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Following a neo-structuralist perspective, this study presents a development puzzle concept for Latin American countries (LACs) as a triangular relation amongst peripherality (increased terms-of-trade volatility and technological backwardness), income inequality, and per-capita income. We employ a simultaneous equation model using three-stage least squares (3SLS) to analyse this triangular relation. We find that a decrease in income inequality and an increase in per-capita income were mutually reinforcing in 14 LACs during 1995–2014. Although technological progress increases per-capita income, it partly mitigates this increase by increasing income inequality. Additionally, the increasing effects of foreign sources of technology, including foreign direct investment (FDI), on income inequality are mitigated in countries with higher technological capabilities. While an improvement in commodity terms-of-trade expectedly increases per-capita income and decreases income inequality in South American countries, their volatility is mostly insignificant.

Keywords: commodity terms-of-trade; volatility; technological progress; foreign direct investment (FDI); neo-structuralism

1. Introduction

A prominent economic feature of Latin American countries (LACs) is vulnerability to external shocks and higher volatility (Bértola & Ocampo, 2012; Hausmann & Gavin, 1996; Titelman & Pérez-Caldentey, 2016). The growing instability in global economy has caused a substantial change in this region's economic growth perspectives, poverty, and income inequality. This high vulnerability is more puzzling considering the region's desirable features for economic development: resource-richness, proximity to North American markets, upper-middle-income status, and a relatively developed manufacturing base.

To address this puzzling vulnerability, we evaluate the region's peculiar characteristics. In revisiting the literature, we find that Latin American structuralism (henceforth structuralism), which has a principal objective of analysing a system (i.e. interactive relations between its elements as a whole) rather than individual elements in isolation (Palma, 1987), provides some clues. Thus, the objective of this study is to present a simultaneous equation model that depicts the relations between key economic variables based on structuralist ideas, and to test whether these relations held in LACs from 1995 to 2014, during which they experienced the upheaval in commodity prices and the Great Recession.

As discussed in Section 2, structuralists specifically address two phenomena: income inequality and economic peripherality (i.e. factors that restrict an economy to the underdeveloped peripheral position as opposed to highly developed central economies). A salient feature of peripherality is the deterioration of terms-of-trade in commodity-dependent LACs (Prebisch, 1950). Accompanying increased intra-industry and intra-firm trade and financial globalisation, other new distinctive attributes of peripherality emerged as technological backwardness (Economic Commission for Latin America and the Caribbean [ECLAC], 1990) and vulnerability to external shocks caused by volatile commodity prices and short-term international capital inflows (Ocampo, 1998). In this regard, since around 1990, the structuralist perspective has been amplified and transformed to a neo-structuralist one, which focuses more on macroeconomic and financial issues, and emphasises technological backwardness as fundamental difficulties (Bielschowsky, 2009; Di Filippo, 1998).[1]

We argue that the distinctive feature of the system that neo-structuralists present is that there is an interactive relation between income inequality and economic development (measured by per-capita income), and that the aforementioned peripheral features affect both income inequality and per-capita income. Therefore, a novel contribution of this study is to model the triangular relation between peripherality, income inequality, and per-capita income as simultaneous equations, and empirically demonstrate this relationship in LACs since the mid-1990s. Moreover, this model can not only reveal the complex relations between these three variables, but also explain the occurrence of significant economic fluctuations in LACs, thereby revealing the reasons behind the region's puzzling vulnerability. Although some empirical studies have partly analysed these relations in other developing countries or LACs in previous periods, studies focusing on LACs in the chosen period are rare. To the best of our knowledge, this study is the first to model the neo-structuralist ideas using simultaneous equations and analyse these triangular relations holistically.

This paper is organised as follows. Section 2 explains the triangular relation amongst peripherality, income inequality, and per-capita income, following the neo-structuralist perspective, and briefly reviews the theoretical and empirical literature. Section 3 presents the simultaneous equations and describes the data used to empirically evaluate the triangular relations in LACs during 1995–2014. Section 4 presents the estimation results. The final section concludes the discussion.

2. Triangular relation amongst peripherality, inequality, and per-capita income in LACs

Following the neo-structuralist concept of peripherality, this section explains the triangular relation amongst peripherality, income inequality, and per-capita income, as shown in Figure 1, and briefly reviews whether any formal economic models and empirical findings have supported these arguments.

[Figure 1 near here]

2.1. The relation between income inequality and per-capita income

Traditional structuralists argued that inequality in LACs, primarily because of structural heterogeneity (i.e. significantly diverse productivity across different sectors) combined with historical factors such as land tenure systems, was the driving force behind chronic inflation, thereby harming economic growth and depressing per-capita income (Prebisch, 1950). Numerous empirical studies based on cross-country or panel data analysis, including LACs, have supported the argument that income inequality decreases per-capita income growth (e.g. Alesina & Rodrik, 1994; Bengoa & Sanchez-Robles, 2005; Woo, 2011). Moreover, Al-Marhubi (2000) showed that the initial level of income inequality was positively associated with subsequent inflation rates in developed and developing countries including LACs. Bengoa and Sanchez-Robles (2003) found inflation rates to be significantly associated with low per-capita income growth in LACs.

In contrast, neo-structuralists consider the relation between income inequality and per-capita income to be bidirectional rather than unidirectional and emphasise that decreasing inequality and increasing per-capita income are mutually reinforcing (ECLAC, 1990; Fajnzylber, 1990). On the one hand, they argue that less income inequality can contribute to higher per-capita income directly by promoting human capital and physical capital investment, and indirectly through technological progress by human capital accumulation (ECLAC, 1990; Fajnzylber, 1990). On the other hand, neo-structuralists argue that higher per-capita labour income can contribute to decreasing income inequality, as it is more likely to increase than other sources of income if a structural change is accompanied by an increase in labour productivity (ECLAC, 1990; Fajnzylber, 1990). Galor and Zeira (1993) theoretically supported this argument. Their model predicts that countries with a more equal income distribution will have higher per-capita income because of the larger share of individuals who can afford human capital investment. Meanwhile, countries with higher per-capita income will have more equal income distribution because wages of unskilled workers will increase such that even they can afford to invest in human capital and thereby become skilled workers. Therefore, it predicts the mutual reinforcement of less income inequality and higher per-capita income, thereby supporting the neo-structuralist argument.

However, empirical studies on the determinants of income inequality in LACs, including Székely and Mendoza (2017), ignore the effects of per-capita income. Studies concerning the latter, including Bengoa and Sanchez-Robles (2005), Cornia (2010), and Morley (2000), do not regard income inequality and per-capita income as determined simultaneously. As such, we test whether our empirical analysis supports the neo-structuralist argument in LACs since the mid-1990s.

2.2. The relation between peripheral features and per-capita income

Traditional structuralists believed that deterioration of terms-of-trade would harm per-capita income growth and lower per-capita income in LACs. They considered that the downward pressure on the export price occurs through specialisation in primary commodities with low income elasticity and wage reduction due to the low productivity arising from the unproductive labour surplus in the primary sector (Prebisch, 1959). Subsequently, Thirlwall (1979) extended this idea and formally modelled it as the balance-of-payments constraint model. It predicts that long-term economic growth of commodity-dependent countries is constrained by stagnant export growth and high income elasticity of demand for imports, as evidenced by Cimoli et al. (2010) for LACs. However, the findings of empirical studies based on cross-country or panel data are inconclusive. Although some studies (e.g. Cavalcanti et al., 2015; Deaton & Miller, 1996; Mendoza, 1997) found a positive association between terms-of-trade and per-capita income level or growth in developing or commodity-exporting countries, others (e.g. Blattman et al., 2007) found no significant association.

In contrast, according to the neo-structuralist perspective, terms-of-trade volatility is the relevant factor explaining the region's excess economic volatility; it adversely affects per-capita income growth and level by discouraging productive investment and distorting macroeconomic prices (Titelman & Pérez-Caldentey, 2016). Moreover, neo-structuralists have repeatedly argued that this volatility related to terms-of-trade has been increasingly exacerbated by volatility of international capital flows in LACs under their pro-cyclical fiscal and macroeconomic policies (Bértola & Ocampo, 2012; Ocampo, 1998, 2001, 2011; Titelman & Pérez-Caldentey, 2016). Indeed, Hausmann and Gavin (1996) empirically found that both terms-of-trade volatility and capital flow volatility are critical determinants of real income volatility in LACs. Numerous empirical studies have found that higher terms-of-trade volatility is associated with lower per-capita income growth in developing countries (e.g. Mendoza, 1997) and commodity-exporting countries (e.g. Blattman et al., 2007; Cavalcanti et al., 2015). However, they do not analyse LACs since the mid-1990s.

Additionally, neo-structuralists argue that low productivity stemming from low levels of technological progress, rather than primary commodity dependence, is a fundamental feature of peripherality in LACs (Di Filippo, 1998; Hounie et al., 1999). Since LACs have a limited source of endogenous technological progress, as evidenced by their low research and development expenditure, foreign direct investment (FDI), which facilitates access to advanced technology, managerial knowledge, and foreign markets, is considered a major channel for their technological progress (Di Filippo, 1998; ECLAC, 1990). Similarly, intra-industry trade, especially trade in capital goods that embody advanced technology, is also considered an important channel of technology acquisition, thereby contributing to productivity improvements (Fajnzylber, 1990). Nevertheless, structuralists had traditionally argued that FDI would be detrimental to per-capita income in LACs because it generated substantial reverse capital flows in the form of profit and interest remittances to developed countries, thereby causing negative effects on balance of payments (Pinto & Kñakal, 1973; Prebisch, 1969).

Empirical literature also provides mixed evidence. Bengoa and Sanchez-Robles (2003) and Prüfer and Tondl (2008) found that FDI inflows indeed enhanced per-capita income and productivity growth in LACs, respectively. On the other hand, Alencar et al. (2019) found that income derived from FDI indeed adversely affected economic growth by its negative impact on the balance of payments in several LACs. Interestingly, some studies showed that the positive effects of FDI on per-capita income do not occur automatically. Borensztein et al. (1998) found that the contribution of FDI inflows to a developing country's per-capita income growth was positive only when the country had more than a threshold level of human capital. Similarly, Prüfer and Tondl (2008) found that the positive impact of FDI on productivity growth crucially depended on the country's absorptive capacity (e.g. institutional quality) in LACs. Hence, we test whether the expected positive association between FDI and per-capita income has held in LACs since the mid-1990s.

2.3. The relation between peripheral features and inequality

We consider the peripherality effects on income inequality. First, structuralists generally regard the highly concentrated ownership of natural resources as a fundamental reason for uneven income distribution and elite concentration in LACs (Fajnzylber, 1990). Thus, they consider that rising commodity terms-of-trade will increase income inequality by increasing rents from natural resources (Sánchez-Ancochea, 2019). Moreover, rising terms-of-trade will worsen income inequality by preventing efforts for technological progress and structural changes (Cimoli & Rovira, 2008). However, empirical studies including Cornia (2010), Gasparini et al. (2011), and Székely and Mendoza (2017) found that an improvement in terms-of-trade was associated with decreasing inequality in recent LACs. Sánchez-Ancochea (2019) argued that the governments' improving ability to redistribute the windfall profits from the commodity boom through public social spending and taxes can explain the unexpected association.

In contrast, neo-structuralists emphasise the regressive distributional effects of economic volatility because of its asymmetric effects across different income groups (Ffrench-Davis, 2016; Ocampo, 1998). Theoretical and empirical studies also support the adverse effects of economic volatility on income inequality. Theoretically, extending the seminal work of Galor and Zeira (1993), Checchi and García-Peñalosa (2004) showed that since a more volatile economy requires higher non-labour income to invest in human capital, it induces more unequal human capital distribution, thereby increasing income inequality. Some empirical studies based on cross-country or panel data analysis find that higher economic volatility, including commodity price volatility, is indeed associated with increasing income inequality (Woo, 2011) or worsening social welfare indicators (Makhlouf, et al., 2017) in developing countries. Although Hausmann and Gavin (1996) found the regressive distributional effects in LACs from 1975 to 1989, they do not analyse LACs since the mid-1990s.

Second, according to the neo-structuralist perspective, structural changes from specialisation based on natural resources or cheap labour to a diversified, knowledge-intensive production structure based on technological progress can reduce inequality by increasing labour productivity and workers' wages, and distributing rents more equitably (Cimoli and Rovira 2008; ECLAC, 1990). However, they admit that technological progress is likely to increase inequality, at least temporarily, because it takes some time for technological progress to encompass low-productivity sectors in LACs, which have significant structural heterogeneity between high and low productivity sectors and scarce linkages between them (ECLAC, 1990; Ocampo 2001). The recent evolution of the relation between technological progress and inequality is in line with this prediction. Although skill-biased technological changes (SBTCs) were widely observed in LACs in the 1980s and 1990s, the SBTC effects faded in the 2000s; the observed income inequality decrease during this period is mostly attributable to decreased skill premiums (Gasparini et al., 2011). These findings support the argument that technological progress increases (decreases) short-term (long-term) income inequality.

Additionally, according to the neo-structuralist perspective including Di Filippo (1998), the development of production linkages with multinational enterprises (MNEs) can be expected to contribute to the mentioned reduction in inequality in LACs. Especially, such linkages are expected to provide local firms, including small and medium enterprises, with unprecedented opportunities to access new technologies and foreign markets, thereby leading to sustained increases in productivity and wages (ECLAC, 2014). Nevertheless, traditional structuralists, especially dependency theorists, argued that since MNEs were involved in capital intensive activities in peripheral countries, FDI would increase inequality between the limited number of highly paid skilled workers and the large number of marginalised unskilled workers (Bornschier & Chase-Dunn, 1985). This argument is well developed by the model of Feenstra and Hanson (1997), which predicts that since MNEs tend to locate in relatively skill-intensive sectors in LACs, their activities tend to cause a relative expansion of those sectors, thereby increasing inequality. Moreover, if the productivity improvements through spillover effects from foreign to local firms, which usually occur through demonstration, labour turnover, and vertical linkages, are associated with the introduction of skill-biased technologies, they are likely to further increase inequality (Berman & Machin, 2000). Indeed, recent empirical studies based on cross-country panel data analyses (e.g. Herzer et al., 2014; Suanes, 2016) found that FDI was positively associated with Gini coefficients in LACs. Interestingly, Wu and Hsu (2012) found that FDI was associated with increasing inequality, especially in countries with less absorptive capacities. These findings indicate that the expected distributional effects are not automatically guaranteed. Hence, we test the distributional effects of FDI in recent LACs, considering the role of absorptive capacity.

2.4. Summary

According to the triangular relation, a decrease (increase) in peripheral features, including increased terms-of-trade volatility and technological backwardness, is expected to increase (decrease) per-capita income both directly and indirectly by reducing (increasing) income inequality (see Figure 1). Since adverse external shocks are associated with increasing peripheral features, LACs exhibit a stronger negative effect on per-capita income in bust periods. Consequently, this increase in the effect of external shocks on per-capita income within the triangular relation might reveal the puzzling vulnerability of LACs.

3. An empirical analysis of the triangular relation in LACs

3.1. Empirical specification

This section describes our empirical assessment of the triangular relation amongst peripherality, inequality, and per-capita income, using panel data of 14 LACs from 1995 to 2014, for which data on both sectoral FDI and number of patent applications is available. The 14 countries are Argentina, Brazil, Chile, Colombia, Ecuador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, and Venezuela. This period is chosen not only because it covers the recent transition from bust to boom but also because data obtained before 1995 are not necessarily reliable because of hyperinflation and currency fluctuations.[2] As discussed in Section 2, the model assumes that per-capita income and income inequality are determined simultaneously, and are affected by the peripheral features.

In equation (1), following the specification for estimating the per-capita production function, log per-capita real GDP (*y*) is determined by log per-capita real capital stock (*k*), variables indicating the peripheral features, and controls. Next, in equation (2), income inequality measured by the Gini coefficient of household per-capita income (*Gini*) is determined by a linear and a quadratic term of per-capita income, variables indicating the peripheral features, and controls.

Regarding the controls, we include inflation rate (annual change of consumer price index, *inflation*) and trade openness (share of sum of exports and imports of goods to GDP, *trade*) in equation (1), and additionally include share of social expenditure (sum of education, health, social security, and housing expenditure, *social*) in equation (2), as we assume that it does not directly affect the dependent variable in equation (1).[3]

We use the following variables as measures of the peripheral features. First, we assess the effects of primary commodity dependence by log commodity terms-of-trade (*CTOT*) and their volatility (*CTOTV*). Following Spatafora and Tytell (2009), we define the terms-of-trade as the ratio of commodity export prices to commodity import prices, with each price weighted by the share of the relevant commodity in the country's total trade. Following Blattman et al. (2007), we measure the volatility by the 12-month standard deviation of departures from a Hodrick-Prescott filter trend of monthly *CTOT*.[4] Second, we assess the domestic technological capabilities by the number of patent applications per thousand population including residents and non-residents (*Patent*), while we assess the foreign sources of technology by the share of net FDI inflows in GDP (*FDI*), share of intermediate goods (sum of parts and components, i.e. Broad Economic Categories codes 42 and 53) exports in all exports (*Intermediate_X*), and share of intermediate goods imports in all imports (*intermediate_M*). Alternatively, we use the share of FDI net inflows in manufacturing sectors (*FDI_m*) instead of the aggregated total FDI because the knowledge spillover from FDI usually occurs in manufacturing sectors based on the literature. Additionally, we include interaction terms between the number of patent applications and each of the measures of foreign sources of technology in equations (1) and (2).[5] The interaction terms in equation (1) are expected to enhance the positive effects of foreign sources of technology on per-capita income because the absorptive capacity including the host country's technological capabilities would enhance the positive spillovers (Borensztein et al., 1998; Prüfer & Tondl, 2008). The interaction terms in equation (2) are also expected to enhance the decreasing effects on income inequality because the positive productivity effects are more likely to overflow to other firms or sectors if they have higher absorptive capacity (Wu & Hsu, 2012). Therefore, the simultaneous equations are as follows:

$$\begin{aligned} y_{it} &= \beta_0 + \beta_1 k_{it} + \beta_2 Gini_{it} + \beta_3 CTOT_{it} + \beta_4 CTOTV_{it} + \beta_5 Patent_{it} + \beta_6 FDI_{it} \\ &+ \beta_7 Intermediate\_X_{it} + \beta_8 Intermediate\_M_{it} + \beta_9 Patent_{it} * FDI_{it} \\ &+ \beta_{10} Patent_{it} * Intermediate\_X_{it} + \mathbf{X}'_{it}\beta_{11} + \alpha_{1i} + e_{1it} \end{aligned} \tag{1}$$

$$\begin{aligned} Gini_{it} &= \gamma_0 + \gamma_1 y_{it} + \gamma_2 y_{it}^2 + \gamma_3 CTOT_{it} + \gamma_4 CTOTV_{it} + \gamma_5 Patent_{it} + \gamma_6 FDI_{it} \\ &+ \gamma_7 Intermediate\_X_{it} + \gamma_8 Intermediate\_M_{it} + \gamma_9 Patent_{it} * FDI_{it} \\ &+ \gamma_{10} Patent_{it} * Intermediate\_X_{it} + \mathbf{X}'_{it}\gamma_{11} + \mathbf{Z}'_{it}\gamma_{12} + \alpha_{2i} + e_{2it} \end{aligned} \tag{2}$$

where *i* and *t* respectively denote country and time; *X* is a vector of control variables that would affect both per-capita income and income inequality (comprising *inflation* and *trade*); *Z* is a vector of control variables that would affect only income inequality (comprising *social* and dummies indicating sample characteristics explained in subsection 3-2); α represents the unobservable time-invariant country characteristics; and e is the error term.

Since the per-capita income and Gini coefficient are simultaneously determined in equations (1) and (2), estimation methods that assume that the error terms are orthogonal to each other lead to biased estimates. This simultaneity bias can be corrected by applying equation-by-equation two-stage least squares (2SLS). However, the error terms of these equations are likely to be contemporaneously correlated because unobservable factors that affect the error term in one equation likely also affect that in the other. Given this possibility, we obtain inefficient estimates if we ignore this correlation and estimate the simultaneous equations by 2SLS. Thus, we use the three-stage least squares (3SLS), which estimates all equations estimated by 2SLS simultaneously with generalised least squares and yields more efficient estimates than 2SLS (Zellner & Theil, 1962). Since equation (2) includes a nonlinear endogenous variable (the quadratic term of log per-capita GDP, y^2), following Wooldridge (2002), we use a quadratic term of log per-capita capital stock k^2 as the additional instrument for y^2.

Based on the neo-structuralist perspective, Table 2 presents the coefficients of the main explanatory variables. As discussed in Section 2, we expect that increasing income inequality, deteriorating commodity terms-of-trade, and their higher volatility decrease per-capita GDP, while technological progress increases it. We also expect that per-capita GDP decreases the Gini coefficient up to a threshold level. Improving commodity terms-of-trade and their higher volatility increase the Gini coefficient, while technological progress decreases it.

[Insert Tables 1 and 2]

3.2. Data and descriptive statistics

Table 1 reports the data sources. Since no single data source provides complete balanced panel data for the Gini coefficient of household per-capita income and sectoral FDI inflows in LACs (Blanco et al., 2019; Suanes, 2016), we source the two variables from several different sources to construct a panel dataset with minimum missing observations (see Tables A1-A2 in Supplemental File). Moreover, to control potential time-invariant effects arising from different sample characteristics, we include dummy variables indicating the geographical coverage (urban areas only versus whole country) and the data source of Gini coefficients in equation (2).

Following Blanco et al. (2019), the remaining missing observations of the Gini coefficient, share of FDI inflows in manufacturing sectors, and number of patent applications are filled in by linear interpolation; this accounts for 15% of all observations, which is acceptable. Table 3 reports the descriptive statistics. To test the robustness of the results, we estimate the simultaneous equations by 1) only using observations that are not interpolated; 2) including interpolated observations of the Gini coefficient and number of patent applications; and 3) including interpolated observations of the three variables and using the share of FDI inflows in manufacturing sectors instead of total FDI.

[Insert Table 3]

4. Results

4.1. Estimation results

Table 4 presents the estimation results of the simultaneous equations. Although we estimated them by pooled, random effects, and fixed effects 3SLS, the equation-by-equation F tests and the Hausman specification test strongly justify the use of fixed effects model in all specifications estimated in this section. Thus, in Tables 4–6, we present the estimation results by fixed effects (FE) 3SLS only. Note that regarding the negative value of the Hausman test statistic, following Schreiber (2008), we use its absolute value to reject the random effects model.

Regarding equation (1), expectedly, the Gini coefficient has a significant negative effect, while the number of patent applications, share of intermediate goods exports, and share of FDI have significant positive effects, with the latter's effect being larger in manufacturing sectors, thereby supporting the arguments in Section 2. However, the commodity terms-of-trade are expectedly positive but weakly significant. Unexpectedly, their volatility has positive effects, and the interaction terms have negative effects, though they are mostly insignificant. The log per-capita capital stock is positively significant, as expected. The control variables (i.e. inflation ratio and trade openness) are mostly insignificant.

Regarding equation (2), the linear term of the log per-capita GDP is significant and negative, whereas its quadratic term is positive, showing a U-shaped relation between log per-capita GDP and Gini coefficient, thereby contradicting earlier studies (e.g. Bengoa & Sanchez-Robles, 2005; Morley, 2000). Moreover, the Gini coefficient is a decreasing function of per-capita GDP over our analysis period. Therefore, a decrease in inequality and an increase in per-capita income are interactive and reinforcing in LACs, as argued in subsection 2-1. Furthermore, the effect is economically important; according to the estimates from the first specification in Table 4, while the Gini coefficient explains 5.3% of the total variance in the log per-capita GDP, the log per-capita GDP and its quadratic term explain 52.2% of the total variance in the Gini coefficient, which makes the largest contribution.[6] The commodity terms-of-trade have significantly decreasing effects, supporting the recent empirical findings mentioned in subsection 2-3, whereas their volatility is insignificant. The technological progress measures, especially FDI in manufacturing sectors, have significantly increasing effects, contradicting some neo-structuralist arguments, but supporting theoretical and empirical FDI studies mentioned in subsection 2-3. However, expectedly, the interaction terms have decreasing effects on the Gini coefficient, supporting Wu and Hsu (2012) and indicating the importance of absorptive capacity in receiving positive spillovers from foreign technology. Nevertheless, the estimates from the first specification in Table 4 indicate that the number of patent applications in LACs is much smaller than the threshold level necessary to surpass the observed increasing effect of FDI (0.192). None of the average values of the 14 LACs exceeds this threshold. Expectedly, the share of social expenditure is negatively significant. Together with the finding on the effects of commodity terms-of-trade, progressive social policies financed by revenues from commodity exports contributed to decreasing inequality, supporting Sánchez-Ancochea (2019). The control variables are insignificant; the insignificance of trade openness indicates that commodity terms-of-trade rather than trade openness is the primary determinant of the change in labour demand resulting from the region's integration into the global economy.

The mentioned results are robust to the inclusion of interpolated observations and the use of different FDI measures. Therefore, the findings indicate that although technological progress increases per-capita income directly, it partly mitigates the increase indirectly by increasing income inequality. Using the average values, the estimates in Table 4 demonstrate that the direct positive effects dominate the indirect negative effects on per-capita income except for the share of intermediate goods exports in the first specification.[7] However, the indirect effects are economically important;

according to the estimates from the first specification, although a 1% increase in the share of FDI leads to a 1.48% increase in the log GDP capita directly, it leads to 0.47% decrease indirectly.

[Insert Table 4]

4.2. Robustness checks

To test the robustness of our results, we perform two additional exercises. First, we estimate the equations using different country groups, considering economic and political heterogeneities across the region. The insignificance of commodity-related variables may be due to the inclusion of Mexico and some Central American countries, which are integrated into manufacturing value chains and have low levels of commodity dependence. Thus, following Székely and Mendoza (2017), we concentrate our analysis on South American countries excluding Guatemala, Honduras, Mexico, Nicaragua, and Panama. Additionally, we exclude Nicaragua and Venezuela from the original 14 countries, considering recent differences in their political regimes.

Table 5 reports the estimation results for the two different groups. Note that these estimations include the interpolated observations and use the share of FDI inflows in manufacturing sectors. We find that the baseline results remain unchanged: decreasing inequality and increasing per-capita income are mutually reinforcing; technological progress increases per-capita income and income inequality; and higher technological capabilities mitigate the increasing effects on inequality derived from foreign sources of technology. As expected, in South American countries, an improvement in commodity terms-of-trade not only decreases income inequality, but also increases per-capita income with substantially larger effects than in other countries. Thus, they receive stronger positive effects on per-capita income not only directly, by improved commodity terms-of-trade, but also indirectly, by reduced income inequality in the boom period and vice versa in the bust period, thereby explaining the puzzling vulnerability. In contrast, their volatility remains insignificant.

Second, following Suanes (2016), we estimate the simultaneous equations using triennial data (i.e. 36-month standard deviation of the departures from the trend of monthly *CTOT* and three-year average including interpolated observations for other variables) for the period from 1995 to 2012. The use of triennial data allows us to analyse longer-term relations between the variables, eliminating the impacts of short-term fluctuations. Table 6 reports the estimation results. Again, the baseline results remain unchanged; we confirm the mutually reinforcing relation between lower income inequality and higher per-capita income, the increasing effects of technological progress on per-capita income and inequality, and the insignificance of commodity terms-of-trade volatility.

[Insert Tables 5–6]

5. Conclusion

Although LACs present some desirable features for economic development, they are highly vulnerable to global economic changes. To explore their puzzling vulnerability, we revisited the neo-structuralist idea and presented the region's development puzzle concept as a triangular relation amongst peripherality, income inequality, and per-capita income, testing it on 14 LACs during 1995–2014. The empirical findings are summarised below.

First, decreasing income inequality and increasing per-capita income were found to be mutually reinforcing in LACs. Therefore, the reduction of income inequality promoted an increase in per-capita income, which in turn contributed to decreasing income inequality, thereby supporting the neo-structuralist arguments. This finding provides new evidence related to the growth and inequality in LACs and forms this study's novel contribution to the literature.

Second, technological progress increased per-capita income and income inequality. These findings indicate that technological progress partly mitigated the increase in per-capita income indirectly by increasing income inequality. Moreover, the increasing effects of foreign sources of technology including FDI on income inequality were mitigated in countries with higher technological capabilities, thereby requiring policies that promote both of them simultaneously.

Third, expectedly, improved commodity terms-of-trade increased per-capita income and decreased income inequality in South America countries. Therefore, their per-capita incomes benefited from the stronger positive effects directly through improved commodity terms-of-trade and indirectly through reduced income inequality in the boom period and vice versa in the bust period, thereby revealing the puzzling vulnerability through this triangular relation. In contrast, the effect of commodity terms-of-trade volatility was insignificant; this may indicate the fact that the vigorous counter-cyclical policies implemented by most of the region's governments would mitigate or offset the negative impacts of economic volatility, especially after the 2008 financial crisis. The fiscal consolidation efforts in prior periods prepared the space for the counter-cyclical actions (ECLAC, 2012). Flexible exchange rate regimes adopted in prior periods may also mitigate adverse external shocks. The findings are robust to the inclusion of interpolated observations and the use of different measures of FDI, different country groups, and triennial data.

The observed positive association between the foreign sources of technology and income inequality, which causes unexpected negative effects on per-capita income by increasing inequality, demands further analysis. One possible explanation is that international production linkages might not have generated sufficient unskilled labour demand because of lack of scale attributable to bottlenecks, such as insufficient infrastructure and market segmentation. If so, it would be crucial to adopt a policy for the additional promotion of regional integration within LACs. Although this issue is beyond the scope of this study, it represents an intriguing subject for future research.

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Disclosure statement

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Notes

1. More specifically, traditional structuralists defined the "peripheral status" as specialization in primary commodities, while neo-structuralists associate it with the lack of genuine competitiveness stemming from technological progress, human capital skill development, and social equity (Bielschowsky, 2009). Thus, for neo-structuralists, the distinction between primary commodities and industrial products has lost economic significance (Di Filippo, 1998; Hounie et al., 1999). Furthermore, neo-structuralists consider that the lack of genuine competitiveness leads to external vulnerability through balance-of-payments predominance (Ocampo, 2011).

2. None of the 14 LACs reported the three-digit inflation rate during 1995–2014.

3. The reason is as follows. Since there are several channels through which government expenditure affects economic growth, both positively (e.g. by enhancing human capital) and negatively (e.g. through distortionary taxes), the overall effect can be insignificant, as indicated by Churchill et al. (2017) who found that the effect was indeed insignificant in developing countries. Regarding LACs in recent times, although there have been extensive studies showing that cash transfer programs, the mainstay of social policy in this period, improved education outcomes and reduced inequality and extreme poverty (e.g. Soares et al., 2010), to the best of our knowledge, there is no convincing empirical research on the effects on economic growth. This may be due to the time-lag that exists before the impacts are realised and the fact that the demand expansion of cash transfer is localised and irrelevant at the national level, given the geographical concentration of poor households eligible for such programs. Moreover, since our dependent variable is the level rather than growth of per-capita income, it is more likely that the share of social expenditure, which indicates a degree of income transfers among different income groups, will not affect the average per-capita income level in a given country. Indeed, the share of social expenditure

is insignificant with respect to per-capita income in all specifications estimated in Section 4 (see Supplemental File).

4. Alternatively, we measure it by the 12-month standard deviation of monthly *CTOT*. However, the measure generates remarkably similar results (see Supplemental file).

5. The interaction with the share of intermediate goods imports is not included because the variable is mostly insignificant in both equations.

6. The sum of the product of each variable's standardised coefficient and its correlation with the dependent variable is equal to the overall R-squared. For more details, see Pratt (1987).

7. Indirect effects can be calculated by multiplying the Gini coefficient from equation (1) with the coefficient of the variable in question from equation (2).

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Table 1. Variable definitions and data sources

Variable	Data Source
y	Statistical Yearbook for Latin America and the Caribbean of Economic Commission for Latin America and the Caribbean (ECLAC)
k	Penn World Table ver. 9.0
Gini	See Table A-1 in Supplemental File
CTOT	International Monetary Fund (IMF) data
CTOTV	IMF data
Patent	World Intellectual Property Organization (WIPO) Statistics Database
FDI	Statistical Yearbook for Latin America and the Caribbean of ECLAC
FDI_m	See Table A-2 in Supplemental File
Intermediate_X	United Nations (UN) Comtrade Database
Intermediate_M	UN Comtrade Database
Inflation	Statistical Yearbook for Latin America and the Caribbean of ECLAC
Trade	Statistical Yearbook for Latin America and the Caribbean of ECLAC
Social	CEPALSTAT of ECLAC

Table 2. Expected signs of explanatory variables

	Equation (1)	Equation (2)
k	+	
Gini	–	
y		–
y^2		+
CTOT	+	+
CTOTV	–	+
Patent	+	–
FDI	+	–
Intermediate_X	+	–
Intermediate_M	+	–

Note: + (–) denotes that the explanatory variable has a positive (negative) effect on the dependent variable.

Table 3. Descriptive statistics

Variable	Observations	Mean	Standard deviation	Min	Max
y	280	8.543	0.660	7.018	9.578
k	280	10.364	0.580	9.350	11.477
Gini	232	0.509	0.049	0.378	0.595
Gini[a]	280	0.511	0.047	0.378	0.595
CTOT	280	4.512	0.329	3.134	5.260
CTOTV	280	0.042	0.033	0.009	0.294
Patent	230	0.084	0.060	0.001	0.237
Patent[a]	280	0.078	0.058	0.001	0.237
FDI	279	0.030	0.023	-0.011	0.141
FDI_m	241	0.008	0.007	-0.009	0.035
FDI_m[a]	280	0.007	0.009	-0.021	0.037
Intermediate_X	276	0.023	0.034	0.000	0.139
Intermediate_M	277	0.079	0.046	0.029	0.226
Inflation	280	0.102	0.127	-0.012	0.999
Trade	279	0.536	0.285	0.120	1.334
Social	277	0.110	0.047	0.025	0.263

Note: [a] indicates that the observations are linear interpolated.

Table 4. Estimation results of equations (1) and (2)

Estimation technique	FE 3SLS		FE 3SLS		FE 3SLS	
	(1)	(2)	(1)	(2)	(1)	(2)
	y	*Gini*	*y*	*Gini*	*y*	*Gini*
k	0.567 ***		0.732 ***		0.750 ***	
	(0.071)		(0.035)		(0.034)	
Gini	-1.795 ***		-0.501 **		-0.479 **	
	(0.573)		(0.201)		(0.191)	
y		-0.279 ***		-0.318 ***		-0.239 ***
		(0.080)		(0.082)		(0.083)
y^2		0.008 *		0.011 **		0.007
		(0.005)		(0.005)		(0.005)
CTOT	0.026	-0.021 ***	0.029 *	-0.013 **	0.030 *	-0.012 **
	(0.031)	(0.007)	(0.017)	(0.006)	(0.017)	(0.006)
CTOTV	0.138	-0.002	0.141	-0.053	0.198 *	-0.039
	(0.140)	(0.036)	(0.116)	(0.038)	(0.116)	(0.039)
Patent	1.471 ***	0.513 ***	0.626 **	0.379 ***	0.710 ***	0.367 ***
	(0.389)	(0.081)	(0.265)	(0.087)	(0.217)	(0.070)
FDI	2.100 ***	0.496 ***	1.193 ***	0.345 ***		
	(0.584)	(0.155)	(0.362)	(0.124)		
FDI_m					2.217 ***	0.924 ***
					(0.765)	(0.251)
Intermediate_X	2.086 **	1.086 ***	0.849	0.793 ***	1.082 *	0.764 ***
	(1.004)	(0.195)	(0.610)	(0.197)	(0.603)	(0.197)
Intermediate_M	-0.457	-0.099	-0.626 **	0.029	-0.588 *	0.084
	(0.382)	(0.099)	(0.301)	(0.102)	(0.302)	(0.101)
*Patent * FDI*	-6.858	-2.578 **	-1.611	-1.679		
	(4.297)	(1.133)	(3.304)	(1.152)		
*Patent * FDI_m*					-1.264	-6.406 **
					(9.594)	(3.248)
*Patent * Intermediate_X*	-14.97 **	-5.486 ***	-5.234	-3.575 **	-5.673	-3.282 **
	(6.730)	(1.574)	(4.553)	(1.502)	(4.541)	(1.504)
Inflation	0.034	0.007	0.029	-0.001	0.031	0.001
	(0.041)	(0.011)	(0.035)	(0.013)	(0.035)	(0.013)
Trade	0.006	0.013	0.072 *	-0.010	0.063	-0.021
	(0.058)	(0.015)	(0.039)	(0.013)	(0.040)	(0.014)
Social		-0.178 **		-0.383 ***		-0.384 ***
		(0.071)		(0.074)		(0.074)
Cons	3.560 ***	2.369 ***	1.270 ***	2.494 ***	1.050 **	2.105 ***
	(1.042)	(0.347)	(0.441)	(0.366)	(0.424)	(0.368)
Linear interpolation	No		Yes		Yes	
Number of obs.	190	190	274	274	274	274
Number of countries	14	14	14	14	14	14
R-squared	0.992	0.913	0.993	0.866	0.993	0.868
F test	157.0 ***	96.91 ***	280.3 ***	86.29 ***	256.8 ***	103.2 ***
Hausman test	-283.5		330.6 ***		-1124	

Note: Numbers in parentheses represent standard errors. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. Dummy variables indicating sample characteristics of the Gini coefficients are included in all specifications of equation (2).

Table 5. Estimation results of equations (1) and (2) using different country groups

Country groups	South America		12 LACs	
Estimation technique	FE 3SLS		FE 3SLS	
	(1)	(2)	(1)	(2)
	y	*Gini*	*y*	*Gini*
k	0.854 ***		0.765 ***	
	(0.034)		(0.037)	
Gini	-0.115 ***		-0.409 *	
	(0.044)		(0.227)	
y		-0.204		-0.355 ***
		(0.217)		(0.070)
y^2		0.005		0.014 ***
		(0.012)		(0.004)
CTOT	0.095 ***	-0.021 ***	0.013	-0.029 ***
	(0.025)	(0.008)	(0.021)	(0.006)
CTOTV	0.138	-0.015	0.165	0.010
	(0.142)	(0.038)	(0.148)	(0.045)
Patent	0.278	0.340 ***	0.678 ***	0.347 ***
	(0.270)	(0.074)	(0.221)	(0.064)
FDI_m	0.961	0.987 ***	1.704 **	1.095 ***
	(0.967)	(0.275)	(0.807)	(0.234)
Intermediate X	-1.570 *	0.651 **	1.201 *	0.754 ***
	(0.922)	(0.286)	(0.611)	(0.181)
Intermediate M	-0.432	-0.105	-0.418	-0.027
	(0.400)	(0.112)	(0.308)	(0.094)
*Patent * FDI_m*	19.61	-10.12 ***	9.971	-7.682 **
	(12.15)	(3.49)	(10.036)	(3.015)
*Patent * Intermediate X*	6.977	-1.929	-5.785	-2.613 *
	(7.974)	(2.166)	(4.599)	(1.382)
Inflation	0.040	0.012	0.031	0.019
	(0.039)	(0.012)	(0.042)	(0.013)
Trade	-0.122	0.014	-0.009	0.026 *
	(0.076)	(0.022)	(0.046)	(0.014)
Social		-0.370 ***		-0.327 ***
		(0.080)		(0.077)
Cons	-0.421	2.074 ***	0.916 *	2.669 ***
	(0.376)	(0.961)	(0.489)	(0.304)
Linear interpolation	Yes		Yes	
Number of obs.	176	176	236	236
Number of countries	9	9	12	12
R-squared	0.986	0.918	0.992	0.875
F test	98.40 ***	266.6 ***	145.6 ***	81.50 ***
Hausman test	7261 ***		454.3 ***	

Note: Numbers in parentheses represent standard errors. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. Dummy variables indicating sample characteristics of the Gini coefficients are included in equation (2).

Table 6. Estimation results of equations (1) and (2) using triennial data

Estimation technique	FE 3SLS	
	y	*Gini*
k	0.691 ***	
	(0.057)	
Gini	-0.702 **	
	(0.307)	
y		0.357
		(0.267)
y^2		-0.026 *
		(0.015)
CTOT	0.069 **	-0.008
	(0.027)	(0.011)
CTOTV	0.262	-0.053
	(0.174)	(0.066)
Patent	0.834 *	0.469 ***
	(0.454)	(0.166)
FDI_m	2.918 **	1.378 ***
	(1.354)	(0.506)
Intermediate_X	2.181 **	0.470
	(1.005)	(0.409)
Intermediate_M	-0.767	0.266
	(0.503)	(0.197)
*Patent * FDI_m*	12.04	-17.52 **
	(19.06)	(7.834)
*Patent * Intermediate_X*	-4.840	-3.795
	(7.90)	(3.000)
Inflation	0.108 *	0.006
	(0.063)	(0.028)
Trade	0.056	-0.077 ***
	(0.069)	(0.026)
Social		-0.448 ***
		(0.152)
Cons	1.550 **	-0.597
	(0.692)	(1.184)
Linear interpolation	Yes	
Number of obs.	84	84
Number of countries	14	14
R-squared	0.996	0.896
F test	89.56 ***	33.99 ***
Hausman test	912.4 ***	

Note: Numbers in parentheses represent standard errors. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. Dummy variables indicating sample characteristics of the Gini coefficients are included in equation (2).

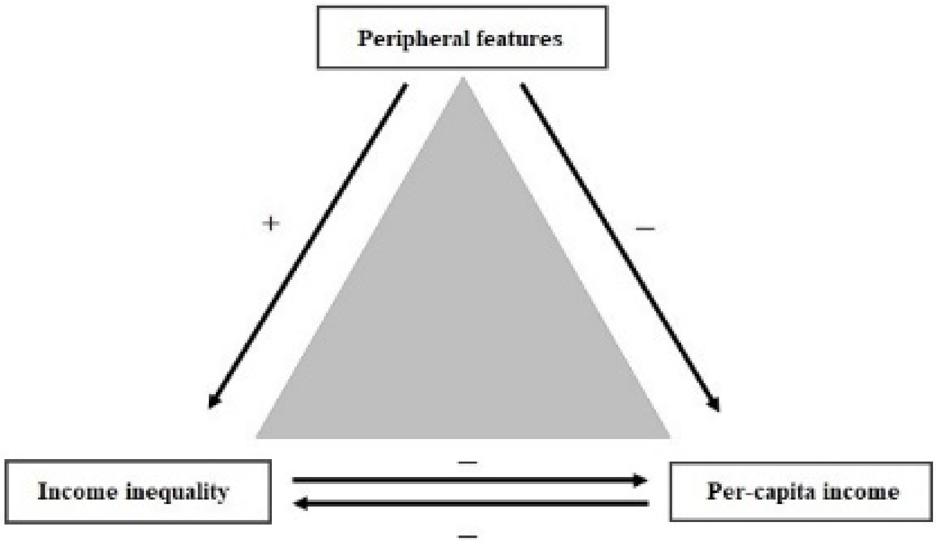

Figure 1.

Figure Captions

Figure 1. Triangular relations amongst peripherality, income inequality, and per-capita income.

Source: Authors' elaboration.

Note: Arrows indicate that the variable in question affects the other variable in the particular direction indicated. + (–) denotes that the variable has a positive (negative) effect.