International trade networks and the integration of Colombia into global trade

Andrés Murcia, Hernando Vargas and Carlos León[1]

Abstract

Global trading activity for different types of goods is mapped using network analysis, comparing the mid-1990s with recent years. Variations in trade patterns through time are described and the rise of new players in different sectors is documented. Subsequently, some features of the integration of Colombia into global trade are presented along with some evidence on the impact of this process on the responsiveness of the manufacturing sector to exchange rate shocks. The main conclusions are the following: (i) globalisation has generated important changes in international trade, increasing the links between countries and making the world trade network (WTN) denser, more reciprocal and more clustered; (ii) the rise of China in global trade is perhaps one of the most important developments in recent years; (iii) nevertheless, this process has been uneven across sectors; (iv) the integration of the Colombian economy into global trade has been significant but imperfect; and (iv) the exposure of Colombian manufacturing firms to international markets on both their demand and cost sides may be an important reason why manufacturing output and trade have not responded much to fluctuations in exchange rates.

Keywords: international trade, network analysis, globalisation, manufacturing sector, real exchange rate, Colombia.

JEL classification: F15, F60, F31.

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1. Introduction

Since the end of the eighties and the beginning of the nineties, the Colombian economy went through a process of economic opening that sought to further integrate the country into global trade. To illustrate the international environment in which this process took place, the next section of this note uses network analysis to map global trading activity for different types of goods. Variations in trade patterns through time are described and the rise of new players in different sectors is documented. The third section then highlights some specific features of the integration of Colombia into global trade. Some evidence about the impact of this process on the responsiveness of the manufacturing sector to exchange rate shocks is examined in the fourth section.

The analysis presented in this note is based on previous work by the staff of Bank of the Republic, some of which has been published in the Bank's working paper series.

2. The world trade network

Cepeda et al (2017) describe the evolution of the world trade network (WTN) from the mid-1990s to 2014. Using network analysis, the authors find that countries' efforts to attain the benefits of trade have resulted in a trade network that is increasingly dense,[2] reciprocal[3] and clustered,[4] suggesting that globalisation has resulted in a larger number of trade relations. However, they found no sizeable effect on their intensity. Hence, trade linkages are homogenously distributed among countries, but their intensity is highly concentrated in few of them.

The study used the United Nations Comtrade Database for the period 1995–2014, for the 106 countries reported in the database that are the main constituents of the WTN.[5] The authors concluded that the value of exports was concentrated on just a few countries during the whole sample period and that 2007–08 marked a turning point in the WTN's evolution from a two-strong group (led by United States and Germany) to a three-strong group (led by United States, Germany and China), forming a hierarchical structure of world trade. Although these countries preside over the most intense trade flows, the links between countries appear to be distributed homogeneously among them. In other words, the WTN is a very dense network that consists of a large number of countries with multiple weak trade relations, and a small set of countries with multiple and intense relations. The authors argue that gravity models (eg Tinbergen (1962)) could explain some important features of global trade, since the proximity of countries in the trade network tends to be associated with

[2] Density is the ratio of the number of actual links to the maximum possible number of links.

[3] Reciprocity measures the probability that a link from country "i" to "j" is complemented by the reciprocal link, from "j" to "i".

[4] Clustering measures the frequency with which loops of tree lengths appear in the network.

[5] Export measures were included for the following sectors: animal and animal products; vegetable products; foodstuffs; mineral products; chemicals and allied industries; plastics and rubbers; raw hides, skins, leather and furs; wood and wood products; textiles; footwear and headgear; stone and glass; metals; machinery and electrical; transportation; miscellaneous; and other (services).

characteristics such as the size of the economies and their geographical location. Nevertheless, some recent changes in the WTN may have to do with a changing pattern in specialisation in global trade, whereby China's rise as a manufacturing exporter has concentrated exports of some countries in raw material sectors. In this process China's emergence has disrupted manufacturing output and exports in many countries, increasing global demand for raw materials.

Cepeda et al (2017) also found that the characteristics of the WTN (density, reciprocity, clustering etc) cannot be understood as the average of the features of the sectoral trade networks. In addition, since globalisation and technological spillovers affect sectors and economic activities in different ways, it is especially relevant to analyse whether there have been differences in the evolution of sectoral trade networks. In this note, we try to go deeper into the analysis in this regard.[6] We report sectoral networks and minimal spanning trees[7] to illustrate the evolution of five components of the WTN – vegetables, minerals, metals, machinery and electrical, and transportation. This yields a clear picture of the differences between the WTN of commodities and high-value added products in the periods 1995–96 and 2013–14.

The sectoral networks used to analyse the evolution of the WTN (Graph 1) are interpreted as follows: the red nodes correspond to countries that pertain to the 90th percentile of exports, and the diameter of each one is the country's contribution to the value of total exports in the respective sector for each period. They are positioned in a circular layout, where the most representative country (by value of exports) is at the rightmost location, and those that follow are positioned in descending counterclockwise order. The links between countries are represented by arrows that follow the direction from exporter to importer, whereas their width and colour (see colour scale on the left) represent their contribution to the total value of exports.

After a simple visual inspection of the sectoral networks (Graph 1) and their respective minimal spanning trees (Graph 2), it is possible to observe that: (i) there are more links between countries in the second period (2013–14) than in the first one (1995–96), suggesting that globalisation has increased trade relations between countries in the last 20 years; (ii) the number of countries in the network in the first three sectors (vegetables, minerals and metals) is larger than in the other two sectors (machinery/electrical and transport), indicating a higher concentration in those sectors with greater value added; (iii) the emergence of new relevant players in most sectors is evident. The salient case is China, which was a satellite node linked to other countries in many sectors in the 1990s, but has become one of the principal nodes 20 years later; and (iv) regional trading blocs are quite relevant.

We now present some results of the visual inspection for different sectors (Graphs 1 and 2) and the evolution of the main network metrics (presented in Graphs 3, 4, 5 and 6).

[6] A similar exercise was performed by Cingolani et al (2017) for the sectors of textiles and electronics. For the mining sector Zhong et al (2017) also use network analysis.

[7] Minimal spanning trees consist of choosing the shortest distances of a connected system of *n* countries in such a way that the resulting system is an acyclic network with *n–1* links.

Vegetables.[8] This is probably the sectoral network with fewest changes during the period studied. The principal nodes in the 1990s were the United States, the Netherlands, Germany and, to some degree, China. For the second period, the most relevant nodes are the same, but China gained importance and India became relevant as well (Graphs 1 and 2). In South America, countries with large agricultural sectors, such as Argentina and Brazil, changed their leading trade link from the United States to China. Based on the summary network statistics (Graphs 3, 4, 5 and 6), it is remarkable that this sector shows the lowest reduction in the average geodesic distance[9] between countries, suggesting that this sector experienced relatively fewer changes in trade patterns. It is also noteworthy that this sector is the only one that presents a reduction in the reciprocity measure and exhibits the lowest change in clustering degree. The role of specialisation in this sector and the difficulty of changing production patterns could be part of the explanation.

Minerals.[10] The most relevant nodes in this network during the 1990s were the United States, Japan and Saudi Arabia and, to a lesser degree, Norway, the Netherlands, Russia and the United Kingdom. Looking at the network of 2013–14, the emergence of China is again noticeable. Also, countries such as Russia and Australia increased their importance in the global minerals trade network. The increase in the density measure of this network has been similar to that of other sectors during the last two decades (Graph 4), suggesting an augmented trading activity with new country destinations. Despite the increase in new trading relations, growth in the measures of reciprocity and clustering has been relatively low. This can be expected in commodity goods sectors such as minerals, given the limited number of country participants in the production chain.

Metals.[11] The evolution of this network mimics that of total international trade (WTN). In the 1990s, trade was dominated by the United States, Germany and Japan. Twenty years later, the most relevant players were China, Germany and, to a lesser degree, the United States. In Latin America, big producers of copper and other minerals, such as Chile, changed their main counterparty from the United States to China during that period. The United States kept an important role through its links with regional partners such as Canada and Mexico. The network statistics suggest that trade links have multiplied during the period analysed: the average distance decreased, while the density, reciprocity and clustering measures increased.

[8] The vegetables group includes live trees and other plants; edible vegetables and certain roots and tubers; edible fruit and nuts; coffee, tea, mate and spices; cereals; products of the milling industry; oil seeds and oleaginous fruits; gums, resins and other vegetable saps; vegetable plaiting materials and animal or vegetable fats and oils.

[9] Average geodesic distance is the average of the shortest path in term of number of links from country i to j.

[10] The minerals group includes salt, sulphur, earths and stone; ores, slag and ash, and; mineral fuels and oils.

[11] The metals group includes iron and steel; article or iron or steel; copper; nickel; aluminum; lead; zinc; tin, other base metals; tools, implements, cutlery, spoons and forks and; miscellaneous articles of base metal.

Machinery/electrical[12] *and transport.*[13] These categories include goods whose production processes are characterised by greater complexity and heavier reliance on technology. Trade in machinery and electrical goods was concentrated in the United States and Germany in the 1990s, whereas in 2013–14 China became an important player, taking the place of the United States in the world trade network of these goods. For the transport sector the biggest nodes remained the same (the United States and Germany), but new relevant players had emerged in 2013–14 (eg Brazil, Sweden and India). Mexico's weight in this network increased markedly and its trade link with the United States is today one of the largest trade relations worldwide (purple line in Graph 1).

Both machinery/electrical and transport networks have recorded increases in their density, reciprocity and clustering measures, as well as significant reductions in the average distance between countries, suggesting that trade links have been substantially enhanced. This may reflect the greater importance of multinational companies in these activities and the extension of global value chains (GVC).

According to BIS (2017), between 1995 and 2007, the ratio of trade in intermediate to final goods and services rose from 1.25 to 1.75. GVCs alter production processes and international links between countries in different ways. In particular, GVCs allow the substitution of foreign production inputs for domestic ones in a flexible manner (BIS (2017)). By shifting production stages geographically and across plants, firms can exploit efficiency gains on a global scale and bypass domestic constraints or bottlenecks. GVCs also include long-term economic relationships between unaffiliated firms that buy and sell inputs specialised for each other's needs (Antràs (2005)). The rise of China can also be seen through the change in GVCs. According to BIS (2017), the share of China in the global trade of intermediate goods and services surged from just 2.2% in 1995 to no less than 9.1% in 2014.

3. The integration of Colombia into global trade

In the beginning of the 1990s, the country undertook a series of structural reforms in order to increase productivity and efficiency. The liberalisation of the foreign trade regime was an important component of this effort. Tariffs were reduced and some quantitative import restrictions were eliminated. The simple average nominal tariff on imports was reduced from 31% to 17% between 1985 and 1992, and to 12% between 1992 and 1997. In 2015, the average tariff on imports was 5.8%.

Despite a significant increase in the value of imports and exports between 1990 and 2015 (Graph 7), the integration of the Colombian economy into global trade has been incomplete and imperfect. The evolution of a common trade openness

[12] The machinery and electrical group includes nuclear reactors, boilers, machinery and mechanical and electrical machinery and equipment.

[13] The transportation group includes railway or tramway locomotives, rolling-stock, vehicle other than railways or tramways; aircraft, spacecraft and parts, and; ships, boats and floating structures.

indicator[14] suggests that Colombia is still closed relative to other countries in the region (Graph 8). Additionally, an increasing part of export trade corresponds to mining and energy commodities, resulting in high levels of concentration in these sectors (Graph 9, red line). This is also evident in the evolution of a Herfindahl concentration indicator (HHI) calculated for categories in the Colombian exports[15] (Graph 9, green line), while diversification by country of destination has recorded some gains (Graph 9, blue line). Based on micro level information, Eaton et al (2007) noticed that export sales have been dominated by a small number of very large and stable exporting firms, suggesting a high firm-level of concentration in the export market.

As for imports, it should be noted that the variety of products imported by the country has been reduced.[16] All this suggests that gains in terms of diversification of markets in this period have been limited.

This pattern is partially explained by the fact that the reduction in tariffs was accompanied by the imposition of other measures with protectionist effects. Although the average tariff fell and the quantitative control of imports was abandoned, the use of non-tariff measures became widespread (García et al (2014)). Since 1991, there has been a steady increase in decrees, regulations and resolutions for technical standards as well as sanitary measures intended to protect consumers or producers, which has resulted in higher prices for consumers and increased protection for producers (García et al (2015A)).

The quality of institutions has also hindered the process of international integration. A central bank survey of logistics operators in early 2013 suggests that regulatory agencies are seldom coordinated and that regulations constitute a barrier to trade because they are opaque, complicated and not disclosed in a timely manner (García et al (2015 B)). Moreover, trade policy in Colombia is defined and executed by several entities (currently more than 20), unlike the period prior to the economic opening, when it was defined and executed by just a few. The present organisational structure has added barriers to foreign trade through the entities' requirements for approval or for giving a favourable concept of imports or exports. All these problems may pose a barrier to trade and tend to reduce its volume significantly (García et al (2015B)). The above-mentioned survey also found high internal non-tariff costs, particularly those relating to internal transport of cargo, port services, agency services, inspections by some sanitary entities other than customs, and prior authorisations. All this suggests that the integration of Colombia into the global economy has been limited and imperfect, and that there is still quite significant room for improvement.

[14] Calculated as the ratio of the sum of exports plus imports to GDP.

[15] This indicator is defined as the sum of the squares of the participation of each category of exports within the total exports (as a measure of market share). Increases in the HHI indicator generally indicate an increase in concentration. We used 180 categories of exports according to the International Standard Industrial Classification of All Economic Activities (ISIC) Rev. 3.

[16] In 1995, Colombia imported goods that corresponded to 6,790 positions of the customs tariffs; in 2015, the number of positions had fallen to 6,459.

4. Manufacturing sector and its responsiveness to exchange rate shocks

Despite the above-mentioned obstacles, a salient feature of the manufacturing sector during the last two decades has been its increased exposure to international trade, thanks to the growing globalisation of its input and output markets. The fact that the manufacturing sector is exposed to exchange rate fluctuations that affect both its demand and its costs has served to mitigate the effects of these shocks. Based on González et al (2017), we present here some insights into how the fluctuations of the exchange rate have affected the Colombian manufacturing sector since 2000 and how globalisation has affected the link between these variables. Recent evidence suggests that, in the context of multi-country production chains, third-country exchange rate effects could generate "complementarities" between real effective exchange rates (BIS (2017)), in the sense that the competitiveness of a home exporting firm that sources heavily from a third country could be affected by changes in the exchange rate of that country.[17] According to BIS (2017), novel quantifications of real exchange rate dynamics in the presence of international input-output linkages find that the magnitude of such effects is material (Bems and Johnson (2016), Patel et al (2014)).

Manufacturing output and exports grew steadily in Colombia until the 2008–09 international financial crisis, when worldwide manufacturing and trade slowed significantly (Graph 10). After 2010, growth in manufacturing output held up, despite the real appreciation of the currency[18] of around 20% between 2001 and 2012. In fact, if anything, manufacturing output and exports seem to be positively correlated with the real exchange rate. Moreover, after the substantial depreciation of the currency after 2014, manufacturing output has not picked up significantly (Graph 10).

The resilience of manufacturing to the fluctuations of the exchange rate is partly explained by confounding factors that affect both, such as the strength of external and internal demand. Furthermore, in an increasingly globalised economy, firms that produce tradable goods using tradable inputs are exposed to exchange rate shocks in both their final goods markets and their input markets. These effects may offset each other, especially if they differentially affect the currencies of the countries from

[17] BIS (2017) presents an example to explain the complementarity of real effective exchange rates: "As German firms source heavily from China, the competitiveness of German producers exporting to France improves if the renminbi devalues against the euro". The authors also claim that "The third-country effects present in GVC-based REERs work in opposite directions to those present in traditional final goods-based REERs. This is because final goods from third nations substitute for domestic exports, whereas input goods sourced from third nations complement domestic production."

[18] The real exchange rate is measured as the ratio of the price of local goods to the price of foreign goods, so that an appreciation of the real exchange rate is equivalent to an increase of the index. To compute the real exchange rate index, let $ER_c=(e_cP)/P_c$ be the bilateral real exchange rate with country c, where (e_c/P_c) is the nominal exchange rate e_c (units of c currency per Colombian peso) with country c divided by country c consumer price index P_c. The real exchange rate index ER is the sum of the bilateral real exchange rates with every trading country, weighted by their trading shares $ER=\sum_c s_c(e_cP)/P_c$, where the shares sum up to one $\sum_c s_c=1$ and depend on the type of goods that we look at.

where inputs are sourced and the currencies of the countries where goods are exported.

To illustrate this point, in Graph 11 we present a computation by González et al (2017) in which they discriminate real exchange rate indices for manufacturing exports and for inputs imported by manufacturing firms. Each index is based on the country shares of trade for each type of good. As shown, the cumulative appreciation of the real exchange rate is larger for imported inputs (blue line) than for exported manufactured goods (green line). Between 2000 and 2014, the real exchange rate of manufacturing exports increased, but the real exchange rate of manufacturing inputs rose even more. Between 2001 and 2012, the real appreciation of exports was around 17%, whereas the real appreciation of input imports was more than 25%.

In other words, there is evidence that, between 2000 and 2014, manufacturing firms hedged the effects of exchange rate shocks by importing inputs disproportionally from countries with relatively undervalued currencies (such as China and the United States), while disproportionally exporting to countries with relatively overvalued exchange rates (such as other Latin American countries). As presented in González et al (2017), this result is probably not a coincidence but, to some extent, an equilibrium result. For example, increased input imports from China might be the result of firms looking for less expensive suppliers, or a consequence of increases in the productivity of Chinese input-producing firms. In a globalised environment, both types of shock should increasingly be reflected in the composition of supply chains and the portfolio of markets of manufacturing firms.

In order to further illustrate the offsetting effects of exchange rate fluctuations, González et al (2017) computed a net real exchange index for the Colombian manufacturing sector since 2001. This index is calculated as the difference between the real exchange rate (RER) of exports and input imports, accounting for the share of exports in total sales, and the share of imported inputs in total costs.[19] This measure is analogous to a standard RER index, except that it accounts for the proportion of output that is sold in the local market, and the proportion of inputs that are sourced from foreign countries. In Graph 12, the yearly percentage change of two measures of the real exchange rate and the change in the net real exchange rate (net RER) are presented. The blue line depicts the change of the RER based on the composition by destination of the manufacturing exports, whereas the red line depicts the change of the RER based on the composition by origin of imports of inputs for the manufacturing sector. The green line represents the yearly percent change of this net RER.

As reported in González et al (2017), the variation of the net RER index is much more muted than the variation of the standard RER. The reason is that input imports provide a natural hedge for firms against exchange rate fluctuations. The index reports some episodes of a real exchange net appreciation up until 2012, and a real exchange rate net depreciation since 2014. It should be pointed out that this index is computed for the whole manufacturing sector and that there should certainly be variation across sectors. In any case, the average net depreciation faced by manufacturing firms since 2014 has been only around 1% per year, which is much

[19] Changes in the net RER are defined as $\Sigma_i \Delta TCR_i (w_i - c_i)$. TCR_i is the CPI-based bilateral RER with country i, w_i is the share of exports to country i in total sales, and c_i is the share of imported inputs from country i in total costs. Zero economic profits are assumed, so that total costs equal total sales and both are approximated by the gross output of the economy.

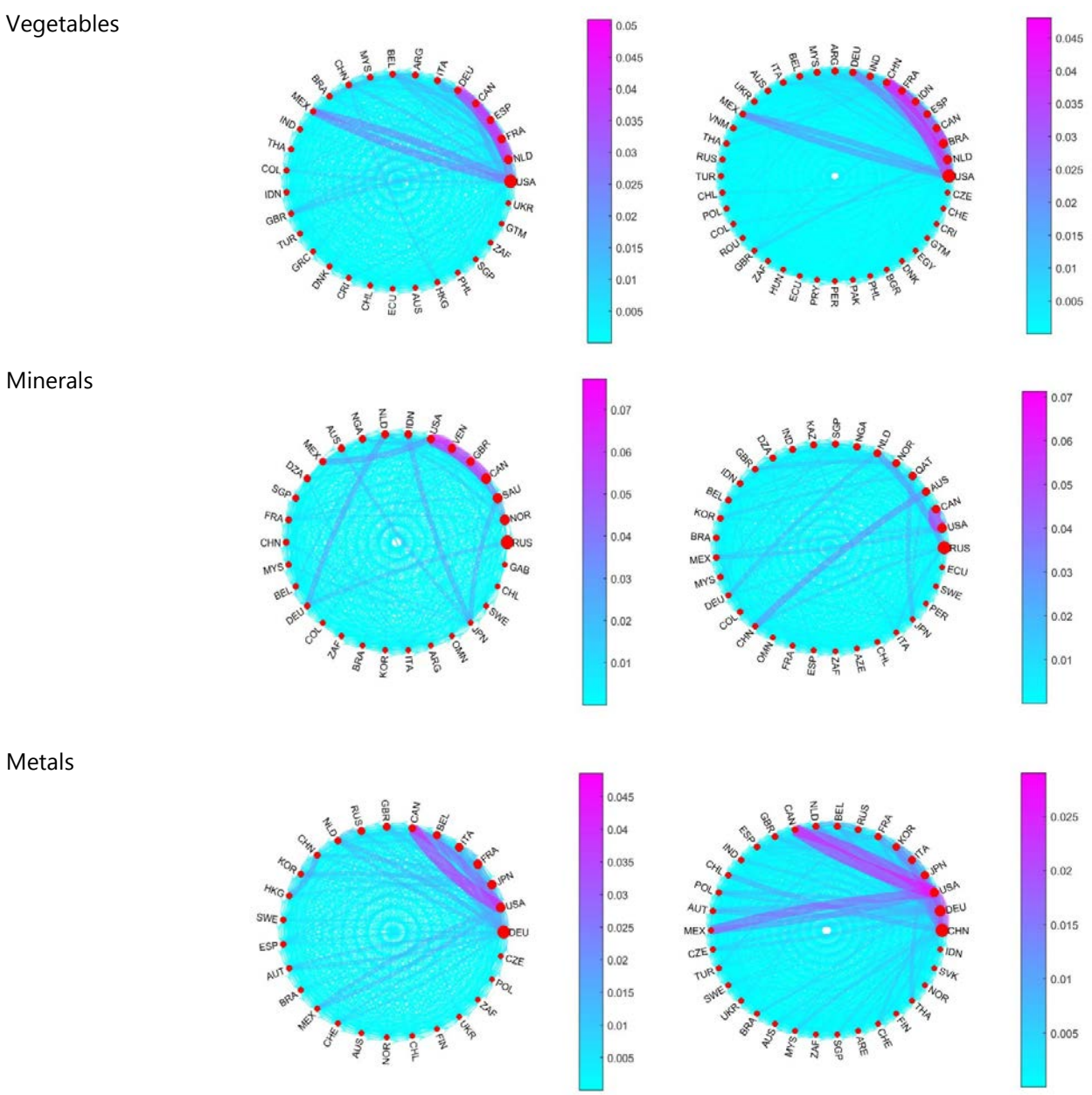
lower than the observed depreciation of the nominal exchange rate. This stability of the net RER explains, at least partly, the weak growth of Colombian manufacturing after the substantial depreciation of the nominal exchange rate after 2014.

5. Conclusion

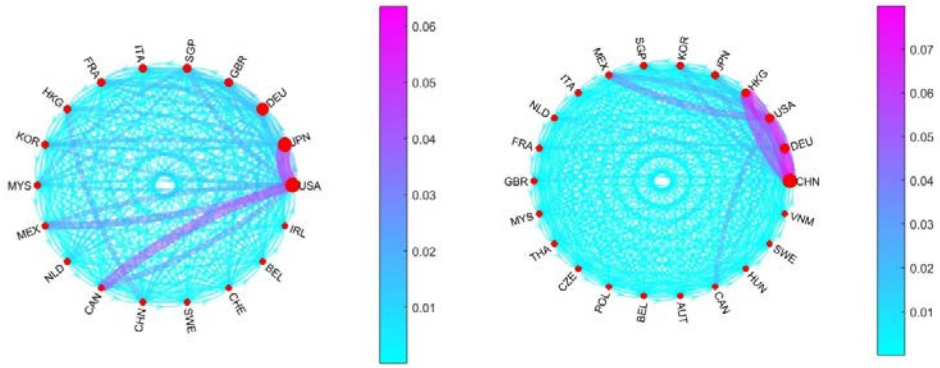
Globalisation has generated important changes in international trade, increasing the links between countries and making the world trade network (WTN) denser, more reciprocal and more clustered. However, the network remains highly concentrated on relatively few countries in terms of export values (Cepeda et al (2017)). The rise of China as an important player in global trade is perhaps one of the most important developments in recent years. This process, however, has been uneven across sectors, as documented in this note. The experience of Colombia in the globalisation process suggests that (i) the integration of the Colombian economy into global trade has been significant but imperfect; (ii) the exposure of manufacturing firms to international markets both on their demand and cost sides may be an important reason why manufacturing output and trade have not responded much to fluctuations in exchange rates. As the international linkages of firms deepen, this resilience could become more robust.

Sectoral networks of global trade

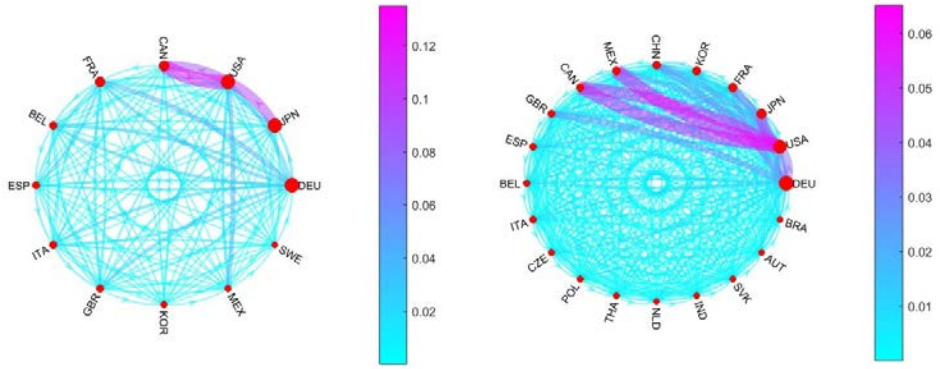
Graph 1



Machinery & Elect.



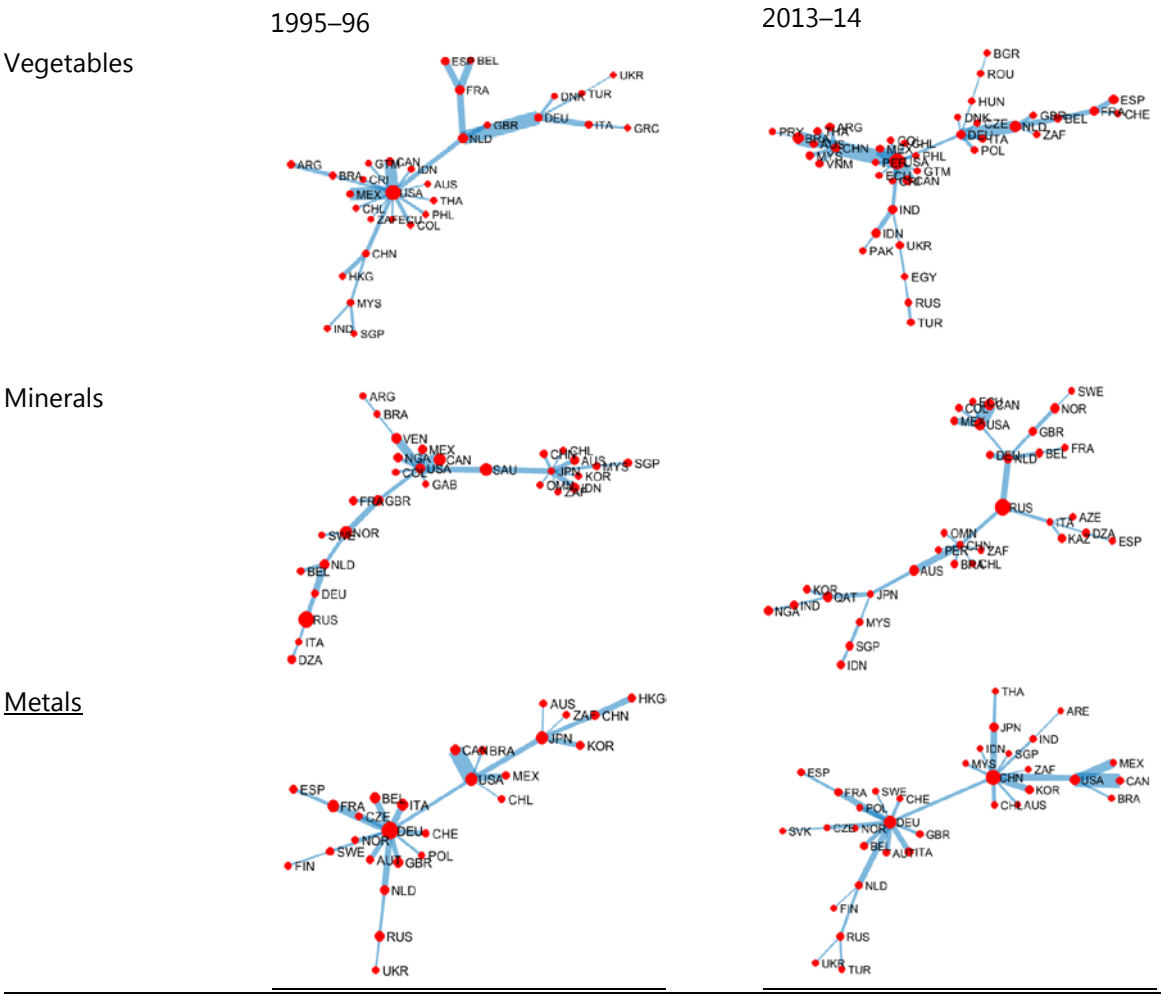
Transport



Source: UN-COMTRADE and Cepeda et al (2017), calculations by Bank of the Republic.

Minimal spanning trees of global trade

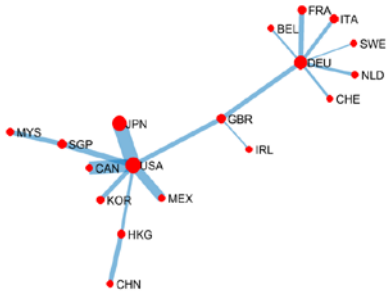
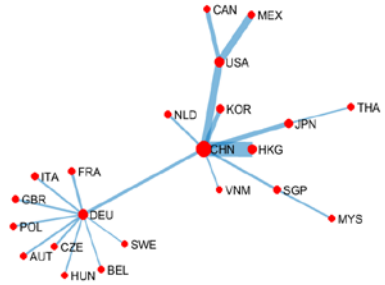
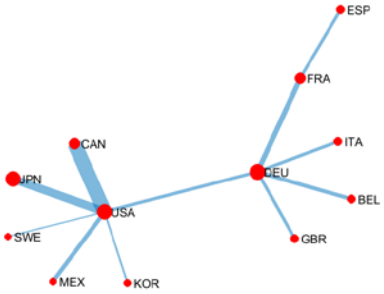
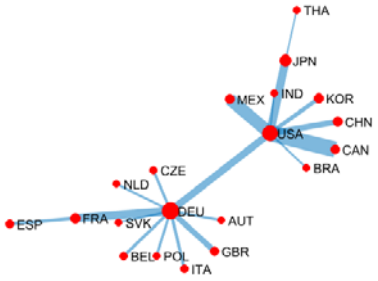
Graph 2



Source: UN-COMTRADE and Cepeda et al (2017), calculations by Bank of the Republic.

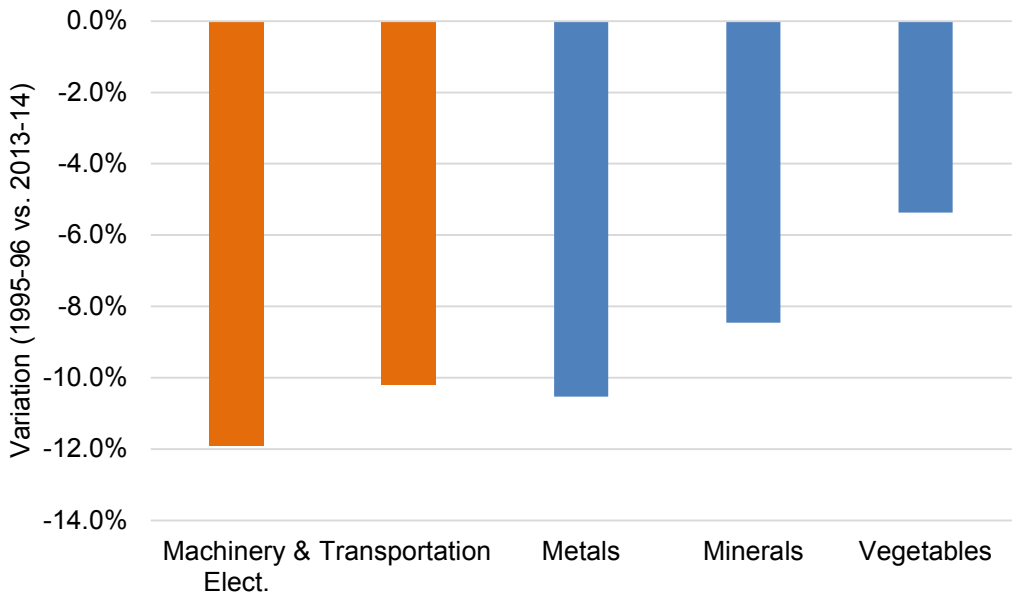
Minimal spanning trees of global trade

Graph 2 (con't)

	1995–96	2013-14
Machinery & Elect.		
Transport		

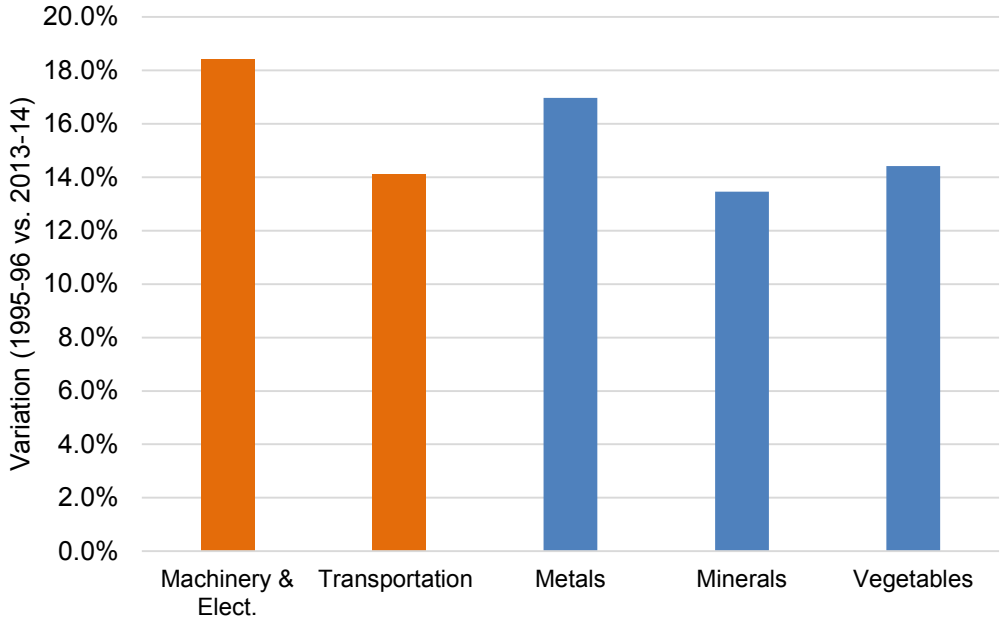
Source: UN-COMTRADE and Cepeda et al (2017), calculations by Bank of the Republic.

Change in average distance in global trade between 1995–96 and 2013–14 Graph 3



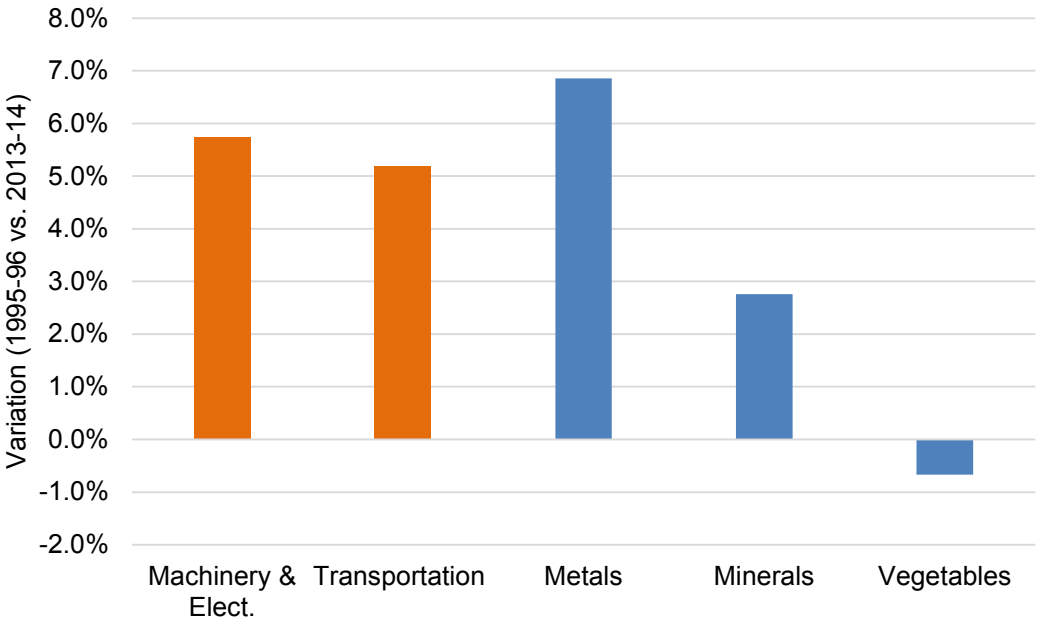
Source: UN-COMTRADE and Cepeda et al (2017), calculations by Bank of the Republic.

Change in density in global trade between 1995–96 and 2013–14 Graph 4



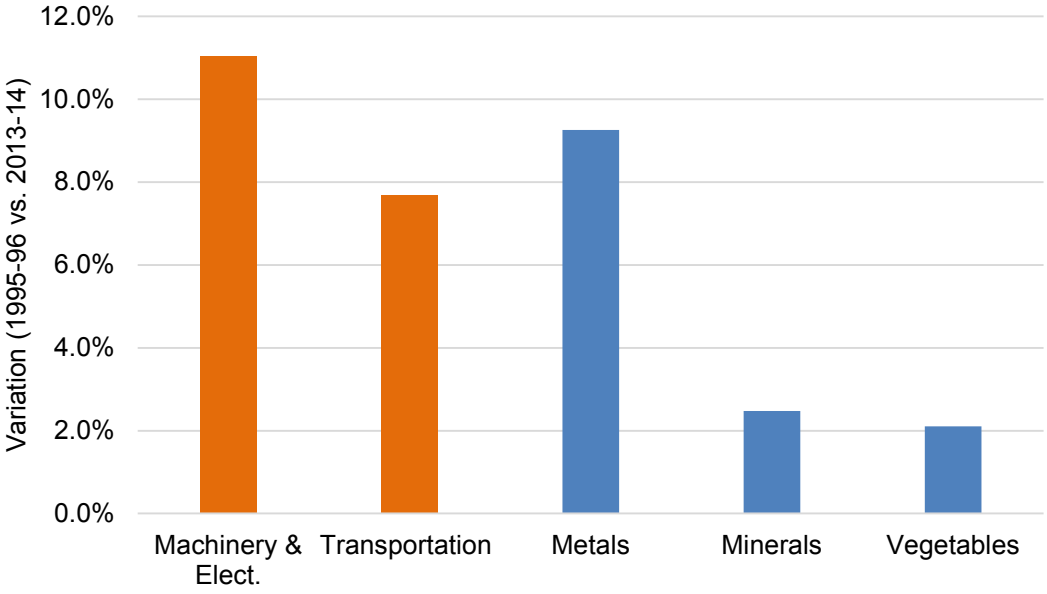
Source: UN-COMTRADE and Cepeda et al (2017), calculations by Bank of the Republic.

Change in reciprocity in global trade between 1995–96 and 2013–14 Graph 5



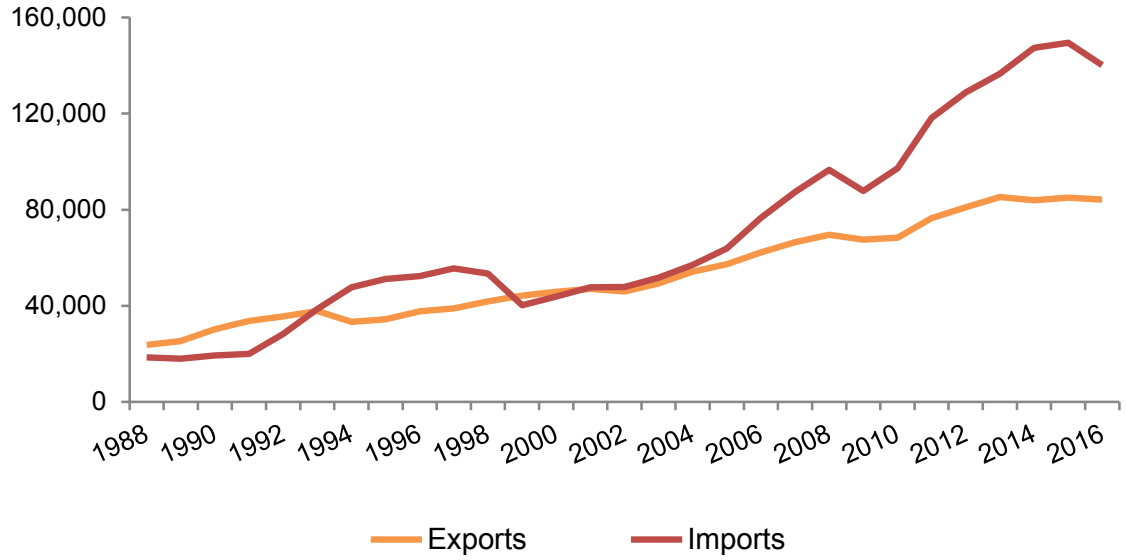
Source: UN-COMTRADE and Cepeda et al (2017), calculations by Bank of the Republic.

Change in clustering in global trade between 1995–96 and 2013–14 Graph 6



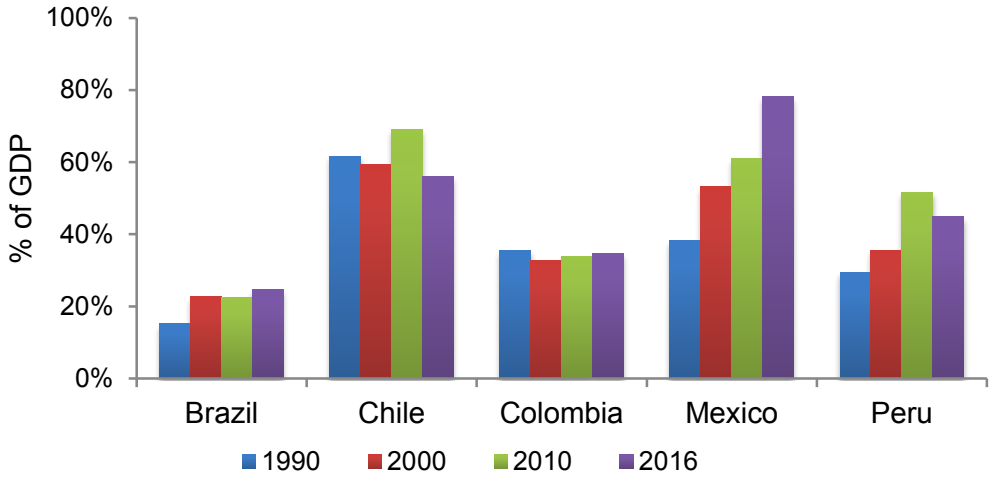
Source: UN-COMTRADE and Cepeda et al (2017), calculations by Bank of the Republic.

Exports and imports in Colombia: 1988–2016 (constant 2005, COP trillions) Graph 7



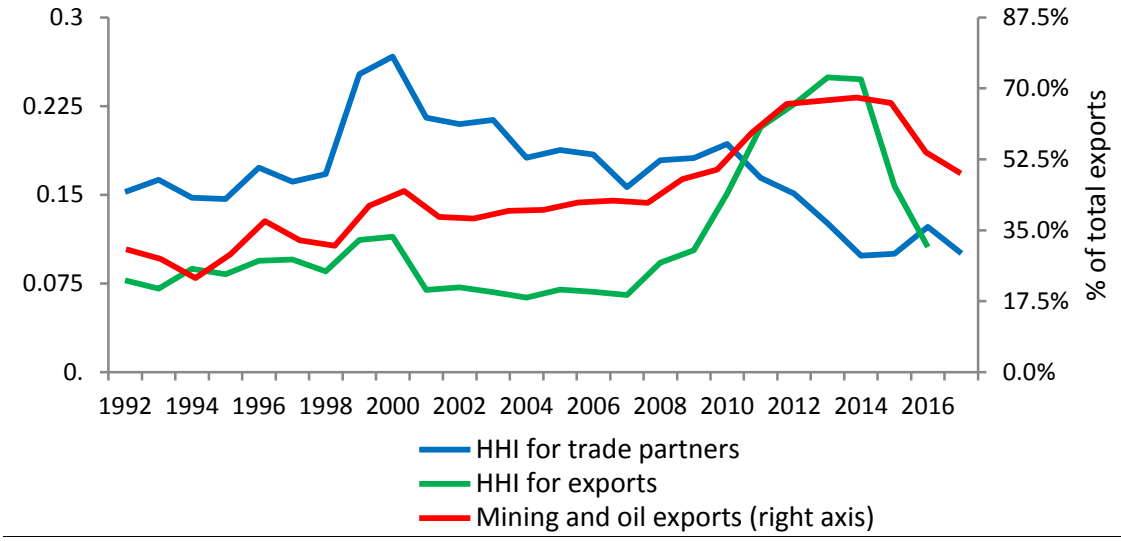
Source: DANE, calculations by Bank of the Republic.

Trade openness indicator: Exports and imports as a percentage of GDP Graph 8



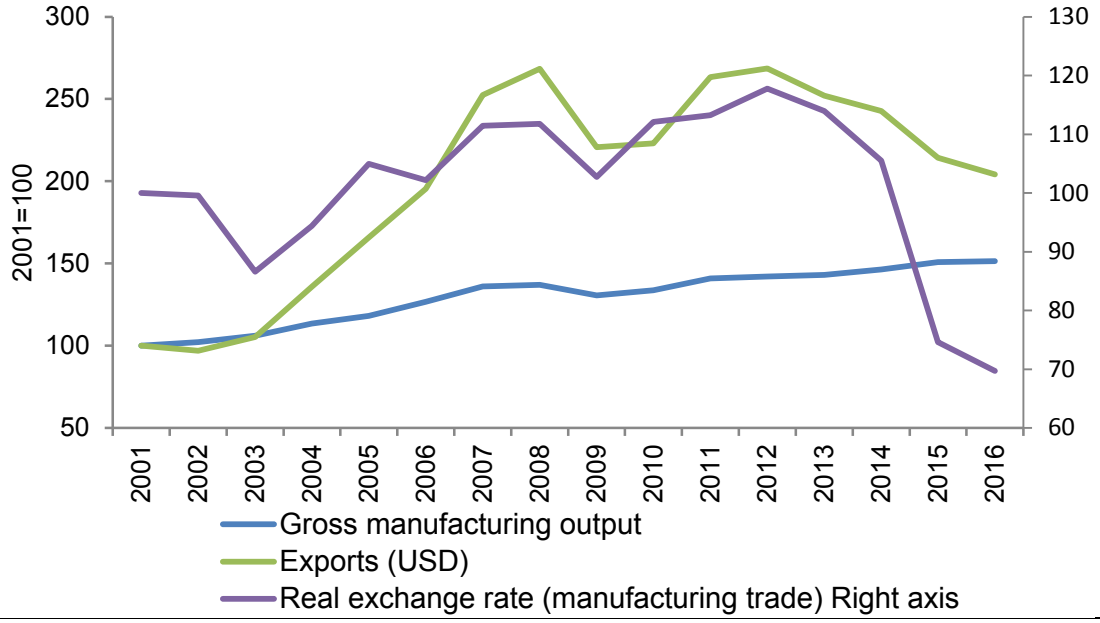
Source: World Bank.

Mining and oil exports as a percentage of total exports and Herfindahl concentration indicator for exports and trade partners, Colombia: 1992–2016 Graph 9



Sources: DANE, calculations by Bank of the Republic.

Manufacturing output, exports and real exchange rate in Colombia, 2001–16 Graph 10

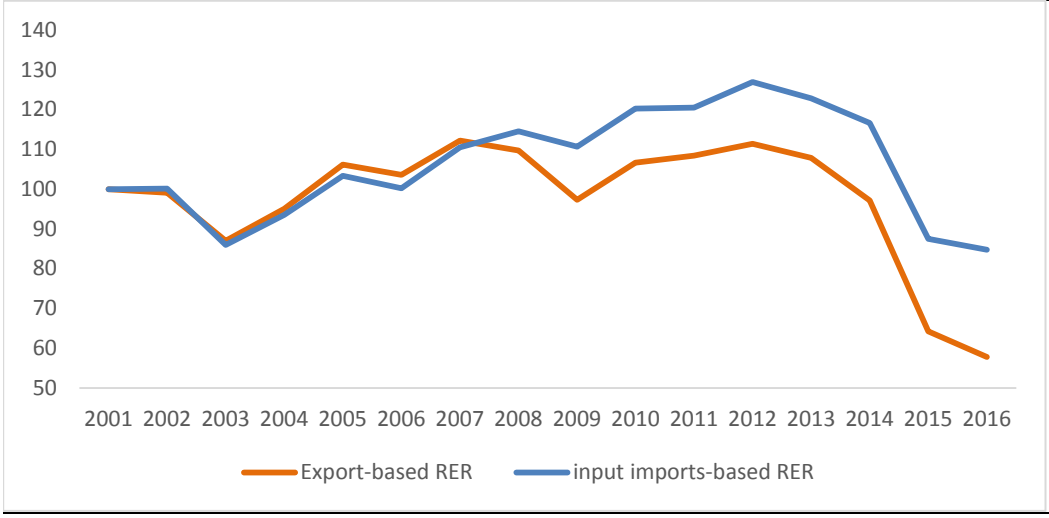


Note: Data include all manufacturing sectors, excluding oil refining.

Sources: DANE, DIAN, calculations by Bank of the Republic.

Manufacturing exports and input imports-based real exchange rate, 2001–16

Graph 11

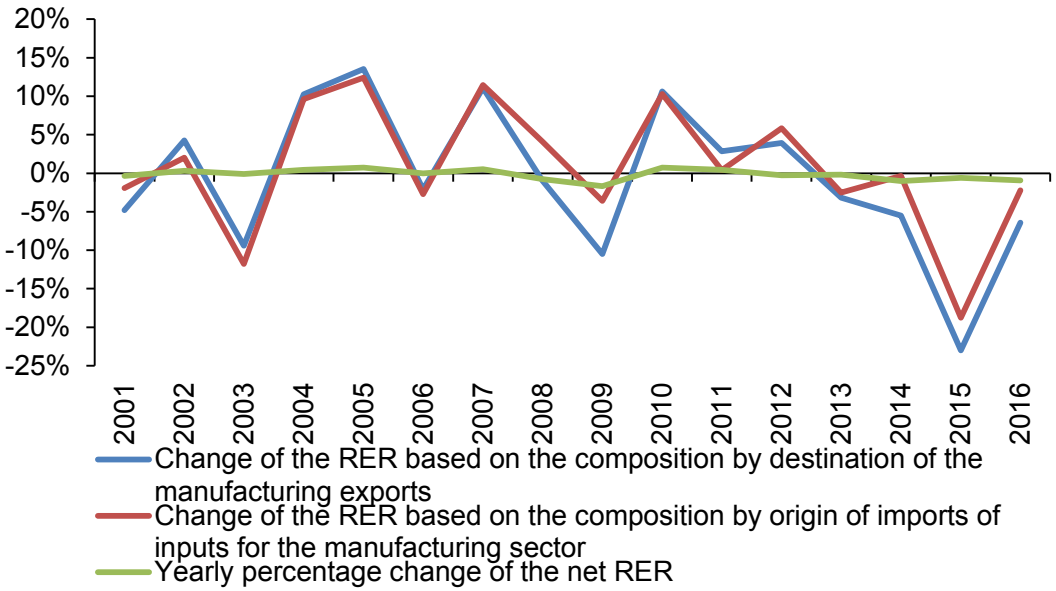


Note: Data include all manufacturing sectors, excluding oil refining.

Sources: DANE, DIAN, Gonzalez et al (2017) calculations by Bank of the Republic.

Annual changes in real exchange rates in Colombia, 2001–16

Graph 12



Note: Changes in the net RER are defined as Σi ΔTCRi (wi - ci). TCRi is the CPI-based bilateral RER with country i, wi is the share of exports to country i in total sales, and ci is the share of imported inputs from country i in total costs. Zero economic profits are assumed, so that total costs equal total sales and both are approximated by the gross output of the economy.

Sources: DANE, DIAN, Gonzalez et al (2017) calculations by Bank of the Republic

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