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Cape Verde, Central African Republic, Chad, Chile, China, Colombia, Congo, Costa Rica, Cote d'Ivoire, Croatia, Cuba, Cyprus, Czechia, Democratic Republic of the Congo, Denmark, Djibouti, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Estonia, Ethiopia, Fiji, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hong Kong SAR, Hungary, Iceland, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kuwait, Kyrgyzstan, Latvia, Lebanon, Liberia, Libya, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Mali, Malta, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Mozambique, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Plurinational State of Bolivia, Poland, Portugal, Qatar, Republic of Korea, Romania, Russian Federation, Rwanda, Samoa, Saudi Arabia, Senegal, Sierra Leone, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Syria, Tajikistan, Thailand, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Arab Emirates, United Kingdom, United Republic of Tanzania, United States, Uruguay, Uzbekistan, Viet Nam, Yemen, Zambia, Zimbabwe.