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Reexamining the Link between Instability and Growth in Latin America: A Dynamic Panel Data Estimation using K-Median Clusters*

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We estimate a dynamic panel data model to assess the relationship between different levels of instability—proxied by growth volatility and inflation—and growth in Latin America from 1960 to 2011. Outlying observations could be mistakenly treated as thresholds or regime switch. Hence we use k-median clustering to mitigate the outlier problem and properly identify "scenarios" of instability. Our key findings are that while high inflation is harmful, low inflation is in fact positively related to growth. Volatility is also found to be significant and negative, but with no differential effect—between low and high levels—on growth.

JEL classification: F43, O41, C33

Keywords: instability, growth, Latin America, clustering

1. Introduction

In recent years the detrimental effects of instability on long-term economic growth have increasingly come into focus in the literature. These effects are particularly robust when tested for a sample of emerging economies, where fluctuations in key economic variables are more frequent and intense, with negative and long-term effects on economic growth. In this regard, one crucial aspect is to identify those indicators that accurately capture the kind of instability that characterizes a particular region.

In general, empirical contributions associate instability with the volatility of certain key macroeconomic variables. In a seminal paper, Ramey and Ramey (1995) found a strong empirical negative link between GDP growth rate and the standard deviation to its mean as

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a measure of volatility. More recent empirical literature has developed along the same lines with ambiguous results. Using the same instability proxy, Martin and Rogers (2000) showed that countries and regions with higher standard deviations of growth and unemployment have lower growth rates, but this negative relationship does not hold for non-industrialized countries. In a cross-country study, Hnatkovska and Loayza (2005) found a negative relationship between output growth rate volatility and long-run economic growth. This is particularly clear in countries that are developing, are institutionally underdeveloped, are experiencing the intermediate stages of financial development, or are unable to implement counter-cyclical fiscal policies. They also found that the negative effect of volatility on growth has become considerably larger in the past two decades, and that this is mostly due to deep recessions ("crisis volatility") rather than minor cyclical fluctuations ("normal volatility").

Other empirical contributions highlight statistical issues, compositional effects or a non-linear relationship between instability and growth. For example, Kneller and Young (2001) found that the sign of the estimated coefficient reverses depending on whether volatility is measured over longer or shorter periods. In turn, Tochkov and Tochkov (2009) pointed out that the ambiguous results they found could stem from common shocks across regions that have a different impact on the growth-volatility relationship in different countries. Kose *et al.* (2008, 2006) showed that this relationship has been changing over time and across different country groups in response to increased trade and financial flows. In particular, the evidence suggests that the nature of this relationship differs even among developing countries, depending on their level of integration into the global economy.

Although not as extensively as the GDP-associated volatility measure, inflation has also been used as a proxy for macroeconomic instability[1]. A negative link between inflation and growth was assessed in Kormendi and Meguire (1985), Barro (1991), Fischer (1993), Bruno and Easterly (1998), Sarel (1995) and Ghosh and Phillips (1998). Not surprisingly, Dabús (2000) and Dabús *et al.* (2012) found that in Latin America inflation is essentially harmful to economic performance in the presence

1. Another measure of instability widely used in the literature is the volatility of government expenditure. Two examples are Afonso and Furceri (2010) and Fatás and Mihov (2013), who showed that the volatility of fiscal policy reduces long-term economic growth. Ocampo (2008) emphasized that the different forms of macroeconomic instabilities are not correlated, so both the broad definition and the trade-offs involved deserve more attention.

of high and hyper-inflation. These results are in line with those found by Loayza *et al.* (2003) and Bittencourt (2012).

In turn, Khan and Senhadji (2001) carried out panel data estimations and found a significant and negative effect of inflation only above a certain a "threshold" inflation value, which is higher for developing countries. Also, Judson and Orphanides (1999) found a significant negative inflation-growth effect for a large panel, but only for inflation rates higher than 10%. Using a panel smooth transition model, Ibarra and Trupkin (2011) estimated an inflation-rate threshold for industrialized countries of 4.1%, while for non-industrialized countries the threshold was 19.1%. Similarly, Kremer *et al.* (2013) estimated that inflation rates exceeding 17% are associated with lower economic growth for non-industrialized countries, while below this threshold the correlation is not significant.

Notwithstanding the relevance of the results attained so far, there is still little evidence about the link between instability and growth for Latin American economies, as most of the empirical work on developing economies focuses on Asian countries or uses a sample of emerging economies in general. Following Edwards (2004), the region has some idiosyncratic features that justify a separate analysis: It stands alone in both inflation rate and GDP growth rate volatility, which brings up differences with other developing regions. In fact, Latin America is on average two to three times more volatile than industrialized regions in terms of non-monetary quantities and has been more volatile than any other region of the world except Africa and the Middle East.

In this sense, our goal is to empirically assess the link between instability and growth in Latin America as well as the sign of that link. In particular, we are interested in analyzing whether low- and high-instability scenarios have a statistically different impact in terms of explaining the growth performance of the region. However, our dataset has several outliers, which means that any procedure used to identify regimes (in the Markov-switching sense) or thresholds (as in panel threshold models) will be distorted by the large variance of these observations.

In light of this issue, our contribution is to go beyond the traditional empirical estimation of a growth model á la Barro, by using pre-estimation clustering techniques to identify different instability scenarios that are not contaminated by the presence of aberrant observations.[2] One

2. We would like to emphasize that we use the term "scenarios," rather than "regimes" or "levels" to make the distinction from other procedures such as Markov switching processes or panel threshold models.

way of dealing with this is to use the k-median clustering algorithm. Its purpose is to partition the data into k-clusters that are less than or equal to the n observations, to minimize the within-cluster sum of squares for every k cluster created. Choosing an appropriate number of clusters allows us to group observations into different categories of low and high instability without considering extreme cases that could indicate a falsely significant relationship between instability and growth.

Our main findings are that the clustering techniques actually help capture the differential performance of economies in the low- and high-instability scenarios. After removing outliers from the sample, the regression outcomes are robust and show that while inflation has a significant and negative effect on economic growth only above an average triannual rate of 57%, our volatility proxy also has a negative and significant impact on growth, but without any differential effect among the various clustering techniques applied to the data.

The structure of the paper is as follows. Section 2 describes the data used and the empirical strategy followed; Section 3 reports our results and Section 4 offers some concluding remarks.

2. Empirical analysis

2.1 Data and summary statistics

We use a sample of 17 Latin American economies and 17 consecutive and non-overlapping three-year periods from 1960 to 2011. The countries in the sample are Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Honduras, Guatemala, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, and Venezuela.

Table 1 summarizes the information about the variables and Table 2 presents the descriptive statistics and Spearman correlations. Following Ramey and Ramey (1995), we begin by calculating the simple correlation of growth and instability. Table 3 shows the country-specific correlations between our variables of interest.

The average correlations between growth, volatility and inflation are small for the complete sample (see Table 2). However, country-specific correlations show high variability across countries. The correlations between economic growth with inflation and growth rate volatility are negative and considerably different from zero in approximately 50% of

Table 1. Variable descriptions and sources

Variable	Description	Source
Growth	Gross domestic product (GDP) per capita growth rate (based on constant 2000 U.S. dollars).	World Development Indicators, World Bank.
Growth volatility	Standard deviation of GDP per capita growth rate.	Authors' calculations based on World Development Indicators, World Bank.
Inflation	Inflation rate of consumer prices (%) in natural logs.	Authors' calculations based on World Development Indicators, World Bank.*
Investment	Gross fixed capital formation/GDP, in natural logs.	World Development Indicators, World Bank.
Merchandise trade	Merchandise trading/GDP, in natural logs.	World Development Indicators, World Bank.

Source: Authors' own elaboration based on World Bank information.
Note: * Inflation rate data for Argentina from 2007 onwards were taken from the web site www.inflacionverdadera.com.

Table 2. Descriptive statistics and correlations

Descriptive statistics	Growth	Growth volatility	Inflation	Investment	Merchandise trade
Mean	1.6277	2.7225	0.1254	1.2672	1.5542
Std. dev.	2.9922	2.2923	0.2642	0.0960	0.1728
Min.	-12.5023	0.1379	-0.0056	0.9884	1.0136
Max.	9.5214	15.2251	1.8800	1.5050	1.8730
Correlations	**Growth**	**Growth volatility**	**Inflation**	**Investment**	**Merchandise trade**
Growth	1				
Growth volatility	-0.2557	1			
Inflation	-0.2023	0.237	1		
Investment	0.0792	0.1613	0.1167	1	
Merchandise trade	-0.1765	0.0904	0.2884	0.1552	1

Source: Authors' calculations based on the data described in Table 1.

cases (see Table 3). Thus, until now the evidence has suggested a negative instability-economic growth association in Latin American countries.

Table 3. Country-specific correlations

Correlations	Growth/volatility	Growth/inflation	Volatility/inflation
Argentina	-0.0824	-0.5222	0.3830
Bolivia	-0.3593	-0.6127	-0.0204
Brazil	-0.0181	0.2010	-0.0883
Chile	-0.6345	-0.3724	0.5040
Colombia	-0.4143	-0.2170	0.0279
Costa Rica	-0.7278	-0.3752	0.0625
Ecuador	0.0050	-0.3794	0.2831
El Salvador	-0.5990	-0.2577	0.2511
Guatemala	0.1074	-0.1476	-0.0931
Honduras	-0.1188	-0.1191	0.2732
Mexico	-0.6340	-0.3410	0.2616
Nicaragua	-0.6860	-0.3353	0.5848
Panama	-0.4711	0.1343	0.0397
Paraguay	-0.1645	0.0799	-0.1683
Peru	-0.6310	-0.6985	0.6450
Uruguay	-0.4345	-0.0112	0.1891
Venezuela	-0.2915	-0.1455	0.1793

Source: Authors' calculations based on the data described in Table 1.

In the following subsection we control for extreme values of the explanatory variables of interest by grouping observations into different clusters and then estimating different models that incorporate a set of control variables and country- and time-specific effects.

2.2 Clustering

Aberrant observations in the panel data set could bias the estimation results, because classical estimators (such as OLS, GLS, 2SLS and GMM) have low breakdown points.[3] Moreover, they can also invalidate the results of non-linear estimations. Outliers may be mistakenly

3. The breakdown point of an estimator is defined as the highest fraction of outliers that an estimator can withstand; it is one of the most popular measures of robustness (Donoho and Huber, 1983; Rousseeuw and Leroy, 1987).

treated as another regime when in fact they are not, thus leading to spurious regression results.[4]

Nonetheless, no formal techniques have been developed so far to detect outliers in panel data frameworks. Therefore we follow the standard practice and use the trimmed mean as a rule of thumb. At first glance, the data indicate that the instability proxies have at least one outlying observation. Table 2 shows that the maximum or minimum values of the variables fall out of the range of the trimmed mean. Because of Latin America's history of instability, our data set could include more outliers, so we partition the inflation and GDP growth-rate volatility data into groups using the k-median clustering method (Jain and Dubes, 1981). This algorithm is a variation of k-means clustering (Hartigan, 1975) where instead of calculating the mean for each cluster to determine its centroid, it calculates the median—which is not affected by extreme values—to minimize error over all clusters with respect to the 1-norm distance metric, as opposed to the square of the 2-norm distance metric used by the k-means algorithm. If there are aberrant observations in the data, they should form groups by themselves. These clusters will not have enough observations and therefore will not be used in the panel data estimations.

The k-median algorithm can be written as:

$$argmin \sum_{i=1}^{k} \sum_{x_j \in S_i} \left\| x_j - \mu_i \right\| \tag{1}$$

where μ represents the median of each cluster. The inner sum represents the sum of squares of the difference between observation x in cluster s and the median of cluster s. The outer sum indicates that the sums of all clusters from i to k are totaled to get a single number that will be minimized.

The algorithm is composed of the following steps:

1) Place k points into the space represented by the objects that are being clustered. These points represent initial group centroids.

4. Knez and Ready (1997) find that the "size effect"—that is, that smaller companies perform better—detected by Fama and French (1988) disappears if outliers are removed from the sample. Similarly, Zhou *et al.* (2004) refute the work of Levine and Zervos (1998) by taking the outliers' effect into account. The authors find that stock market liquidity no longer has any statistically significant effect on GDP growth.

2) Assign each object to the group that has the closest centroid. In our work, we have chosen to work with the Euclidean distance.

3) When all objects have been assigned, recalculate the positions of the k centroids.

4) Repeat steps 2 and 3 until the centroids no longer move. This produces a separation of the objects into groups from which the metric to be minimized can be calculated.

Unfortunately, there is no general theoretical solution to determine the optimal number of clusters for any given data set. A simple approach is to compare the results of multiple runs with different k classes and choose the one that best fits a given criterion. In our case, we tested the number of clusters with the Calinski-Harabasz (1974) pseudo F-index (see appendix).

Figures 1 and 2 show the GDP per capita growth rate plotted against the resulting clusters of growth volatility and inflation. Each triannual observation is represented by one dot.

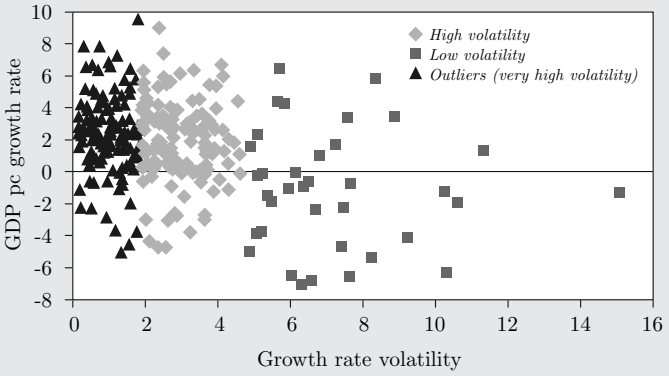
These figures reflect both of the uses we make of the cluster approach. From the distribution of the observations in the plot, it becomes quite clear that if we run a simple regression between GDP growth rate and the interest variable (volatility or inflation), a significant and negative relationship is likely to be found. However, as there are several outliers in the dataset, the result would be spurious since it would be driven by a few events. In this sense, the cluster approach is crucial to identifying aberrant observations.

The second issue is in regard to the remaining observations: If they can form distinct clusters (of low and high levels of the variables), these clusters may have a differential impact on economic growth.

Figure 1 does not clarify this matter, since the low and high volatility clusters look similar. However, there are indeed some differences between both groups: The high volatility cluster has three times the mean of the low volatility cluster, and also a wider range (see Table 10 with this descriptive statistics in the appendix).

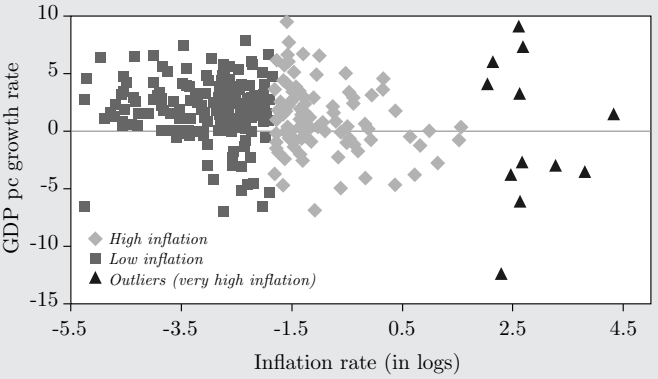
Figure 2 has fewer outliers and more distinct clusters of low and high inflation. At first glance, low inflation seems to be related to positive growth rates, while high inflation might be negatively related to growth.

Figure 1. Growth rate volatility and GDP per capita growth rate, by cluster



Source: Authors' calculations.

Figure 2. Inflation rate and GDP per capita growth rate, by cluster



Source: Authors' calculations.

2.3 Econometric methodology

Following Loayza *et al.* (2003), we estimate a dynamic endogenous growth specification of the form:

$$y_{i,t} - y_{i,t-1} = \alpha y_{i,t-1} + \beta X_{i,t} + \beta' Z_{i,t} + \eta_i + \lambda_t + \psi_{i,t} \quad (2)$$

where $y_{i,t}$ is the natural logarithm of output per capita for country i at time t (triannual averages), and $y_{i,t} - y_{i,t-1}$ is the growth rate of output per capita. $X_{i,t}$ and $Z_{i,t}$ are the vectors of explanatory variables.. The first one includes the instability measures, and the second one includes two control variables: gross investment as a share of GDP and the exports plus imports ratio to GDP[5]. The residual has three components: an unobserved country-specific effect, η_i; an unobserved time-specific effect, λ_t; and an independent and identically distributed error term, $\psi_{i,t}$.

A lagged dependent variable is included, which makes the regression become dynamic in nature. Consequently, we use the system GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998). This estimator combines the first-differenced GMM approach—which uses lagged independent variables as instruments in the levels equations to deal with possible endogeneity issues in the regressors—with the original equations in levels, thus increasing the efficiency of the estimators when the series are very persistent. Therefore, their lagged levels are only weakly correlated with subsequent first-differences (Blundell and Bond, 1998). The estimation of growth models using the system-GMM estimator for linear panel data was introduced by Levine *et al.* (2000) and has now become common practice in the literature (see Durlauf, *et al.*, 2005, and Beck, 2008).

5. These variables have been found to be robust in various estimations of economic growth for Latin American economies (Loayza *et al.*, 2003, Ramírez Rondán, 2007, Dabús *et al.* 2012). We do not include educational variables (captured by proxies such as school attendance, enrollment, and years of schooling, among others) because several studies have found that they are not significant for economic growth when testing a sample of emerging economies. In this regard, Loayza, Fajnzylberg and Calderón (2005) explain that the lack of significance of the educational variable in some of their specifications should serve as a caution about the pitfalls of educational measures as proxies for human capital. The same result is found in Dabús and Laumann (2006). The authors explain that it may be that in these countries, human capital accumulation is not effective in fostering growth because they lack the social and economic context to benefit from a more educated population.

We use a sample of 17 Latin American economies and 17 consecutive, non-overlapping three-year periods from 1960 to 2011. The proxies for economic instability, i.e., inflation rate and GDP growth rate volatility, are treated as exogenous variables.[6] The other explanatory variables can be affected by economic growth so they are treated as endogenous.

To avoid biased estimators resulting from "too many instruments," we follow Roodman's (2009) approach. This consists of limiting the lag depth to one or two instead of using all available lags for instruments. This strategy has been adopted by several researchers in the economic growth field (Levine, Loayza and Beck, 2000; Giedeman and Compton, 2009; Demir and Dahi, 2011). In addition, because the small panel sample size may produce a downward bias of the estimated asymptotic standard errors, we implement Windmeijer's correction procedure (Windmeijer, 2005).

5. Regression results

This section presents the estimations of Equation (2). In Table 4, which contains system-GMM estimates, column 1 shows the results of the estimation using the whole sample and columns 2 through 5 show the results of the estimation of the model when the instability proxies are grouped into two clusters of data, representing low and high levels of inflation and growth volatility, respectively.

To maintain a low number of instruments, we carry out the regressions by collapsing the corresponding variables. All the regressions pass the second-order serial correlation test. The null hypothesis that the error term is not serially correlated cannot be rejected. Most p-values for the Hansen test satisfy the conventional significance levels with an average value of 0.747. The p-values for the difference-in-Hansen tests for the validity of the instruments are also acceptable. The validity of the subsets of instruments is established for almost all regressions.

6. We assume perfect exogeneity for growth volatility because treating it as predetermined—i.e., using lagged values of the variable as instruments in the GMM estimation—generates serious correlation problems and very low p-values of the Sargan tests. This happens because volatility is quite persistent and thus a high number of lags are needed to avoid the endogeneity bias in a growth regression, which would lead to the "too many instruments" problem (Roodman, 2009).

Since Ramey and Ramey (1995), it has been generally accepted that output volatility is detrimental to economic growth. Thus, assuming perfect exogeneity allows us to avoid any endogeneity issues without the need to consider the reverse causality (from growth to volatility).

Table 4. GMM – complete sample and clustered data

Variables	(1) System GMM	(2) Low inflation	(3) High inflation	(4) Low growth volatility	(5) High growth volatility
Lagged GDP growth rate	0.217	0.199	-0.106	0.0258	0.288**
	(0.245)	(0.260)	(0.397)	(0.867)	(0.029)
Growth volatility	-1.334***	-0.807***	-0.819**	-0.744***	-1.020***
	(0.000)	(0.000)	(0.021)	(0.002)	(0.001)
Inflation	0.471	0.794**	-0.551*	0.527	-0.0328
	(0.104)	(0.044)	(0.074)	(0.216)	(0.875)
Investment	8.983	7.262	13.89**	11.48	4.440
	(0.107)	(0.372)	(0.016)	(0.106)	(0.561)
Merchandise trade	-5.728***	-6.436***	-4.982**	-5.574**	-4.625
	(0.003)	(0.000)	(0.016)	(0.011)	(0.261)
Constant	3.492	6.639	-6.532	-1.309	5.822
	(0.639)	(0.482)	(0.333)	(0.855)	(0.373)
Observations	257	154	92	111	113
Number of groups	17	17	15	17	17
Number of instruments	22	22	22	22	22
AR1 test (p-value)	0.003	0.038	0.102	0.153	0.052
AR2 test (p-value)	0.641	0.746	0.365	0.354	0.301
Hansen test (p-value)	0.548	0.692	0.875	0.557	0.638

Source: Authors' estimations based on the data described in Table 1.
Note: Robust p-value in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

In line with Ramey and Ramey (1995) and Martin and Rogers (2000), our results in estimations (1) through (5) show a negative relationship between growth rate volatility and economic growth. This result is robust to all specifications of the model. In turn, inflation is not significant for the total sample. Nevertheless, this variable becomes relevant when we group observations into low- and high-inflation clusters and cut off aberrant observations (e.g., hyperinflation episodes). Although we do not control for non-linearity between inflation and growth, our results partially match those of Kremer *et al.* (2013): we observe that low levels of inflation may be growth-enhancing while very high inflation scenarios are clearly detrimental.

In relation to the control variables, the investment-to-GDP ratio is significant and positive at high inflation. As pointed out by Cheung *et al.* (2012), the conventional assumption about aggregate production functions is that marginal return on investment declines and at some point becomes negative as the capital-output ratio increases. However,

there are reasons to doubt that returns will be zero or negative in an international context where capital flows freely, investment is not only driven by profit considerations, the institutional framework is not stable and financial markets are incomplete, a situation that occurs most frequently in less developed countries.

In fact, Cheung *et al.* (2012) also pointed out that if non-profit-driven capital flows are quantitatively important, the observed link between investment and growth could be weakened. This result is more probable when countries are in the intermediate stages of financial development and the financial system is unable to guarantee assignment of savings flows to productive investment opportunities. Moreover, high inflation disrupts the operation of financial markets, causes uncertainty about relative prices, increases the risk associated with investment and reduces the expected return. Therefore, it is possible to assume that while a non-significant relationship prevails in low/moderate inflation scenarios, a positive and significant coefficient is the norm in a developing economy with high inflation: that is, the lower the output per capita growth, the lower the rate of investment.

The resulting trade coefficients are highly significant but show a negative relationship with growth rate. This result requires explanation since conventional trade theory would predict a positive link. Even before Rodriguez and Rodrik (2001) criticized the robustness of econometric tests of the openness-to-growth causality, scholars became interested in observing certain nonlinearities in the relationship (Miller and Upadhyay, 2000) and understanding the channels through which openness may affect the growth rate (Matsuyama, 1992; Coe and Helpman, 1995; Basu and Weil, 1998). Following Andersen and Babula (2008), openness gives access to foreign inputs and technologies, expands market size and facilitates diffusion of knowledge. However, a minimum level of human capital for adapting techniques is required, or a sufficient stock of general knowledge to change the patterns of specialization after the opening. In developing countries where these requirements are not met, the theoretical literature predicts a probable highly negative relationship between trade and growth, which is what we found for the entire sample of Latin American countries.

Table 5 reports the estimation results using two other variable groupings: the World Bank income-level classification and the geographical location of the countries. The former indicates that the Latin American countries in this study belong either to the upper-middle or low-middle income

level. The geographical criterion divides the sample into South and Central American countries.[7] Our new results on volatility corroborate the conclusions reached in our study, namely, that there is a negative relationship between volatility and growth. Nevertheless, the other explanatory variables become non-significant when the data are grouped according to income and geographical criteria.

Table 5. GMM – Data grouped by income level and geographic region

Variables	(6) Low-medium income	(7) High-medium income	(8) Central region	(9) South region
Lagged GDP growth rate	0.368**	-0.0804	0.158	0.0762
	(0.022)	(0.520)	(0.430)	(0.675)
GDP growth rate volatility	-0.766**	-1.344***	-0.982**	-1.251***
	(0.023)	(0.003)	(0.010)	(0.001)
Inflation in logs	-0.286	-0.0713	-0.0136	0.0442
	(0.391)	(0.802)	(0.979)	(0.880)
Investment in logs	1.489	0.559	8.547	2.089
	(0.725)	(0.943)	(0.266)	(0.874)
Merchandise trade	-1.044	-2.043	-2.812	-2.939
	(0.472)	(0.552)	(0.241)	(0.430)
Constant	1.487	8.607	-2.882	7.322
	(0.845)	(0.390)	(0.781)	(0.605)
Observations	105	152	102	155
Number of groups	7	10	7	10
Number of instruments	22	22	22	22
AR1 test (p-value)	0.042	0.006	0.033	0.014
AR2 test (p-value)	0.333	0.613	0.488	0.680
Hansen test (p-value)	0.989	0.997	1.000	0.941

Source: Authors' estimations based on the data described in Table 1.
Note: Robust p-value in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

7. We had estimated the same models with the incorporation of three different variables that capture the effects of political stability (polity2) and authoritarian (autoc) and democratic (democ) regimes. To do this, we used Polity IV database version 12. These variables are constructed as indexes derived from codings of competitiveness of political participation, constraints on the exercise of power by the executive, and civil liberty guarantees, among other factors considered. None of these variables were found to be significant at a 95% confidence level. They did not significantly alter the major results of our work: growth volatility and inflation were robust in all these specifications. The regressions that include the political variables are available from the authors upon request.

6. Concluding remarks

In this paper we reexamine the relationship between instability and economic growth in Latin America over the last 50 years by means of a dynamic panel data model. Economic instability is approximated by the inflation rate and the volatility of the growth rate. In order to address the presence of aberrant observations and identify different instability "scenarios," we use the k-median clustering algorithm to partition the data into three clusters. The outliers were grouped into one cluster while the rest of the observations were grouped into two other clusters of low and high levels of inflation and GDP rate volatility, respectively.

Our findings show that the different instability scenarios are relevant to explaining economic growth. Indeed, inflation is found to be not significant for the whole sample. However, it becomes significant and positive at low levels and harmful to economic growth at high inflation. On the other hand, growth-rate volatility has a negative and significant impact on growth regardless of the scenario considered and this result is robust to all specifications. This means that while inflation becomes harmful at high levels, volatility is always detrimental to growth. Our evidence suggests that instability can explain most of the economic performance in Latin America in the period studied.

In order to avoid high instability in prices, but most importantly in output, economic policy recommendations should aim for countercyclical aggregate demand policies. However, as in other emerging regions, Latin America not only needs to smooth the normal business cycle, but also needs to reduce the width and frequency of high instability episodes. In turn, as the domestic market is quite restricted, policies should be oriented to facilitating the region's insertion into new and larger markets that would help expand domestic production.

The region has experienced a dramatic improvement in economic performance over the last decade. The reversal in terms of trade and a large increase in demand for Latin American primary goods exports—especially from China—among other factors, have created very favorable conditions for these emerging economies. However, Latin America has little historical experience in dealing with "abundance" scenarios and certain advantages may become problematic. On the one hand, favorable terms of trade carry the risk of currency appreciation and, in the long run, could provide fewer incentives for

innovation activities and technology-based industries; on the other hand, the dualities and structural inequalities of the region could be deepened if inflationary pressures intensify as a result of increasing prices of primary—and necessary—goods. As Fanelli (2008) points out, Latin American countries should design appropriate institutions to manage distribution conflicts, which are the root of most economic collapses in the region: when they occur, there is little (or no) room for countercyclical policies. Although distribution conflicts are not often studied in the context of volatility causes or consequences, the subject merits future research.

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APPENDIX

Choice of clustering method

We chose to work with the k-median clustering method because it is superior to hierarchical methods, as it is less affected by outliers in the sample. This is because the procedure minimizes within-cluster variation and therefore does not rely on a distance measure as hierarchical methods do. For example, if single linkage is used, because it is based on minimum distances it will tend to form one large cluster, with the other clusters containing only one or a few observations each. This is called the "chaining effect." Conversely, the complete linkage method is strongly affected by outliers, as it is based on maximum distances. Clusters produced by this method are likely to be compact and tight. Similarly, the average linkage and centroid algorithms tend to produce clusters with rather low within-cluster variance and similar sizes.

Optimal number of clusters

We use the Calinski and Harabasz (1974) pseudo-F index to determine the optimal number of clusters. Larger values of the index indicate more distinct clustering. We use the Calinski-Harabasz (CH) criterion because various simulation studies (Milligan and Cooper, 1985; Hardy, 1996; Chiang and Mirkin, 2009) find that this criterion most frequently provided the correct number of groups. However, this method takes the form of an ANOVA F-statistic for testing the presence of distinct factors (groups); a critical condition is that the groups have to be approximately of equal sie, or at least contain a sufficient number of observations (at least 5% of the observations in the sample).

Keeping this condition in mind, if we follow the Calinski-Harabasz criterion for the inflation rate, we should choose "two" as the optimal number of clusters. Table 6 presents the resulting index for different numbers of clusters using the k-median clustering algorithm.

Table A1. Different clustering for inflation rate data

Number of clusters	Calinski-Harabasz pseudo-F index
2	324.71
3	162.92
4	109.52
5	81.88
6	65.27
7	71.89
8	55.52

Source: Authors' calculations.

However, the resulting clusters have very different sizes, which could invalidate the efficiency of the C-H criterion. Besides, these two clusters cannot be classified in any economically significant way: the "low inflation" cluster includes observations ranging from a triannual inflation rate of -1.29 to 480.4%, as shown in Table 7.

Table A2. Descriptive statistics of inflation rate clusters – two clusters

Cluster	Obs.	Mean	Std. dev.	Min	Max
1	272	24.557	54.06111	-1.293158	480.424
2	12	2111.953	1970.208	762.7233	7486.894

Source: Authors' calculations.

If we generate three clusters, we obtain the second highest C-H index; again, we obtain the "extreme values" cluster (a third one) and the rest of the observations are grouped into two clusters that are more satisfying in terms of the phenomenon we describe.

Table A3. Descriptive statistics of inflation rate clusters – three clusters

Cluster	Obs.	Mean	Std. dev.	Min.	Max.
1	176	6.426299	4.052284	-1.293158	15.73686
2	96	57.79661	81.12558	16.54102	480.424
3	12	2111.953	1970.208	762.7233	7486.894

Source: Authors' calculations.

Observations grouped in cluster 3 can be identified as "extreme values" while clusters 1 and 2 can be associated with low and high inflation scenarios. Additionally, these two clusters have enough observations to conduct the GMM estimations, so we only discard the observations in cluster 1.

For growth volatility data, the Calinski-Harabasz index returns an optimal number of three clusters. In this case, we follow the index because the clusters formed are similar in size and are economically relevant for the purpose of our work.

Table A4. Different clustering for growth volatility data

Number of clusters	Calinski-Harabasz pseudo-F index
2	280.46
3	507.69
4	435.96
5	426.18

Source: Authors' calculations.

In this case, cluster 1 groups "extreme values" of the GDP volatility variable, while clusters 2 and 3 could be associated with "high" and "low" volatility scenarios.

Table A5. Descriptive statistics of GDP volatility clusters

Cluster	Obs.	Mean	Std. dev.	Min.	Max.
1	37	7.434157	2.548563	4.936426	15.22508
2	127	2.996534	.7352036	1.946945	4.675031
3	125	1.049503	.4972255	.1379393	1.906352

Source: Authors' calculations.

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A CLUSTER ANALYSIS OF FDI IN LATIN AMERICA

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This study contributes to the literature on FDI in Latin America using cluster analysis, a technique rarely employed in studies on this topic, to examine the FDI performance of Latin American countries. The empirical findings reveal three clusters in 2011, compared to just two in 2005. The cluster with better FDI performance (Chile, Panama, Uruguay, and Costa Rica) also performs better in terms of variables such as market size, trade openness, and human capital. Between 2005 and 2011 Argentina left the best-performing cluster and the cluster with poorer performance split into two, indicating heterogeneous evolution of economies in the region.

JEL classification: F21, F23, F59

Keywords: Foreign direct investment (FDI), Latin America, cluster analysis

1. Introduction

Over the last 30 years, worldwide foreign direct investment (FDI) flows have experienced strong growth. According to UNCTAD (2010), since 1982 global FDI flows have increased almost 30-fold due to the expansion of multinational enterprise (MNE) activities.[1] The increase in FDI flows has been sustained by several factors, including the opening of new countries and industries to FDI, greater economic cooperation, privatization, improvements in transport and telecommunications infrastructure, and the increasing availability of financial resources for FDI (UNCTAD, 2010). In 2009, however, due to reduced investment capacity resulting mainly from lower access to credit and weak performance of the world's major economies, FDI inflows decreased globally (UNCTAD, 2010). However, according to the data, in 2011 FDI flows recovered to levels similar to the pre-crisis period (UNCTAD, 2012).

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1. FDI is defined as an investment by an economic entity in a country other than its country of origin. It involves a long-term relationship reflecting an investor's lasting interest in a foreign entity (UNCTAD, 2010).

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The drop in FDI registered in 2009 did not affect all countries in the same way. In developed countries, particularly in North America and Europe, there was a reduction of these flows, while in developing countries, particularly in Latin America and Asia, there was growth (UNCTAD, 2010). This discrepancy has accentuated a trend in which developing economies have increased their importance as FDI recipients. In 1990, FDI inflows to Latin America accounted for 4% of the worldwide total; by 2011 this figure had reached 10%. Individually, however, countries have shown varying performance. According to data from the UNCTAD (2012) report on Latin America, in 2011 Brazil was the largest recipient of FDI in the region, followed by Mexico, Chile, Colombia, and Peru.

In this context, the aim of this study is to analyze the regional distribution of FDI flows in Latin America using cluster analysis to determine if there are homogeneous groups in the data. Therefore, it is important to ascertain the performance of each country and examine why countries differ in terms of attracting FDI. Our focus on this region is due to the fact that there are few studies about FDI in Latin America.

Although the body of literature on FDI is relatively large, we found that the number of articles focusing on Latin American countries is scarce. Some exceptions are Tuman and Emmert (1999), Treviño and Mixon (2004), Santana and Vieira (2005), Amal and Seabra (2007), Biglaiser and Saats (2010), Bucheli and Aguilera (2010), and Ramirez (2010), which address the determinants of FDI attraction to Latin America. This literature dates to prior to the 2008 crisis or uses data from before 2008; therefore, this study using more recent data may provide new evidence.

A country's ability to attract FDI is influenced by several factors closely related to its location advantages. Among these, according to Dunning and Lundan (2008), are the country's natural resources endowment, the quality and price of inputs, the existence of good infrastructure, market size, lack of trade barriers, an adequate legal and regulatory system, investment incentives, and institutional conditions favorable to multinational enterprises. Therefore, we conduct a review of the literature on the factors that explain the direction of FDI flows and complement this review with a cluster analysis to determine how FDI is distributed in Latin America. The countries under study are then divided into categories based on a set of variables directly related to the

determinants of FDI attraction, to find out if there are homogeneous groups in the data and classify countries according to their degree of attractiveness. Since there is little empirical evidence on the reasons why multinationals invest in Latin America, this study aims to contribute to knowledge about the determinants of FDI in this region.

The paper is organized as follows: In Section 2 we present a brief review of the literature on the leading location determinants of FDI. In Section 3 we present the methodology and a brief descriptive analysis of the variables (and their proxies) used in the empirical analysis. In Section 4 we present the empirical results obtained from the cluster analysis. Finally, Section 5 contains the main conclusions, limitations, and suggestions for future research.

2. The location of FDI: A literature review

2.1 Theoretical arguments

The attractiveness of a country for FDI is strictly related to its location advantages, such as natural resource endowments, the prices and quality of inputs (e.g., labor, energy), infrastructure quality (particularly in terms of transport and communication), market size, lack of trade barriers (e.g., import tariffs), the legal and regulatory system (e.g., protection of property rights), investment incentives, and institutional conditions favorable to MNEs (Dunning and Lundan, 2008). Location advantages are one of three types of advantages reported by Dunning (1980) in his eclectic paradigm as being essential for firms when deciding where to engage in FDI. The other two types of advantages are ownership and internalization. Ownership advantages are directly related to the tangible and intangible assets (e.g., technological and financial capacity, organizational skills, corporate culture) that give MNEs an advantage over their competitors, allowing them to benefit from the location advantages offered by host countries (Dunning, 2001). Internalization advantages reflect the preference of MNEs to internalize (engage in FDI) where the benefits of performing internal operations are greater than employing a market solution (e.g., licensing to external entities) (Dunning, 2001).

Along the same lines, Brewer (1993) argues that factors such as market size and growth, labor availability and costs, inflation, external debt, and the balance of payments situation have always been considered the main indicators of the degree of attractiveness of a location for

investment projects and international trade. All of these factors reflect a country's macroeconomic conditions. Also, Nonnenberg and Mendonça (2005) consider that the competitive advantage of a particular location has been evaluated in terms of macroeconomic conditions in the existing literature. Table 1 summarizes the main FDI location determinants frequently referred to in the literature and their expected relationship with FDI.[2]

Table 1. FDI location determinants

FDI determinant	Expected relationship with FDI
Market size	+
Market growth	+
Level of trade openness	+
Human capital	+
Production costs	-
Infrastructure	+
Financial and fiscal incentives	+
Economic stability	+
Corruption, political instability and institutional quality	-/+
Resource endowments	+

Source: Authors.

Market size

According to Bengoa and Sanchez-Robles (2003), the sunk cost of FDI leads multinational firms to invest in countries with larger market size in order to exploit economies of scale. In this way, countries with large markets reflect higher potential demand (Marr, 1997) and should attract more FDI inflows than smaller countries. Therefore, a positive relationship is expected between market size and FDI flows (Jensen, 2003; Janicki and Wunnava, 2004; Mohamed and Sidiropoulos, 2010; and Choong and Lam, 2010).

2. Note that according to Dunning and Lundan (2008) the relative importance of a location-specific determinant depends on the motive underlying multinationals' investment: access to internal and export markets (market-seeking FDI), access to natural resources and low-cost labor (natural resource-seeking FDI), taking advantage of differences in the availability and relative cost of production factors in different countries (efficiency-seeking FDI), and acquiring the assets of foreign firms in order to promote their own global competitiveness (strategic asset-seeking FDI).

Market growth

Regarding market growth, a market with a higher growth rate is expected to receive higher FDI flows (Mohamed and Sidiropoulos, 2010). Multinational firms tend to invest in countries with higher growth performance insofar as they indicate a larger market potential for their products (Marr, 1997).

Level of trade openness

According to Beven and Estrin (2004), FDI is encouraged if the host country has a liberal trade regime because multinational firms have a higher propensity to export. As Beven and Estrin (2004, p. 779) report, "Third-party countries may invest in host economies within customs unions to avoid tariffs on exports." Hence, a positive relationship between trade openness and FDI is expected.

Human capital

Concerning human capital, it has been argued in several studies (Brewer, 1993; Jensen, 2003; Nonnenberg and Mendonça, 2005; Choong and Lam, 2010) that a high level of human capital (or skilled labor) is an important and decisive determinant of FDI because education improves the productivity of the labor force and the propensity for technology use and innovation. Therefore, FDI and the level of human capital should be positively related.

Production costs

Another factor which is usually considered influential in terms of an MNE's decision to engage in FDI is production costs, particularly labor costs. MNEs seek locations where labor costs are lower to increase their competitiveness at the international and local levels (Bevan and Estrin, 2004). Since lower labor costs (measured by wages per worker) generate lower production costs, it is expected that countries with lower labor costs attract/receive more FDI (Dunning and Lundan, 2008).

Infrastructure

According to Vijayakumar *et al.* (2010) and Mohamed and Sidiropoulos (2010), the presence of good infrastructure in a country attracts FDI flows. Poor infrastructure leads to higher transport costs and hampers the movement of goods, thereby affecting firms' location decisions (Mlambo, 2005). It is expected, therefore, that quality of infrastructure and FDI are positively related.

Financial and fiscal incentives

With regard to tax incentives, liberalization of taxes (tax reductions, subsidies and exemptions) in a host country is widely believed to create incentives for MNEs, since this translates into lower initial costs. In this way, a positive relationship with FDI is expected (Root and Ahmed, 1978).

Economic stability

According to Cleeve (2008), a country with a stable economy (characterized by price stability, full employment and an adjusted balance of payments) will tend to attract more FDI flows. Macroeconomic uncertainty or instability leads to a higher perception of risk, negatively affecting both domestic and foreign investment (Mlambo, 2005).

Corruption, political instability, and institutional quality

According to Biglaiser and Staats (2010), political corruption tends to increase the cost of establishing a new plant and creates uncertainty about future payments required by the government. Thus, the existence of corruption will tend to reduce FDI inflows.

Regarding political stability, according to Pastor and Hilt (1993) the type of political system and considerations of economic and political risk may also influence FDI. The authors state that international investors are not attracted by authoritarian regimes. A democratic regime is viewed as providing greater benefits to investors because property rights are better protected than under an authoritarian regime, and are more likely to inspire investor confidence (Pastor and Hilt, 1993). Similarly, Jensen (2003) states that democratic

institutions present advantages of credibility with respect to supplementary property rights, which, in turn, tend to reduce political risks for potential investors. In contrast, Oneal (1994) argues that authoritarian regimes have advantages over liberal regimes insofar as they install a stable investment climate for investors. Authoritarian regimes generally do not face electoral constraints and have the ability to repress any opposition, and in that sense they may offer advantages over democracies.

Treviño and Mixon (2004), in turn, emphasize the influence of institutions on the behavior and decision-making of MNEs. Their study highlights a macroeconomic approach and an institutional approach (examining political instability, institutional quality, and tax incentives, among others) to explain MNE investment in Latin America. Quoting DiMaggio and Powell (1991), Treviño and Mixon (2004) argue that managers of MNEs should be especially cognizant of the macroeconomic conditions in the host country as well as institutional conditions, given that MNEs have to respect the host country's institutional environment and understand the impact of macroeconomic policies and institutional reforms instituted there.

Resource endowments

Finally, regarding resource endowments, according to Dunning and Lundan (2008), MNEs can increase their competitiveness by investing in locations that provide high-quality natural resources at a lower cost than the home country. As a result, we can expect a positive relationship between resource endowments and FDI.

2.2 Empirical findings

Several empirical studies have analyzed location advantages in order to test the importance of the FDI location determinants identified previously.

According to Mohamed and Sidiropoulos (2010), a country with a larger market size and higher growth rates would be expected to receive higher FDI flows. Tuman and Emmert (1999), Bengoa and Sanchez-Robles (2003), Santana and Vieira (2005) and Ramirez (2010), focusing their research on Latin American countries, confirmed the expected relationship: They found a statistically significant positive relationship

between the size and growth of the market and FDI (market size is usually measured by gross domestic product (GDP), GDP per capita and the number of inhabitants, while growth is represented by the growth rate of real GDP).[3]

Theoretically, a positive relationship between trade openness and FDI is expected. The results of this indicator are not, however, free of ambiguity since among the set of countries characterized by a high degree of trade openness, as measured by the weight of foreign trade (exports and imports) in GDP, we find countries with poor results in terms of FDI (ECLAC, 2009). Santana and Vieira (2005), Benito *et al.* (2007) and Amal *et al.* (2010) conclude that FDI is positively correlated with trade liberalization in Latin America. However, Tuman and Emmert (1999) do not obtain the same result in their study, since this factor does not have a significant impact on Japanese FDI directed towards Latin America.

Foreign direct investment and human capital level should be positively related. Bengoa and Sanchez-Robles (2003) and Santana and Vieira (2005) point out that the human capital level shows a positive correlation with FDI in Latin America, especially when evidence of skilled labor is high. Measured using the secondary and primary school enrollment ratio, the effect obtained by Bengoa and Sanchez-Robles (2003) is positive. Additionally, Santana and Vieira (2005) use the enrollment rate in secondary education as a proxy for the human capital level and this variable appears with the expected signal (positive and significant) in determining FDI flows in Latin America.

According to Dunning and Lundan (2008), countries with lower labor costs (and thus lower production costs) are expected to attract more FDI. This effect was confirmed by Vijayakumar *et al.* (2010). However, other authors (e.g., Biswas, 2002) do not obtain clear results on the role of low labor costs in attracting FDI. None of the studies focusing on Latin America (e.g., Bengoa and Sanchez-Robles, 2003; Santana and

3. It is important to stress that these papers focus on various periods of analysis and include different countries in their respective samples. Tuman and Emmert (1999) use a pooled, cross-sectional, time-series data set (1979 to 1992) to develop a multivariate model that examines the impact of macroeconomic and political variables on Japanese FDI in 12 Latin America countries. Bengoa and Sanchez-Robles (2003) focus on the relationship between economic freedom, FDI and economic growth using panel data analysis for a sample of 18 Latin American countries covering 1970-1999. Santana and Vieira (2005) analyze the determinants for attracting FDI in 17 Latin America countries in the period 1970-2000. Finally, Ramirez (2010) estimates a pooled (fixed-effects) FDI investment function in an effort to identify the main economic and institutional determinants of FDI flows to nine Latin American countries during the 1980-2001 period.

Vieira, 2005; Amal *et al.*, 2010; Biglaiser and Staats, 2010), include this variable as a determinant of FDI, with the exception of Tuman and Emmert (1999). These authors attempt to explain Japanese FDI in Latin America in the period 1972-1992 and include a variable for the annual exchange rate of the yen against other currencies in the 12 countries analyzed to examine the effects of production costs. However, the results obtained are not statistically significant.

Although quality of infrastructure and FDI should be positively related, the conclusions are not unanimous. Vijayakumar *et al.* (2010) find a positive and statistically significant relationship while Mohamed and Sidiropoulos (2010) find no statistical evidence for the influence of infrastructure in attracting FDI. Bengoa and Sanchez-Robles (2003) use the physical units of railways variable as a proxy for public investment. This may reflect the level of infrastructure, obtaining a positive correlation between this variable and FDI, but it is not significant.

As stated by Root and Ahmed (1978), a positive relationship between financial and fiscal incentives and FDI is expected. Of the studies analyzed, Cleeve (2008) uses financial and tax incentives as a determinant of FDI, seeking to ascertain to what extent they contribute to attracting FDI to Sub-Saharan Africa. To measure this variable the author uses three proxies: temporary tax exemptions, repatriation of profits, and tax concessions for specific sectors. However, the results are not conclusive, since Cleeve does not find a statistically significant relationship between the three variables and FDI for the sample of countries under study. Focusing on Latin America, Tuman and Emmert (1999) analyze the effects of government adjustment policies (which include reduced corporate tax rates and privatization of state enterprises) and conclude that economic adjustment policies have an important impact on FDI.

According to Mlambo (2005), macroeconomic stability promotes investment. Several indicators are used to assess a country's economic stability, but the inflation rate and exchange rate are the most common (Benito *et al.*, 2007). Thus, high inflation rates and large fluctuations in those rates are a symptom of economic instability and may become an obstacle to FDI (Botrić and Škuflić, 2006). Economic freedom is also used to evaluate economic stability. Studies focusing on economic freedom in Latin American countries provide evidence of a positive effect in terms of attraction of FDI inflows. Using indicators from the Heritage Foundation and the Fraser Institute (both organizations

evaluate characteristics such as the openness of the economy, government intervention, distortions in the economy and levels of corruption), Bengoa and Sanchez-Robles (2003) and Ramirez (2010) show that the level of economic freedom has a positive and significant effect on attracting FDI inflows. Amal *et al.* (2010) and Ramirez (2010) use the exchange rate to measure economic stability and conclude that its effect is debatable. A depreciation of the currency of the host country encourages multinationals to acquire assets in the country, leading to an increased flow of FDI to the host country. However, an appreciation of the host country's currency may prompt an increase in the purchasing power of citizens, which may also have a positive impact on FDI aimed at supplying the foreign market (market-seeking FDI). In regard to inflation, Bengoa and Sanchez-Robles (2003), Amal *et al.* (2010) and Benito *et al.* (2007) demonstrate that the rate of inflation negatively affects FDI in Latin America.

Harms and Ursprung (2002) test the popular hypothesis that multinational firms prefer to invest in countries where civil and political rights are not respected; their results do not support the hypothesis. On the contrary, they conclude that multinational firms seem to be attracted to countries in which individual freedoms are upheld. According to Biglaiser and Brown (2004), the preference for political stability remains an important factor for investment in Latin American countries. The investment risk related to the protection of property rights has a significant effect on attracting FDI to Latin America, together with the existence of a liberal government in the host country (Benito *et al.*, 2007). The differences in macroeconomic and institutional environments between countries are used by Treviño and Mixon (2004) to explain FDI flows to seven countries in Latin America (Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela) over the period 1988-1999. The results indicate that the institutional environment dominates the macroeconomic environment as a determinant of FDI in Latin America. Since MNEs (who engage in FDI) must deal with the institutional environment of the host country, they undertake FDI in countries where the institutional distance between the home and host country is minimal. Amal and Seabra (2007), exploring the role of institutional variables as determinants of FDI in Latin America, obtain statistically significant coefficients with the expected sign.

Several empirical studies (Deichmann *et al.*, 2003; Asiedu, 2006; Cheung and Qian, 2009; Ledyaeva, 2009, Mohamed and Sidiropoulos, 2010)

confirm the expected positive relationship between resource endowment and FDI. None of the studies analyzing Latin America (e.g., Bengoa and Sanchez-Robles, 2003; Santana and Vieira, 2005; Amal *et al.*, 2010; Biglaiser and Staats, 2010) include resource endowment as a determinant of FDI.

In sum, several empirical studies have been performed to identify the main determinants of attraction of FDI to a particular location. However, although these studies have focused on emerging markets (e.g., Brewer, 1993), developing countries (e.g., Root and Ahmed, 1978; Nonnenberg and Mendonca, 2005; Neumayer and Spess, 2005; Mohamed and Sidiropoulos, 2010), European transition economies (Bevan and Estrin, 2004) and BRICS[4] (Vijayakumar *et al.* (2010), there have been relatively few studies on Latin America. Those that focus on Latin America identify several determinants of the flow of FDI to this region, including market size and growth, level of trade openness, human capital (education level), tax liberalization, and economic and political stability of the host country (although the latter factor reveals a certain ambiguity about the expected effect). As reported by Porzecanski and Gallagher (2007), there is unanimity among empirical studies on FDI in Latin America that the key determinants of FDI in the region are the (large) size and growth of the market, and a (low) level of inflation and debt (that is, macroeconomic stability). In this paper, our aim is to improve our knowledge about FDI in Latin America using cluster analysis, a technique rarely used in studies on this topic. Cluster analysis allows for grouping countries according to their similarities in terms of a set of variables directly related to FDI location determinants.

3. Methodological approach

3.1 FDI in Latin America

As stated by the International Monetary Fund (IMF, 1993, p. 86), "Direct investment is the category of international investment that reflects the objective of a resident entity in one economy obtaining a lasting interest in an enterprise resident in another economy. (...) The lasting interest implies the existence of a long-term relationship between the direct investor and the enterprise and a significant degree

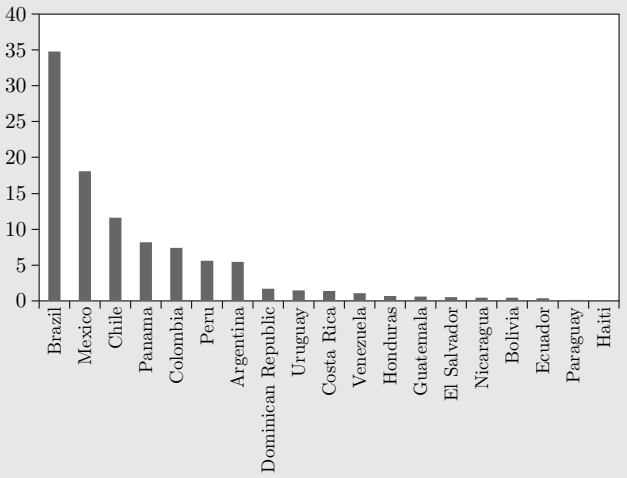
4. Brazil, Russia, India, China, and South Africa.

of influence by the investor on the management of the enterprise." Components of FDI include equity capital, reinvested earnings, and other capital associated with inter-company debt transactions.

Foreign direct investment is regarded as the type of capital flow that causes the fewest adverse effects in the host country (ECLAC, 2009). In the case of Latin America, FDI has been an important source of external financing for growth, reducing problems associated with the lack of domestic savings (Santana and Vieira, 2005). This region has also seen an increase in its importance as a recipient of FDI: In 1990 Latin America absorbed 4% of global FDI, while in 2011 it accounted for 10% (UNCTAD, 2012). When considered individually, however, the countries in Latin America perform very differently (Figure 1).

Figure 1. FDI inflows to Latin America by host economy

(% of total FDI to Latin America, average 2007 - 2011)



Source: Authors' calculations, based on UNCTAD data.

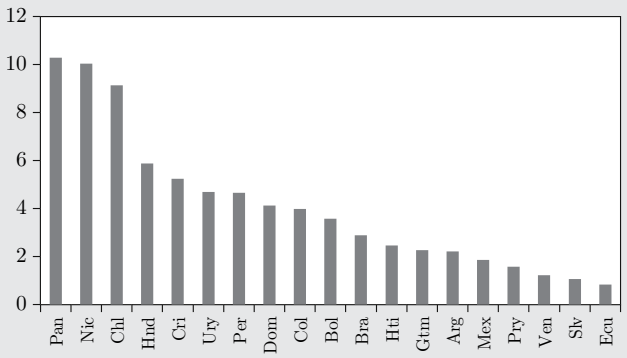
To measure the performance of countries in this region, we compare each country's share of FDI inflows to total FDI flows to Latin America. We use the average for a five-year period, 2007-2011, to account for variations over the period analyzed since FDI flows can fluctuate significantly from year to year.

Of the 19 countries in Latin America, we find that Brazil is the largest recipient of FDI, followed by Mexico, Chile, Panama, and Colombia.[5] At the other end of the spectrum are Haiti, Paraguay, and Ecuador. Although intraregional investment is important—according to UNCTAD (2013a), about half of the investment in Chile in 2011 originated in the Latin American and Caribbean region, namely Brazil and Colombia—the United States is a major investor in the region, as about half of FDI in Mexico in 2011 originated in the U.S. (UNCTAD, 2013b).

A comparison of the share of FDI net inflows to GDP significantly changes the ranking of countries, but there is still a very uneven distribution: Panama is at the top of the list, followed by Nicaragua, Chile, and Honduras, while Ecuador appears at the bottom of the ranking (Figure 2).

Figure 2. FDI, net inflows, 2011

(% of GDP)



Source: Authors' calculations, based on World Bank data.

It is clear that FDI is not distributed uniformly in the region, as just one country absorbs more than one-third of all FDI flows.

5. Cuba was not included in the study due to the lack of statistical information for most of the selected variables.

Regarding the variables related to the determinants of attracting FDI identified in Section 2, similar to OECD (2012) we include a set of economic, social, and institutional variables that are indicative of a country's structural characteristics. Given the international dimension of our sample (19 countries in Latin America) we identify the variables associated with each factor, which may prove important in explaining the growth and direction of FDI flows in this region. The variables and their proxies that serve as the basis of this analysis are shown in Table 2, which also provides descriptive statistics of the data.

Since the aim of this study is to analyze the regional distribution of FDI and the characteristics of countries in each cluster in relation to FDI determinants, we use FDI net inflows as a percentage of GDP (because larger markets are expected to attract more FDI). Panama has the highest value at 10.3% and Ecuador has the lowest one (0.8%); the average is 4.1%.

In regard to the remaining variables, starting with GDP per capita (the proxy used for market size, similar to Bengoa and Sanchez-Robles, 2003; Santana and Vieira, 2005; and Ramirez, 2010), we find an average of USD 6,879.80. Chile has the highest value (USD 14,501.20) and Haiti has the lowest value (USD 732.20). To measure market growth, we use the annual growth rate of real GDP as a proxy, following Tuman and Emmert (1999). The average value for the region is 5.5%, with Panama at the top of the ranking (10.6%) and El Salvador at the bottom (2.2%).

As for economic stability, we use the inflation rate as a proxy for this factor. High inflation rates are a classic symptom of a runaway economy in a country, both fiscally and monetarily, so the inflation rate is used to measure the level of economic instability (e.g., Nonnenberg and Mendonça, 2005). The average recorded for this variable is 7%. Venezuela has the highest value (24.5%) while Chile and Mexico have the lowest inflation (3%).

To measure the level of trade openness we use the weight of foreign trade (sum of exports and imports) in GDP, following Janicki and Wunnava (2004) and Benito *et al.* (2007). The highest value corresponds to Panama (168.2%) while Brazil has the lowest value (24.5%), and the average is 72.7%.

To measure the quality of infrastructure we use two proxies: the number of telephone lines per 100 inhabitants and the Logistics Performance Index. Given that this study focus mostly on developing countries, we understand, as did Mohamed and Sidiropoulos (2010), that the first

Table 2. Variables related to determinants of attracting FDI

Variables	Proxy	Minimum	Maximum	Mean	Std. deviation
FDI	FDI net inflows (% of GDP)	0.83	10.29	4.11	2.93
Market size	GDP per capita, PPP (current international USD)	732.21	14,501.25	6,879.77	4,266.09
Market growth	GDP growth (annual %)	2.22	10.60	5.46	2.08
Economic stability	Inflation rate	2.97	24.52	6.96	4.74
Level of trade openness	(X + M) / GDP	24.50	168.20	72.69	32.26
Infrastructure	Logistics Performance Index	2.17	3.10	2.53	0.25
	Telephone lines (per 100 people)	0.49	28.55	15.00	7.85
Human capital	Literacy rate, adult total (% of people ages 15 and above)	49.00	98.60	88.65	11.53
Production costs	Minimum wage per month (USD)	0.00	456.90	225.44	122.05
Institutional governance	Control of Corruption Index	7.00	91.00	42.26	23.69
	Political Stability and Absence of Violence / Terrorism Index	12.00	78.00	37.37	18.24
	Government Effectiveness Index	2.00	86.00	43.10	21.54
Fiscal incentives	Total tax rate (% of profits)	25.00	108.20	52.30	20.18

Source: Authors' calculations based on data from the World Bank and ECLAC (trade openness, inflation, and literacy rate) and Doing Business (minimum wage).
Note: All variables are from 2011 except the literacy rate and Logistics Performance Index data, which are from 2010.

proxy may better reflect the degree of development in this region. The average of this variable is 15, the highest value (28.5) corresponds to Uruguay and the lowest value (0.5) is obtained by Haiti. The Logistics Performance Index, meanwhile, is intended to measure the quality of trade and transport-related infrastructure, with values ranging from 1 to 5 (1=lowest, 5=highest). The average for the region is 2.5, with the highest value of 3.1 recorded for Brazil and the lowest value of 2.2 recorded for Haiti, Nicaragua, and Bolivia.

To measure the human capital level, we use the total literacy rate of adults (which corresponds to the percentage of people aged 15 years and above who can read and write) since it depicts the accumulated stock of human capital in the region (e.g., Tuman and Emmert, 1999). The literacy rate average is 88.7%. Note that Haiti registers the minimum value of 49% while Chile has the highest literacy rate (98.6%).

Concerning production costs, particularly labor costs, we used the minimum monthly wage (USD) obtained from Doing Business to measure this determinant. For this variable, with an average of USD 225.40, the highest value (USD 456.90) is obtained by Argentina while the minimum value (0) is obtained by Chile.

In terms of institutional governance, we used the three dimensions of governance included in the Worldwide Governance Indicator of the World Bank: the Control of Corruption Index, the Political Stability and Absence of Violence Index, and the Government Effectiveness Index.

The Control of Corruption Index measures "the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as 'capture' of the state by elites and private interests" (Kaufmann *et al.*, 2007, p. 4). The range of this index is 0 to 100. A high (low) index represents low (high) perception of corruption. The average for this variable is 42.3, where Chile has the highest value at 91, indicating that it has a low perception of corruption, and Haiti has the lowest value of 7, evidencing a high perception of corruption.

The Political Stability and Absence of Violence Index measures "perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including domestic violence and terrorism" (Kaufmann *et al.*, 2007, p. 3) and ranges from 0 (lowest) to 100 (highest). The Government Effectiveness Index reflects "the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the

government's commitment to such policies" (Kaufmann *et al.*, 2007, p. 3) and ranges from 0 (lowest) to 100 (highest). These two indexes were also used by Benito *et al.* (2007) and Amal *et al.* (2010) as proxies for political stability in a country. The average for the Political Stability and Absence of Violence Index is 37.4: Uruguay has the highest value at 78, maintaining a stable policy without any conflicts, while Colombia registers the lowest value of 12. Lastly, the Government Effectiveness Index average is 43.1: Chile registers the highest value of 86 and Haiti shows the lowest efficiency in government, with a value of 2.

To represent tax incentives, including tax reduction, we use the total tax rate, which measures the amount of taxes to be paid by firms after accounting for deductions and exemptions (World Bank, 2004). Regarding the tax rate, with an average of 52.3%, the highest value is 108.2% in Argentina, while Chile records the lowest value of 25%.

To sum up, the descriptive analysis reveals striking differences between countries concerning the variables reported. Next, using cluster analysis, a multivariate exploratory technique that allows for grouping entities with common characteristics (Maroco, 2007), we intend to gauge whether the 19 Latin American countries contain homogeneous groups and identify the factors that contribute to this homogeneity.

3.2 Cluster analysis

Through cluster analysis we can partition entities about which we have detailed information into relatively homogeneous groups or clusters (Johnson and Wichern, 1998 in Yu and Zhang, 2007). In this way, countries (entities) within a cluster are more similar to each other than to countries outside the cluster. Note that according to Maroco (2007), this method is appropriate when there is great variability in the data and for small samples, which is the case in this study: the sample consists of 19 Latin American countries with varying performance in terms of FDI inflows.

Several authors have adopted cluster analysis in different contexts. This technique was used by Duran and Ubeda (2001) in a new approach to the theory of "investment development path (IDP)." The authors conclude that variables related to education, research, development and patents, tariffs and taxes, and health help to better define the level of development. Yu and Zhang (2007) also use cluster analysis to study the regional distribution of FDI in China. Yu and Zhang's (2007) empirical results reveal some insights into the ability

of Chinese regions to attract FDI. For example, the authors conclude that Guangdong Province has the highest level of FDI, which is consistent with its leading position in hosting FDI and its perceived economic development. Yu and Zhang (2007) argue that the results of cluster analysis are consistent with reality. Additionally, Boudier-Bensebaa (2008, p. 38), analyzing "whether or not the differences in the FDI-assisted development paths among the CEECs have become more significant" also resort to cluster analysis in order to form more homogeneous groups of countries. Finally, the OECD (2012), in a study aimed at reviewing the experience of Costa Rica in terms of attracting knowledge-intensive FDI, also uses this technique to position Costa Rica in relation to its regional peers and emerging countries in Asia and the OECD.

As mentioned above, cluster analysis is a procedure of multivariate statistics that attempts to organize a set of entities (individuals or objects), for which detailed information is known in regard to several variables, into relatively homogenous groups (Maroco, 2007). In our study, the set of entities corresponds to 19 Latin American countries. The cluster analysis enables us to classify the countries on the basis of existing information, so that countries belonging to the same group are as similar as possible, and always more similar to the members of the same group than to members of other groups. Regarding the variables, in addition to FDI flows we focus on a set of economic, social, and institutional variables that are presented in Table 2. This analysis enables identification of groups of countries that are more likely to receive FDI and development of hypotheses concerning the structural relationships between variables (Maroco, 2007). Cluster analysis, therefore, shows how countries are positioned in relation to their regional peers, which is not possible using regression methods.[6]

The use of cluster analysis requires the definition of a similarity (or distance) measure between two countries and selection of an aggregation method that defines a split algorithm. For the aggregation, we apply the hierarchical method to form clusters.[7] Under the hierarchical clustering method each observation (country) is a small cluster at the beginning.

6. Note that cluster analysis is different from regression methods (e.g., OLS) since the aim of cluster analysis is to segment the data, dividing the sample based on the similarity of the observations, whereas regression methods are used to reveal relationships between dependent and independent variables (Liang, 2010).

7. There is a hierarchical and non-hierarchical method for the formation of clusters. We did not use the non-hierarchical method since it does not seek a dendrogram. Alternatively, it creates partitions among a fixed number of classes (the number of clusters must be chosen in advance) (Brochado, 2005).

Subsequently, the distances between clusters are calculated and the two closest clusters are merged to form a new, larger cluster (clusters are merged according to similarity). This procedure is repeated until all observations are merged into a final, large cluster that consists of the entire sample (Liang, 2010). Therefore, it becomes necessary to define a method of grouping the clusters. For the statistical method we use the method of the furthest distance (complete linkage or furthest neighbor).[8] In this method, the distance between two groups is the maximum distance between pairs of elements, which tends to produce more compact clusters (Brochado, 2005) and minimize the distance between clusters. This method is also one that produced an interpretable solution to the study, as confirmed by the dendrogram (Figure 3). Regarding the measure of similarity (distance), there are several possible measures (see Maroco, 2007 for a review of them). In our study we use the squared Euclidean distance, since it is the measure most frequently used in cluster analysis (Maroco, 2007)[9]: The smaller the Euclidean distance, the smaller the dissimilarity (or the greater the similarity or proximity) between two countries, and the greater the Euclidean distance, the greater the dissimilarity (or distance) between the countries under analysis (Maroco, 2007). To avoid dependence on measurement units, we follow Kaufman and Rousseeuw's (2005) suggestion and standardize the data.

4. FDI in Latin America: Empirical results

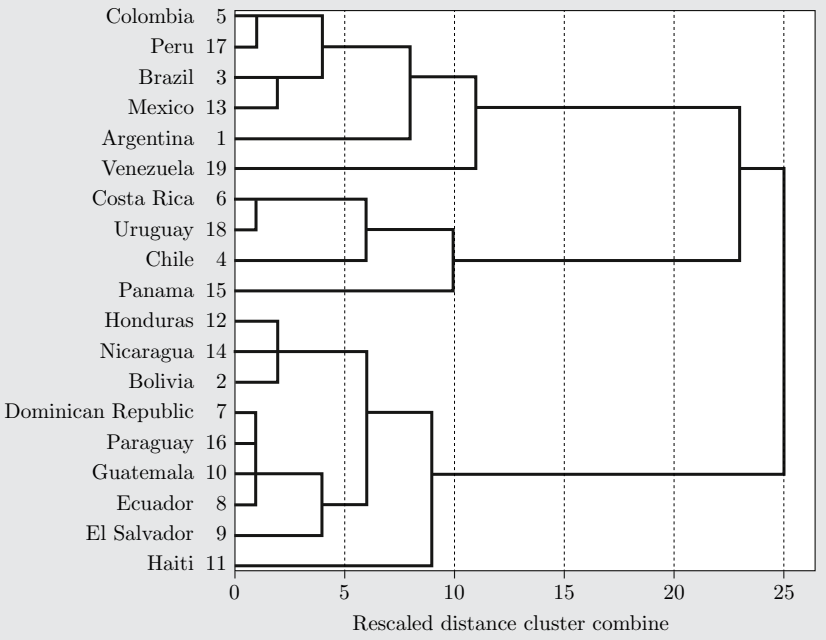
The present study seeks to analyze the regional distribution of FDI flows in Latin America using a cluster analysis method. This analysis will determine if there are homogeneous groups in the data with respect to the main attractiveness factors identified in the literature as explaining FDI flows to Latin America, such as market size and growth, level of trade openness, quality of infrastructure, human capital, production costs, and economic and political stability. The results are presented in Figure 3.

8. There are other connecting methods available for calculating the distance between clusters. We highlight the method of least distance (nearest neighbor) and other methods that tend to have intermediate characteristics between the two most extreme methods (Johnson, 1998 in Maroco, 2007).

9. According to the author (Maroco, 2007, quoting Johnson and Wichern, 2002), for p variables the Euclidean distance between individuals i and j is given by $D_{ij} = \sqrt{\sum_{k=1}^{p}(x_{ik} - x_{ij})^2}$ where xik and xjk are the values of variable k in the subjects i and j, respectively.

Figure 3. Cluster analysis dendrogram (2011)

Furthest neighbor method



Source: Authors' calculations, using SPSS.

Table 3. Cluster analysis results, 2011

Cluster 1 (6 countries)	Cluster 2 (9 countries)	Cluster 3 (4 countries)
Peru (7)	Nicaragua (2)	Panama (1)
Colombia (9)	Honduras (4)	Chile (3)
Brazil (11)	Dominican Republic (8)	Costa Rica (5)
Argentina (14)	Bolivia (10)	Uruguay (6)
Mexico (15)	Haiti (12)	
Venezuela (17)	Guatemala (13)	
	Paraguay (16)	
	El Salvador (18)	
	Ecuador (19)	

Source: Authors' calculations.

From the dendrogram we obtain different structures (varying numbers of groups) by cutting the dendrogram at different levels. To obtain the optimum number of groups we use a visual inspection approach, that is, visually identifying classes that are relatively dense and entirely distinguishable from each other, such that more compact clusters are formed (Brochado, 2005). Thus, by making a horizontal cut at a distance of 15 (or 20), we obtain three groups (clusters). Countries within each cluster are shown in Table 3. Each country's ranking in terms of FDI as a percentage of GDP in 2011 is also presented in parentheses.

The group of four countries included in cluster 3 (see Table 3) suggests that this cluster has better performance in terms of FDI, since all the countries included present a value above average for FDI as a percentage of GDP variable. We then examine the three clusters by comparing the averages of several variables using the Kruskal-Wallis nonparametric test in order to verify if the differences are statistically significant (see Table 4).

According to Table 4, in terms of FDI (percentage of GDP), cluster 3 has a higher average than the other two clusters and the differences are statistically significant. Thus, the countries in cluster 3 may be regarded as the most attractive for FDI.

Concerning the variables usually identified in the literature as affecting FDI flows, we find that there are statistically significant differences between the three clusters in regard to several variables, namely GDP per capita, level of trade openness, the Logistics Performance Index, the number of telephone lines per 100 inhabitants, the literacy rate, the Control of Corruption Index, the Political Stability and Absence of Violence/Terrorism Index, and the Government Effectiveness Index. These variables, particularly GDP per capita, reflect a country's level of economic development (Thorn, 1968). Thus, the cluster analysis performed allows us to separate the 19 Latin American countries into three groups that each represent a quite distinct level of economic development. There are no statistically significant differences regarding the variables of GDP growth, inflation rate, minimum wage, and total tax rate.

Table 4 shows that cluster 3, which performs better in terms of FDI, also exhibits better performance in almost all of the variables, namely GDP per capita, level of trade openness, number of telephone lines per 100 inhabitants, literacy rate, and the three indexes related to institutional governance. This is in line with what we would expect according to FDI location determinants.

Table 4. Mean differences among the three clusters (2011) - Kruskal-Wallis nonparametric test

Proxy	All countries (19)	Cluster 1 (6 countries)	Cluster 2 (9 countries)	Cluster 3 (4 countries)	*p*-value
FDI net inflows (% of GDP)	4.109	2.807	3.540	7.342	0.042
GDP per capita (current USD)	6,879.770	9,511.4869	3,153.295	11,316.767	0.001
GDP growth (annual %)	5.461	5.534	4.801	6.836	0.327
Inflation rate	6.958	8.192	6.952	5.121	0.272
(X + M) / GDP	72.695	45.333	81.644	93.600	0.005
Logistics Performance Index	2.528	2.748	2.324	2.658	0.001
Telephone lines (per 100 people)	15.005	19.088	8.971	22.457	0.003
Literacy rate, adult total (% of people ages 15 and above)	88.656	93.273	81.988	96.731	0.004
Minimum wage per month (USD)	225.442	273.783	176.478	263.100	0.199
Control of Corruption Index	42.263	42.667	28.000	73.750	0.010
Political Stability and Absence of Violence / Terrorism index	37.368	28.167	32.222	62.750	0.019
Government Effectiveness Index	43.105	46.167	29.333	69.500	0.005
Total tax rate (% of profits)	52.300	67.833	46.611	41.800	0.130

Source: Authors' calculations.
Note: The significance level is 0.05 (shaded variables mean that we reject the null hypothesis that the distribution of the variable is the same across categories; in the other situations, the null hypothesis holds).

Regarding the other two clusters (cluster 1 with six countries and cluster 2 with nine countries), both have an average FDI variable below the overall average (all countries), although cluster 2 has performed better. In terms of the remaining variables, cluster 2 also has better indicators for level of trade openness and political stability, suggesting that countries with higher scores in these variables also have better performance in terms of FDI.

In summary, we find that cluster 3, consisting of four countries (Chile, Panama, Uruguay, and Costa Rica), performs better in terms of a set of FDI determinants such as market size, level of trade openness, quality of infrastructure, human capital, and institutional governance.

In order to compare the evolution of country homogeneity profiles we perform a similar analysis for an earlier year (2005). From the dendrogram (Figure A1 in the Appendix), making a horizontal cut at a distance of 15 (or 20) we obtain two groups (clusters). The countries in each cluster are shown in Table 5. The results of the Kruskal-Wallis nonparametric test are presented in Table A1 in the Appendix.

Table 5. Cluster analysis results, 2005

Cluster 1A (5 countries)	Cluster 2A (14 countries)	
Chile	Brazil	Guatemala
Panama	Mexico	El Salvador
Uruguay	Colombia	Nicaragua
Costa Rica	Peru	Bolivia
Argentina	Dominican Republic	Ecuador
	Venezuela	Paraguay
	Honduras	Haiti

Source: Authors' calculations.

The group of five countries in cluster 1A (see Table 5) suggests that it has higher performance in terms of FDI, since almost all the countries (except Argentina) present an above average value for the FDI as a percentage of GDP variable. Cluster 1A also performs better in terms of other variables, namely GDP per capita, the Logistics Performance Index, the number of telephone lines per 100 inhabitants, the literacy rate, the Control of Corruption Index, the Political Stability and Absence of Violence/Terrorism Index, and the Government Effectiveness Index (Table A1 in the Appendix).

Comparing Table 5 with Table 3, it is evident that between 2005 and 2011 Argentina moved away from the group of countries with the best performance in terms of FDI. Additionally, the other cluster (cluster 2A), which in 2005 comprised 14 countries, split into two clusters: one consisting of six countries and the other with the remaining nine countries (clusters 1 and 2, respectively). This division into two clusters indicates that the group of nine countries (cluster 2) became more attractive for FDI, performing better than the six countries in cluster 1. Since these two clusters also show statistically significant differences for other variables–in particular cluster 2 has on average better results for the level of trade openness and political stability variables–the growth between 2005 and 2011 seems to indicate that countries that evolve favorably in terms of these variables were able to capture more FDI. These results have important and encouraging policy implications, particularly for countries that have traditionally received smaller amounts of FDI, indicating that it is possible to attract FDI by promoting political stability and opening borders to international trade.

5. Conclusions

Increased global FDI flows in recent decades have resulted from the expansion of activities by MNEs abroad. This expansion has been sustained by several factors, including greater openness of more countries and industries to foreign direct investment, increased economic cooperation, privatization, improvements in transport and telecommunications infrastructure, and the growing availability of financial resources for FDI (UNCTAD, 2010). This expansion has largely taken place in developing countries, specifically in Latin America and Asia (UNCTAD, 2010). Although FDI flows fell worldwide in 2009 as a result of reduced access to credit and sluggish economic performance following the crisis (UNCTAD, 2010), not all countries were affected in the same way. In fact, in developed countries, notably in North America and Europe, there was a reduction in these flows while developing countries, particularly in Latin America and Asia, saw an increase (UNCTAD, 2010).

To understand the growth of FDI flows, particularly in Latin America, this study sought to examine the distribution of FDI in the region. Using cluster analysis, the 19 Latin American countries (Cuba was excluded due to missing data) were divided according to a set of

variables directly related to FDI determinants such as market size (measured by GDP per capita), the quality of infrastructure (measured by the number of telephone lines per 100 inhabitants and a Logistics Performance Index), human capital (measured by literacy rates), and institutional governance (measured by the Control of corruption Index, the Political Stability and Absence of Violence Index, and the Government Effectiveness Index), among others.

According to the results of the cluster analysis, and based on the Kruskal-Wallis nonparametric test, in 2011 there were three clusters that show statistically significant differences in terms of several variables: FDI as a percentage of GDP, GDP per capita, level of trade openness, Logistics Performance Index, number of telephone lines per 100 inhabitants, literacy rate, Control of Corruption Index, Political Stability and Absence of Violence/Terrorism Index, and Government Effectiveness Index. Cluster 3, which consists of four countries (Chile, Panama, Uruguay, and Costa Rica), performs better on these variables that have been identified in the literature as influencing the attraction of FDI (except for the Logistics Performance Index). Additionally, a comparison of the homogeneity profiles between 2005 and 2011 reveals significant differences. In 2005 there were just two clusters, and the one with better performance in terms of FDI is made up of five countries, four of which remain in the cluster with the best FDI performance in 2011 (Argentina was no longer in that group). The fact that between 2005 and 2011 one of the clusters split into two clusters indicates that there were differences in FDI attraction patterns among the region's countries. The cluster analysis shows quite distinct levels of economic development among Latin American countries, suggesting that the group of countries with better performance in terms of certain variables is the one that also has the highest FDI flows.

The cluster of countries with the highest levels of development (Chile, Panama, Uruguay, and Costa Rica) is also the cluster in which FDI is above average; this may indicate, in line with the results obtained by other authors (e.g., Tuman and Emmert, 1999; Bengoa and Sanchez-Robles, 2003; Santana and Vieira, 2005; Biglaiser and Saats, 2010; Ramirez, 2010) that market size, quality of infrastructure, trade openness, and political stability are important determinants of FDI in Latin America.

It should be noted, however, that this study has some limitations, including gaps in the statistical information regarding most of the

selected variables; this is particularly true for Cuba, causing its exclusion from the analysis. In future studies on FDI in Latin America it would be interesting to study whether it is possible to prove the importance of the variables examined in this paper as determinants of FDI using multivariate econometric analysis.

In terms of policy implications, the governments of host countries with lower FDI inflows should increase their support for promoting and sustaining investment to generate development and economic growth, defining the best government policy for this purpose along the lines of Pastor and Hilt (1993) and Jensen (2003) concerning the political regime and political stability. Additionally, since the empirical results reveal insights into the ability of countries to attract FDI, they are important to those making decisions about future investment.

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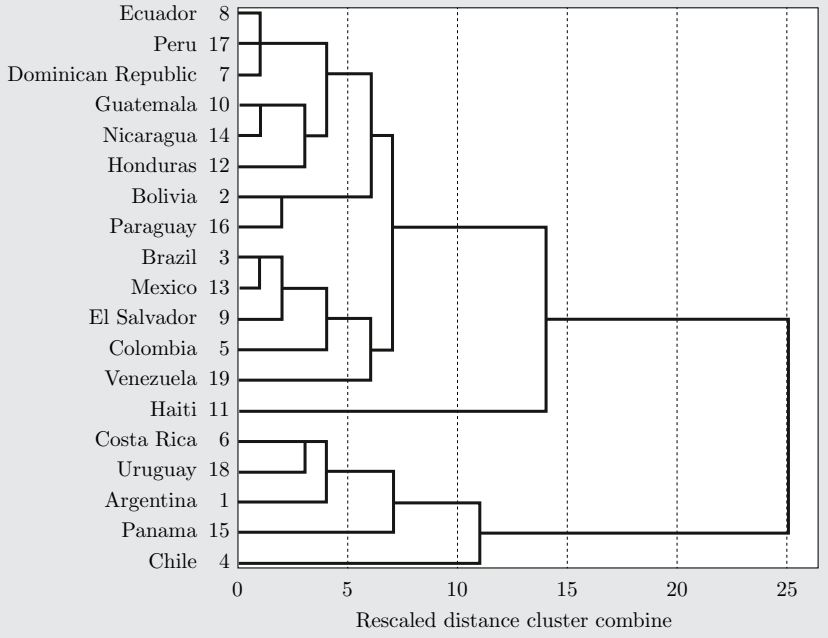
APPENDIX

Figure A1. Cluster analysis dendrogram (2005): Furthest neighbor method



Source: Authors' calculations, using SPSS.

Table A1. Mean differences between the two clusters (2005) - Kruskal-Wallis nonparametric test

Proxy	All countries (19)	Cluster 1A (5 countries)	Cluster 2A (14 countries)	*p*-value
FDI net inflows (% of GDP)	3.122	4.941	2.472	0.042
GDP per capita (current USD)	3,580.439	5,358.422	2,945.444	0.026
GDP growth (annual %)	5.450	7.055	4.876	0.052
Inflation rate	6.902	6.414	7.076	0.711
(X + M) / GDP	70.321	84.040	65.421	0.331
Logistics Performance Index	2.433	2.694	2.339	0.026
Telephone lines (per 100 people)	14.519	24.502	10.954	0.005
Literacy rate, adult total (% of people ages 15 and above)	87.126	95.500	84.135	0.004
Minimum wage per month (USD)	155.132	200.440	138.950	0.229
Control of Corruption Index	40.632	65.000	31.929	0.016
Political Stability and Absence of Violence / Terrorism Index	34.053	59.600	24.929	0.002
Government Effectiveness Index	40.895	64.800	32.357	0.002
Total tax rate (% of profits)	54.579	61.860	51.979	0.517

Source: Authors' calculations.
Note: The significance level is 0.05 (shaded variables mean that we reject the null hypothesis that the distribution of the variable is the same across categories; in the other situations, the null hypothesis holds).

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FOREIGN DIRECT INVESTMENT IN LATIN AMERICA AND THE CARIBBEAN: AN EMPIRICAL ANALYSIS

KEVIN WILLIAMS*

Competition for foreign direct investment (FDI) among developing countries has intensified in recent years. Using a sample of 68 developing countries across different regions, with data from 1975-2005, this paper investigates whether Latin America and the Caribbean (LAC) differs from non-LAC regions in regard to determinants of FDI; the evidence suggests that there are differences. In particular, the stock of infrastructure attracts FDI to LAC and constraints on the executive and high debt discourage FDI to non-LAC. These findings are robust to sample size, different estimators, endogeneity, and country fixed effects.

JEL classification: F21, O54, H63

Keywords: FDI, infrastructure, constraints on the executive, debt, Latin America and the Caribbean

1. Introduction

Developing countries have pursued a development agenda that is favorable to foreign direct investment (FDI) because of the potential benefits FDI is likely to generate for their economies. In particular, developing countries perceive FDI as a conduit for technology transfer, managerial know-how, access to foreign markets, and other "growth-inducing" characteristics. For example, Kobrin (2005) suggests that over the period 1992-2001, 95% of the economic reforms initiated by developing countries were favorable to FDI.

Latin America and the Caribbean (LAC), however, pursued protectionist economic policies in the 1950s and 1960s. In response to the first oil crisis of 1973-1974, the subsequent oil crisis of 1978-1979 and later the debt crisis of the 1980s, LAC countries began liberalizing their development strategies. Governments in the region, for example, have integrated their economies with the global economy by reducing trade barriers, privatizing state-owned enterprises, and removing controls on prices and capital accounts (Hernández and Parro, 2008). But has this

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liberalization increased inflows of FDI beyond what would have been obtained in its absence, or does it simply motivate reallocation of the existing stock of FDI to earn greater profits (Gastanga *et al.,* 1998)?

Today, many policymakers in the developing world seem to believe that FDI offers a source of foreign capital that supports their goal of achieving growth and this is reflected in vigorous policy competition to attract FDI. Developing countries demonstrate a great deal of confidence in FDI's ability to solve economic woes because it does not create debt and is long term (partially irreversible).

This paper investigates whether LAC is different from other developing countries in terms of the determinants of FDI, providing evidence that LAC and non-LAC differ in three important ways: the stock of infrastructure attracts FDI to LAC, while government debt and constraints on the executive discourage FDI to non-LAC. Two recent papers—Campos and Kinoshita (2008) and Kolstad and Villanger (2008)—look at data on FDI in LAC. In particular, Campos and Kinoshita (2008) examine the role of structural reforms in attracting FDI in a small sample of LAC and transition economies over a short time period. Kolstad and Villanger (2008) investigate whether Caribbean countries (excluding Latin America) are different from a sample of 135 countries.

The present study, however, departs from these studies in a number of ways: Instead of looking at transition economies, our dataset covers a broader set of developing countries, and we specifically investigate whether LAC is different in terms of the determinants of FDI compared to developing countries in general. Kolstad and Villanger (2008) use a simple OLS estimator and do not control for country fixed effects and endogeneity.

Studies that do not control for country fixed effects and endogeneity produce biased estimates that do not take into account variation in colonial heritage, institutions, and national policies, so to obtain reliable estimates it is important to control for these effects. This paper corrects for these biases by using more robust estimators to investigate whether LAC is different from developing countries overall.

The remainder of the paper is structured as follows: Section 2 presents FDI trends in LAC and reviews the empirical literature on FDI flows to LAC. Section 3 presents the data and the empirical specification, while the empirical results and discussion are contained in Section 4 and Section 5 concludes.

2. FDI Trends in LAC and Empirical Literature

Table 1. FDI inflows to selected countries in LAC

(USD millions) – 1970-2011

Country	1970-79	1980-89	1990-99	2000-11
Argentina	148.7	86.3	6813.1	5485.5
Brazil	1269.9	1721.3	9921.7	29563.5
Chile	64.5	481.3	3246.6	9279.75
Colombia	53	77.9	1870	6307.9
Honduras	8.2	25.4	86.1	620.67
Mexico	447	2070.8	8537.6	22910.9
Peru	40.7	31.5	1584.2	4052
Uruguay	44	52	116.1	1108
Venezuela	8.2	25.4	86.1	620.67

Source: United Nations Conference on Trade and Development (2011).

Table 1 reports annual average net FDI inflows to selected LAC economies since the implementation of market-oriented reforms. As is evident, these countries attract relatively large inflows, especially since the 1980s. The largest economies in LAC account for a disproportionate share of FDI inflows. For the three decades ending in 2011, the leading recipients of FDI inflows are Argentina, Brazil, Chile, and Mexico. Brazil, Mexico, and Chile are among the top 20 countries in the world receiving the greatest share of FDI flows in 2010.

As a region, LAC receives larger FDI inflows for the period 2005-2010 relative to other developing regions except for South, East and Southeast Asia. This is surprising, as U.S. FDI in LAC earns the lowest return (14%) compared to Africa (30%), Asia and the Pacific (21%), and developing countries as a group (16%) for 1991-1996 (Asiedu, 2002). FDI as a proportion of gross fixed capital formation is larger in LAC than in Asia (Wang, 2012). Recent trends of large inflows to LAC are explained by good economic performance and higher commodity prices (UNCTAD, 2011).

2.1 Brief review of empirical literature on FDI in LAC

The strategic proximity of LAC to the largest economy in the world (the U.S.) and its relative political stability make LAC an attractive market for U.S. FDI, an opportunity that was seized during the boom decade

of the 1990s. The "China effect," however, seems to have had an impact on this trend, and policymakers in LAC have expressed fear of inflows being diverted to China. "The fear of PRC [People's Republic of China] is floating in the atmosphere here. It has become a challenge to the Americas not only because of cheap labor, but also on the skilled labor, technological and foreign investment fronts" (Cesar Gavin, Organization of American States; cited in Chantasasawat *et al.*, 2004).

In contrast, Garcia-Herrero and Santabarbara (2005) argue that China has a small diversion effect on FDI flows to LAC, mostly affecting Mexico and Colombia during 2000 and 2001. The concern of policymakers in LAC therefore should not be for the region as a whole, but only for those two countries. Chantasasawat *et al.* (2004) suggest that policymakers should focus instead on economic growth, reducing corporate taxes, and linking their economies to the global economy, as these may offset China's influence on reducing FDI flows to LAC. And Galan and Gonzalez-Benito (2006) argue that the decision to place Spanish FDI in LAC is based on features unique to the region including shared cultural characteristics resulting from the region's colonial history.

Following economic reforms in LAC, Trevino *et al.* (2002) find that privatization exerts a positive effect on FDI inflows and this effect is persistent. Biglaiser and DeRouen (2006), however, find that financial and trade liberalization are more likely to explain FDI. Shatz (2001) asserts that the Andean group (Bolivia, Colombia, Ecuador, Peru, and Venezuela) attracts large FDI inflows (1994-1998) because policies toward FDI during the 1970s and 1980s became less restrictive. Hostility toward FDI had been influenced during the "core-periphery" debate in the 1950s and 1960s by LAC economists, many of whom argued in favor of an interventionist role for the state in economic development (Bengoa and Sanchez-Robles, 2003).

The evidence in De Gregorio (1992) suggests that FDI increases growth in LAC and the marginal contribution is greater relative to other types of investments. This is not surprising as FDI is relatively efficient. Moreover, FDI targeted to high-skilled industries has a greater probability of boosting growth (Alfaro and Charlton, 2007), while the wage differential between Mexico and the U.S. attracts U.S. FDI to Mexico (Love and Lage-Hidalgo, 2000).

None of these studies, however, investigates the potential differential effects of the determinants of FDI in LAC relative to a global sample

of developing countries. The papers that come closest to the present study are Campos and Kinoshita (2008) and Kolstad and Villanger (2008). Again, what distinguish these studies from the present paper are sample composition and size, a particular emphasis, and methodology.

3. Data and Empirical Specification

The data cover the period 1975-2005 inclusive, with a sample of 68 developing countries: 20 in LAC, 13 in Asia, 31 in sub-Saharan Africa (SSA), and 4 in North Africa. This time period was chosen due to the existence of large gaps in the data prior to 1975 for most of the variables for these countries. Information on the majority of the variables is based on published data from the World Bank's World Development Indicators (2006). We use the ratio of FDI to GDP (net FDI inflows) as the dependent variable, as is standard in the FDI literature. The following is a very brief explanation of the explanatory variables.

Following Aseidu (2002), Agiomirgianakis *et al.* (2006), and others, we use the ratio of imports and exports of goods and services to GDP to measure trade openness. The number of telephones per 1,000 people is used as a proxy for infrastructure (Campos and Kinoshito, 2003). GDP growth is used to measure the size of the domestic economy (Quartey and Tsikata, 2007). The ratio of government debt to GDP is used as a proxy for debt burden.

We use constraints on the executive as a proxy for good governance, from the Polity IV Project (2004). Constraints on the executive are based on a scale of 1 to 7: A higher score indicates more constraints (better governance). Revolution measures political instability (Cross-National Time Series Data Archive, 2003) and for macroeconomic stability, we use the annual change in consumer prices to capture inflation.

3.1 Empirical specification

We adopt an empirical model similar to that used in the literature to explore the determinants of FDI inflows (FDI/GDP) for a sample of developing countries, with a specific emphasis on LAC. The model takes the general form

$$y_{it} = \beta\lambda_{it} + v_{it} \tag{1}$$

where the composite error is $v_{it} = \alpha_i + \varepsilon_{it}$ and i and t represent countries and time periods. α_i is unique to each unit (country), ε_{it} is idiosyncratic disturbances, y_{it} is the dependent variable, and λ_{it} is the vector of explanatory variables. We include α_i to control for unobserved country fixed effects. There is another important issue with Equation (1): If the unobserved country fixed effects are correlated with the vector of explanatory variables, fixed effects is the appropriate estimator. However, if there is no correlation between the unobserved country fixed effects and the vector of explanatory variables, random effects is the appropriate estimator. This can be assessed by using the Hausman test of no-correlation between the vector of explanatory variables and α_i (Wooldridge, 2009).

Specifically, the regression estimated is

$$\begin{aligned} FDI/GDP_{it} = {} & \beta_0 Trade_{it} + \beta_1 Infrastructure \\ & + \beta_2 Growth_{it} + \beta_3 \text{Revolution}_{it} + \beta_4 Debt_{it} \\ & + \beta_5 Constra\,\text{int}\, sonexecutive_{it} + \beta_6 Inflation_{it} \\ & + \alpha_i + \varepsilon_{it} \end{aligned} \tag{2}$$

Initially, three econometric approaches are used to estimate Equation (2): pooled OLS, fixed effects (FE), and random effects (RE) with period averaged data for 1975-79, 1980-84, 1985-89, 1990-94, 1995-99, and 2000-05. The advantage of using period averages is to smooth out business cycle effects (Chitiga and Kandireo, 2003) and random year-on-year volatility. The analysis is then extended to address endogeneity concerns using lagged explanatory variables and a general method of moments (GMM) estimator. The paper implements an unbalanced panel, that is, there are missing observations for some countries and years, so the empirical results should be interpreted with caution.

4. Empirical Results and Discussion

The empirical analysis begins by using the full sample to investigate the determinants of FDI in developing countries. As a first step, pooled OLS, fixed effects (FE), and random effects (RE) estimators are used to estimate Equation (2). Concerns of potential endogeneity arising from the explanatory variables and the dependent variable are ignored. Later in the paper, the preferred estimator, GMM, is used to address

endogeneity and to check the robustness of the determinants of FDI for the full sample. Finally, the robust determinants of FDI are then investigated to determine whether there are differences in terms of FDI between LAC and non-LAC. This approach is consistent with the main contribution of the paper, that is, to isolate differential effects of the determinants of FDI in LAC and non-LAC. Kolstad and Villanger (2008) and Asiedu (2002) follow a similar approach.

The results of the pooled OLS, fixed effects (FE), and random effects (RE) estimators are reported in Table 2.

Table 2. Determinants of FDI, entire sample of countries

Independent variables	Pooled OLS	Fixed effects	Random effects
Trade	0.024 (0.000)***	0.017 (0.002)***	0.022 (0.000)***
Debt	-0.002 (0.737)	-0.017 (0.049)**	-0.009 (0.243)
Growth	0.121 (0.000)***	0.161 (0.000)***	0.143 (0.000)***
Infrastructure	0.004 (0.001)***	0.004 (0.000)***	0.004 (0.000)***
Inflation	6.1 (0.956)	-0.001 (0.011)**	-0.000 (0.126)
Revolution	0.149 (0.337)	0.17 (0.433)	0.158 (0.43)
Constraints on executive	0.046 (0.338)	0.007 (0.902)	0.028 (0.55)
F-statistic	16.15		
Observations	336	336	336
R^2	0.38		
: within		0.31	0.3
:between		0.41	0.48
:overall		0.34	0.37

Notes: The dependent variable is FDI. P-values are in parentheses. *** Significance at 1% level and ** significance at 5% level. Estimates are based on robust standard errors. All specifications include a constant. The Hausman test, *p*-value 0.01 and χ^2 17.39, is significant: fixed effects is preferred over random effects.

Across the three estimators, only three variables are consistently significant determinants of FDI–trade, growth, and infrastructure–and all have the expected positive sign (with broadly similar coefficient estimates). Countries with higher trade volumes, faster growth,

and larger stock of infrastructure attract more FDI. This is not a surprising result, and confirms previous findings. With fixed effects (as the preferred specification based on the Hausman test), inflation and government debt also appear significant with a negative sign, as expected. We must assess if these results are robust before considering the implications in terms of whether LAC is different from non-LAC.

Although fixed effects OLS is the preferred specification, it only accounts for unobserved country-specific factors; there is still the potential for endogeneity. This arises if a regressor in a model that is expected to determine the dependent variable is in turn determined by the dependent variable, or if both variables are jointly determined by a third unobserved variable. For example, FDI may be attracted to countries with good growth performance, but if growth is to be included as a determinant of FDI inflows it is important to control for potential endogeneity arising because FDI may itself have an impact on growth, or there may be an unobserved factor that affects both FDI and growth. The same applies to trade; that is, a country with a high trade volume may attract FDI and FDI in turn may determine its trade volume or both may be determined by a third variable such as the exchange rate.

Time-series data from developing countries is biased because of endogeneity (Chitiga and Kandiero, 2003). The authors address endogeneity with the generalized method of moments (GMM), using lagged regressors as instruments, due to Arellano and Bond (1991). Ndikumana and Verick (2007) address endogeneity with lagged (one period) explanatory variables. Lensink and Morrissey (2006) use both the 2SLS estimator and lagged explanatory variables to address potential endogeneity between FDI (and FDI volatility) and growth and find that lagged explanatory variables perform better (because, as is often the case, it is difficult to find suitable instruments).

Table 3 reports results using both lagged explanatory variables and GMM to control for potential endogeneity. In addition to providing valid internal instruments, GMM controls for country fixed effects (Cameron and Trivedi, 2006). The validity of the instruments can be assessed with the Hansen/Sargan test of over-identifying restrictions (OIR), with a chi-square distribution under the null that the OIR is valid and there is no-second order serial correlation in the residuals, providing an additional check of the model specification. Specifically, a p-value above 0.05 for both the OIR and no-second order serial correlation in the disturbances suggest that the instruments are valid and the model is correctly specified (Cameron and Trivedi, 2006).

Table 3. Determinants of FDI, entire sample of countries

Independent variables	Pooled OLS	Fixed effects	Random effects	GMM
$Trade_{t-1}$	0.021 (0.000)***	0.005 (0.53)	0.017 (0.000)***	0.012 (0.422)
Debt	-0.009 (0.199)	-0.042 (0.000)***	-0.022 (0.013)**	-0.045 (0.015)**
$Growth_{t-1}$	0.024 (0.46)	0.036 (0.305)	0.03 (0.341)	0.357 (0.000)***
Infrastructure	0.004 (0.001)***	0.004 (0.000)***	0.004 (0.000)***	0.003 (0.090)*
Inflation	-0.000 (0.193)	-0.001 (0.000)***	-0.001 (0.024)**	-0.001 (0.004)***
Revolution	0.118 (0.514)	0.044 (0.859)	0.081 (0.732)	0.652 (0.251)
Constraints on executive	0.081 (0.141)	-0.03 (0.685)	0.048 (0.398)	-0.393 (0.027)**
F-statistic	11.37			
Observations	290	290	290	270
R^2	0.3			
: within		0.25	0.22	
: between		0.17	0.39	
: overall		0.19	0.29	
AR(1)				0.001
AR(2)				0.34
Hansen Test				0.61

Notes: Dependent variable is FDI/GDP. P-values are in parentheses. *** Significance at 1% level, ** significance at 5% level, and significance at 10% level. Estimates are based on robust standard errors. GMM includes full time indicators. The AR(2) test of no-second order serial correlation does not reject the null and the Hansen test is used for over-identifying restrictions, which suggests the instruments are valid and hence the model is correctly specified. AR(1) is the test of no-first order serial correlation, indicating first order serial correlation, as expected. The Hausman test, *p*-value 0.00 and χ^2 23.93, is significant: fixed effects is preferred. All specifications have a constant.

Estimates are for the full sample with trade and growth lagged (one period) in pooled OLS, fixed effects, and random effects for comparison with Table 2; in general, the results are weaker and infrastructure is significant across all three methods with the expected sign. As GMM is our preferred method, we focus on those results.

For GMM debt, inflation, infrastructure (weakly), growth, and constraints on the executive are significant and all except constraints on the executive have the expected sign; trade is insignificant, as is revolution. The AR(2) test of no-second order serial correlation and the Hansen statistic of

over-identifying restrictions suggest that the instruments are valid and the model is correctly specified. Insofar as the lags are valid instruments and the GMM controls for unobserved country-specific factors, it gives relatively efficient estimates and is therefore the preferred estimator. Thus, FDI appears to be attracted to countries exhibiting growth, with physical infrastructure and macroeconomic stability (relatively low inflation and debt-servicing costs).

The most surprising result is that the coefficient on constraints on the executive is negative: Good governance or rules-based institutions as measured by constraints on the executive appear to discourage FDI in the full sample of developing countries. This negative result may occur because we could not control for the type of FDI; for example, foreign investment attracted by natural resources or privatization may be less subject to concerns about governance than market-seeking FDI or investment for manufactured exports. It is possible that in some developing countries with low values for positive determinants of FDI (growth, infrastructure, and macroeconomic stability) but which have other features attractive to FDI (such as resources–these are not country-specific as they are present in a range of countries), constraints on the executive tend to be relatively low and hence this variable picks up these FDI-attracting features across a number of countries.

The values of the principal determinants (growth, infrastructure, and macroeconomic stability) explain much of the cross-country variation in FDI inflows, in particular investment for manufactures (market-seeking or export-oriented); countries with high values of these variables may also tend to have relatively significant constraints on the executive. Other features that are attractive to FDI, such as natural resources or large-scale privatization, may tend to be present in countries with relatively low values of the principal determinants and relatively weak governance (low constraints on the executive). Thus, conditional on principal determinants, low constraints on the executive capture FDI motivated by other features.

This negative relationship with constraints on the executive supports the finding by Quartey and Tsikata (2007). Kolstad and Villanger (2008) also find a negative correlation between FDI and regulation quality in the Caribbean. High levels of debt and high inflation discourage FDI: A heavily indebted host country increases the risk of expropriation and restrictions on profit repatriation, while high and variable inflation make future profits uncertain, so foreign investors

are likely to consider these variables when looking at locations. These findings are supported by many studies, but contradict others that plausibly argue that the willingness of foreign investors to invest in developing countries with significant debt and high inflation is due to the high rates of return obtained, after adjusting for these distortions. High rates of return on investments (typically natural resources) also explain why FDI flows to violent and corrupt regimes.

4.1 Is LAC different?

Having identified potential determinants in the full sample of developing countries, in this section we investigate the main question of the paper: Is LAC different from other developing countries in terms of the determinants of FDI? To address this question, we interact a LAC dummy with the determinants that are significant in the most robust estimator–GMM–although we check the results with fixed effects and random effects. Results are reported in Table 4.

Infrastructure is positive and significant in LAC, suggesting that the stock of infrastructure attracts FDI in LAC, while infrastructure is insignificant in non-LAC, suggesting that the stock of infrastructure is not a determinant in non-LAC.[1] Constraints on the executive have a negative and significant effect on FDI inflows to non-LAC, and while the coefficient is positive for LAC, it is not significant at conventional levels in the GMM specification.

Constraints on the executive in the full sample (Table 3, GMM) is negative, but is positive for LAC and negative for non-LAC in Table 4. The change in sign may be due to measurement error, but constraints on the executive are often used to measure governance[2] and the specification closely follows the FDI literature. Moreover, given that we have averaged the data over 5-year periods, "some measurement errors wash out in time averages" (Mulligan *et al.*, 2004: 62). The likely reason, however, for the difference is that because Table 3 contains determinants for the full sample, it masks differences between LAC and non-LAC. These differences are highlighted when LAC is interacted with determinants in Table 4 (this is supported when we construct subsamples for LAC and non-LAC in Table 5 below).

1. In the appendix we experiment with an Asian dummy interacted with determinants as in Table 4, and the results are somewhat weaker.

2. See Acemoglu, Johnson, and Robinson (2002) and Asiedu (2002).

Table 4. Determinants of FDI in LAC and non-LAC

Independent variables	Fixed effects	Random effects	GMM
Trade_{t-1}	0.009	0.02	0.019
	(0.23)	(0.000)***	(0.267)
Debt	-0.054	-0.048	-0.028
	(0.000)***	(0.000)***	(0.34)
Growth_{t-1}	0.024	0.023	0.163
	(0.549)	(0.519)	(0.167)
Infrastructure	0.000	0.000	-0.004
	(0.97)	(0.679)	(0.215)
Inflation	-0.009	0.003	0.014
	(0.218)	(0.662)	(0.282)
Revolution	0.058	0.165	0.504
	(0.813)	(0.458)	(0.266)
Constraints on executive	-0.167	-0.095	-0.448
	(0.080)*	(0.178)	(0.039)**
Debt×LAC	0.032	0.05	0.004
	(0.152)	(0.004)***	(0.879)
Infrastructure×LAC	0.006	0.006	0.005
	(0.001)***	(0.000)***	(0.031)**
Growtht-1 ×LAC	0.03	0.062	0.071
	(0.688)	(0.357)	(0.672)
Inflation×LAC	0.008	-0.003	-0.015
	(0.271)	(0.601)	(0.245)
Constraints on executive×LAC	0.267	0.266	0.319
	(0.071)*	(0.029)**	(0.27)
LAC		-2.168	
		(0.010)***	
Observations	290	290	270
R^2			
: within	0.3	0.28	
: between	0.29	0.54	
: overall	0.25	0.39	
AR(1)			0.01
AR(2)			0.3
Hansen Test			0.18

Notes: Dependent variable is FDI/GDP. LAC is a (1, 0) dummy for Latin America and the Caribbean. We used variables that are statistically significant in the preferred specification (GMM) from Table 3 (to interact with LAC dummy). GMM includes full time indicators. All specifications have a constant. The AR(2) test and the Hansen tests support the GMM specification. The Hausman test, *p*-value 0.00 and χ^2 34.98, is significant: fixed effects is preferred. Estimates are based on robust standard errors. *P*-values are in parentheses. *** Significance at 1% level, ** significance at 5% level, and * significance at 10% level.

One interpretation of the negative coefficient on constraints on the executive in non-LAC is that democratic institutions in these countries are relatively poor and therefore protection of property rights are non-existent or unlikely to be enforced. Poor democratic institutions increase the risk of expropriation and discourage FDI inflows to non-LAC. Poor governance (high risk of expropriation) in developing countries likely explains the disproportionate flows of FDI to developed countries. The positive coefficient on constraints on the executive for LAC provides some evidence (weakly), however, that better governance in LAC provides greater incentives for foreign investors. This is supported by Bai *et al.* (2013) who argue that decisions by firms in Vietnam to relocate across provinces are influenced by the quality of governance.

There is some evidence of a negative and significant effect for government debt in non-LAC, although the coefficient is insignificant (at conventional levels) in the preferred specification, GMM. Developing countries with poor governance are likely to have high government debt, as political elites who face few constraints on spending fiscal resources are likely to pursue unsustainable debt. The estimate is consistent with the hypothesis: Low governance in non-LAC also suggests high government debt which in turn increases the risk of expropriation.

The estimate for government debt is positive for LAC but insignificant in the GMM specification, suggesting that FDI inflows in LAC may be indifferent to government debt.[3] This could be the case if investors believe that property rights are secure, or if the risk-adjusted rates of return on their investments are relatively high. The evidence is consistent with Agosin and Machado (2007) who argue that LAC has gone the furthest in implementing policies favorable to FDI since the 1980s, while Asia is selective in its FDI regimes, a practice that is absent in LAC. Taken together, does this mean that LAC is different from non-LAC in terms of the determinants of FDI?

Thus far the evidence suggests that the answer is yes, but we check the robustness of the results in Table 5. We construct two subsamples of 20 (LAC) and 48 (non-LAC) countries. The size of these subsamples renders the use of the GMM estimator infeasible, as "the GMM estimators are asymptotically biased in a small sample" (Campos and Kinoshita, 2003). Again, we use random effects and fixed effects with potential endogenous variables (trade and growth) lagged one period. Table 5 reports results for both LAC and non-LAC.

3. I would like to thank an anonymous referee for pointing out this interpretation.

Table 5. Determinants of FDI for LAC and non-LAC

Independent variables	LAC Fixed effects	non-LAC Fixed effects	LAC Random effects	non-LAC Random effects
Trade_{t-1}	0.003	0.011	0.022	0.019
	(0.821)	(0.193)	(0.000)***	(0.000)***
Debt	-0.021	-0.054	0.006	-0.048
	(0.339)	(0.000)***	(0.703)	(0.000)***
Growth_{t-1}	0.071	0.017	0.096	0.02
	(0.345)	(0.649)	(0.155)	(0.555)
Infrastructure	0.006	-0.000	0.006	-0.001
	(0.000)***	(0.938)	(0.000)***	(0.685)
Inflation	-0.001	-0.009	-0.001	0.002
	(0.008)***	(0.211)	(0.115)	(0.775)
Revolution	0.433	-0.271	0.412	-0.055
	(0.301)	(0.385)	(0.279)	(0.842)
Constraints on executive	0.134	-0.161	0.192	-0.096
	(0.321)	(0.065)*	(0.090)*	(0.155)
Observations	96	194	96	194
R^2				
: within	0.43	0.17	0.4	0.15
: between	0.29	0.25	0.65	0.39
: overall	0.34	0.23	0.45	0.3

Notes: Dependent variable is FDI/GDP. P-values are in parentheses . *** Significance at 1% level and * significance at 10% level. All specifications are based on panel data for the six sub-periods. Estimates are for the 20 LAC and 48 non-LAC countries and based on robust standard errors. All regressions include a constant. The Hausman test, p-value 0.01 and χ^2 19.52, is significant: fixed effects is preferred for non-LAC. The Hausman test, p-value 0.06 and χ^2 13.56, is significant: fixed effects is preferred for LAC.

Constraints on the executive retains its sign and significance for both LAC and non-LAC from Table 4; that is, FDI is negatively correlated with constraints on the executive in non-LAC, while there is a positive association with FDI in LAC. These effects are economically large. For example, the estimate of 0.192 (column 3) implies that a 10% higher score for constraints on the executive is typically associated with a 2% increase in FDI inflows in LAC. In contrast, a 10% higher score for constraints on the executive (column 2) is associated with a 2% reduction in FDI inflows in non-LAC. The negative coefficient of constraints on the executive in non-LAC provides further evidence that the negative correlation between constraints on the executive and FDI in Table 3 is driven by non-LAC. Government debt is also negative and significant and the size of the estimate is the same as in Table 4 for non-LAC. The magnitude of the estimate–0.054 (column 2)–suggests that a 10% increase in the size of government debt reduces FDI inflows by 0.54% in non-LAC. The stock of infrastructure attracts FDI inflows to LAC, implying that a 10% increase in the number of telephones per 1,000 people is associated with a 0.06% increase in FDI inflows. There is some evidence of an effect for inflation and trade in LAC and non-LAC, although these effects are not robust.

Following Paternoster *et al.* (1998), a test of equality of coefficients (columns 1 and 2) finds that infrastructure is the most robust determinant of the differences in FDI inflows to LAC and non-LAC (z-test of 4.17 with p-value 0.00 rejects the null of equal effect in both regressions).[4] A test of equal effect across regressions for government debt and constraints on the executive for LAC and non-LAC is statistically insignificant at conventional levels.

Based on the empirical analysis and the preceding discussion, there is evidence that LAC and non-LAC are different in terms of the determinants of FDI. The stock of infrastructure is likely to attract FDI in LAC, but there is no evidence of an effect for non-LAC. Constraints on the executive discourage FDI inflows to non-LAC, and there is evidence of a positive effect for LAC. Finally, high debt is likely to discourage FDI inflows to non-LAC, but does not seem to matter for FDI inflows to LAC.

4. This test is computed as follows: $z = 0.006 - 0.0001 / \sqrt{\left(0.001\right)^2 + \left(0.001\right)^2}$. LAC: estimate 0.006, s.e. 0.001; non-LAC: estimate 0.0001, s.e.= 0.001.

5. Concluding Remarks

Because FDI inflows bring perceived advantages, policymakers in the developing world have taken an accommodating stance, competing to attract FDI. This paper investigates whether LAC is different from non-LAC in terms of the determinants of FDI inflows. In particular, the main findings suggest that the stock of infrastructure attracts FDI inflows to LAC, high debt discourages FDI inflows to non-LAC, and constraints on the executive discourage FDI inflows to non-LAC. This evidence suggests that LAC is different from non-LAC in regard to the determinants of FDI in at least three dimensions.

The implication of these findings is that LAC governments could have an advantage over other developing countries in attracting FDI by focusing not only on expanding the stock of infrastructure but also its quality. Because exports are important to the region's economic success, LAC countries should incorporate seaport and airport infrastructure development into their overall infrastructure goals to take full advantage of international markets. Infrastructure development in general suggests one channel through which policymakers in LAC can improve the welfare of their countries by attracting greater levels of FDI inflows. Furthermore, "public investments in infrastructure (e.g., water, sanitation, roads, ports, and power grids) are vital to support growing cities" (McCord and Sachs, 2013: 09). This is even more important, as debt does not appear to constrain FDI to LAC and foreign investors seem to believe that their property rights are likely to be protected in the region.

Because an investigation of FDI inflows at the industry level was beyond the scope of this paper, we are not able to determine which industries are likely to be affected by the determinants that differentiate LAC from non-LAC. One approach for future study is to examine the determinants of FDI at the industry level and test whether there is heterogeneity across regions (although we suggest that poor governance may not discourage FDI attracted by natural resources, we did not investigate that hypothesis).

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APPENDIX

Table 1A. Study sample of 68 countries

SSA	LAC	ASIA	North Africa
Benin	Bolivia	Bangladesh	Algeria
Bostwana	Brazil	China	Egypt
Burkina Faso	Chile	Indonesia	Morocco
Cameroon	Colombia	Malaysia	Tunisa
Central Africa	Costa Rica	Nepal	
Congo, Dem. Republic	Ecuador	Pakistan	
Congo, Republic	El Salvador	Philippines	
Cote d'Ivoire	Guatemala	South Korea	
Gabon	Guyana	Sri Lanka	
Gambia	Haiti	Thailand	
Ghana	Honduras	India	
Guinea	Jamaica	Papua New Guinea	
Guinea Bissau	Mexico	Singapore	
Kenya	Nicaragua		
Madagascar	Paraguay		
Malawi	Peru		
Mali	Trinidad and Tobago		
Mauritania	Mozambique		
Mauritius	Uruguay		
Mozambique	Venezuela		
Niger			
Nigeria			
Senegal			
Sierra Leone			
South Africa			
Swaziland			
Tanzania			
Togo			
Uganda			
Zambia			
Zimbabwe			

Table 2A. Determinants of FDI in Asia

Independent variables	Fixed effects	Random effects	GMM
$Trade_{t-1}$	0.016 (0.016)**	0.02 (0.000)***	0.036 (0.11)
Debt	-0.044 (0.000)***	-0.022 (0.015)**	-0.049 (0.345)
$Growth_{t-1}$	0.015 (0.679)	0.025 (0.464)	0.361 (0.17)
Infrastructure	0.005 (0.000)***	0.005 (0.000)***	0.000 (0.975)
Inflation	-0.001 (0.001)***	-0.001 (0.023)**	-0.003 (0.136)
Revolution	-0.022 (0.93)	0.122 (0.596)	1.433 (0.309)
Constraints on executive	-0.105 (0.209)	0.026 (0.675)	-1.424 (0.233)
Debt×ASIA	0.01 (0.795)	-0.01 (0.701)	-0.105 (0.414)
Infrastructure×ASIA	-0.008 (0.004)***	-0.007 (0.001)***	-0.012 (0.098)*
$Growth_{t-1}$×ASIA	0.013 (0.909)	0.071 (0.423)	-0.156 (0.69)
Inflation×ASIA	-0.003 (0.961)	-0.048 (0.415)	0.042 (0.867)
Constraints on executive×ASIA	0.229 (0.18)	0.048 (0.674)	2.192 (0.288)
Observations	290	290	290
R^2			
:within	0.29	0.26	
:between	0.2	0.4	
:overall	0.19	0.31	
AR(1)			0.15
AR(2)			0.96
Hansen test			0.91

Notes: Dependent variable is FDI/GDP. ASIA indicator is 13 countries. *** significance at 1% level, ** significance at 5% level, and * significance at 10% level. All specifications include a constant. Interaction terms are statistically significant variables from Table 3. GMM includes full time indicators. AR(1) and AR(2) are first and second order serial correlation tests. The Hansen test is the test of instrument validity. There is no second order serial correlation and the instruments are valid. The Hausman test, p-value 0.00 and χ^2 29.93, is significant: fixed effects is preferred. Estimates are based on robust standard errors. *P*-values are in parentheses.

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A NOTE ON THE S-CURVE DYNAMICS OF COMMODITY TRADE BETWEEN BRAZIL AND THE UNITED STATES

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The S-curve hypothesis postulates that the correlation coefficient between the current exchange rate and past trade balance values may be negative. However, the correlation between the current exchange rate and future values of the trade balance may be positive. Previous research using aggregate trade flows between Brazil and rest of the world find weak support for the curve. When we disaggregate Brazil's trade flows with the U.S. and investigate 95 industries that trade between the two countries, we find support for the S-curve in 51 industries. Small and large industries and durable and non-durable commodities are found to benefit from currency devaluation.

JEL classification: F31

Keywords: S-curve, industry data, Brazil, the United States

1. Introduction

A country that is experiencing a decline in its net exports may adhere to currency devaluation or allow its currency to depreciate, but due to adjustment lags such as recognition, production, delivery, etc. the trade balance may continue to deteriorate, with improvement coming later. This short-run pattern of movement of the trade balance subsequent to devaluation has been tested by two concepts that rely upon two different approaches. The J-curve introduced theoretically by Magee (1973) and tested empirically by Bahmani-Oskooee (1985) mostly relies upon a reduced-form trade balance model and different estimation techniques and regression analysis. The S-curve introduced by Backus *et al.* (1994) relies upon a cross-correlation function between past and future values of the trade balance and the current terms of trade or the real exchange rate. Bahmani-Oskooee and Hagerty (2010) provide a comprehensive review of both concepts, classifying all studies into three categories. The first group uses aggregate trade flows between

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one country and the rest of the world. To reduce aggregation bias, the second group uses trade flows between two countries. To further reduce the aggregation bias, the third group uses trade flows between two countries disaggregated by commodity. The evidence in support of both the S-curve and the J-curve increases with the level of disaggregation.

In this paper we concentrate on the experience of Brazil. Can Brazil enjoy an improvement in its trade balance in the future as a result of currency depreciation? Four studies have tried to answer this question by relying upon the J-curve concept. The results are mixed at best. Bahmani-Oskooee and Malixi (1992), who test the J-curve phenomenon for several developing countries, include Brazil in their sample and find support for the J-curve in Brazil. So do Gomes and Paz (2005), who only consider the case of Brazil. However, Moura and Da Silva (2005), who also use Brazilian data, do not find any support for the J-curve. The three studies use aggregate trade data between Brazil and rest of the world, hence they may suffer from aggregation bias. To reduce the bias and search for further evidence in support of the J-curve, Bahmani-Oskooee *et al.* (2012) concentrate on trade between Brazil and its major trading partner, the United States, and consider the experiences of 92 industries. Using the bounds-testing approach to cointegration and error-correction modeling, which distinguishes the short-run effects of currency depreciation from its long-run effects, they are able to support the J-curve in almost one-third of the industries.

As for Brazil's experience with the S-curve, only two studies have estimated the curve for developing countries. While Senhadji (1998), who tests the curve for 36 developing countries using aggregate trade data, does not include Brazil in his analysis, Parikh and Shibata (2004), testing the curve for 64 developing countries, include Brazil and find weak support for the S-curve there. These studies use aggregate trade flows between each country and rest of the world, the same procedure as Backus *et al.* (1994), who test the curve for 11 OECD countries. In an effort to reduce aggregation bias, Bahmani-Oskooee and Ratha (2007a) disaggregate trade flows by trading partners and provide more support for the S-surve in trade between the U.S. and each of its major trading partners. Unfortunately, they do not include Brazil as a partner.

In this paper, we examine trade between the U.S. and Brazil exclusively and try to find stronger support for the S-curve using bilateral trade flows. To further bolster our results we disaggregate bilateral trade

flows and estimate the curve for each of the 95 industries that trade between the two countries, finding support for the S-curve in 52 cases. To demonstrate how we arrive at our findings, in Section 2 we explain the method of generating the S-curve. The findings are reported in Section 3 and a summary is provided in Section 4.

2. Data and Methodology

As indicated in the previous section, the S-curve is based on the cross-correlation between the current real exchange rate and future as well as past values of the trade balance. Thus, following Bahmani-Oskooee and Ratha (2007b) and the literature, we define the cross-correlation coefficient (COR) between the trade balance (TB) and the real exchange rate (RE) as:

$$COR = \frac{\sum (RE_t - \overline{RE})(TB_{t+k} - \overline{TB})}{\sqrt{\sum (RE_t - \overline{RE})^2 (TB_{t+k} - \overline{TB})^2}} \tag{1}$$

where $\overline{RE}$ and $\overline{TB}$ are the mean of all observations over the study period. By allowing k to take negative values such as -5, -4, -3, -2, and -1, we calculate cross-correlation coefficients between the current exchange rate and past vales of the trade balance. And by allowing k to take positive values such as 1, 2, 3, 4, and 5, we calculate the same correlation between the current exchange rate and future values of the trade balance. The S-curve is then produced by plotting constructed correlation coefficients against corresponding lags and leads.[1]

Before we proceed, it should be mentioned that since the industry-level data are reported by the U.S., we define the TB and RE from the U.S. perspective. Thus, for each industry i, the trade balance is defined as $TB_i = (X_i - M_i)/GDP_{US}$ where X_i is U.S. exports of industry i to Brazil, M_i is U.S. imports of the same industry from Brazil, and $GDPUS$ is U.S. gross domestic product. All variables are measured in nominal U.S. dollars so that the ratio measures the trade balance in terms of domestic output. This definition is followed by all previous research on the S-surve. The real exchange rate between the U.S. dollar

1. It is common practice to detrend the data; the Hodrick-Prescott filter is used for this purpose.

and the Brazilian *real* is defined as $RE = P_{BR}/(P_{US} \cdot E)$ where P_{BR} is the price level in Brazil, PUS is the price level in the U.S., and E is the nominal exchange rate defined as the number of Brazilian *real* per U.S. dollar. Thus, an increase in RE reflects a real depreciation of the dollar, which implies that the contemporaneous correlation coefficient between the two variables is expected to be positive.[2]

3. Results

We are now in a position to plot our constructed COR variable against a number of lags and leads to see if we can provide stronger support for the S-curve at the commodity level. We first summarize our findings in Table 1, which contains information such as industry code, name, their trade share, and an indication of whether the S-curve is supported.

Table 1. Industries studied and their trade shares

Code	Industry name	Trade share	Support
13	Meat in airtight containers n.e.s.	0.001688	
48	Cereal preps. and preps. of flour	0.000634	Yes
51	Fruit, fresh, and nuts excl. oil	0.004393	
53	Fruit, preserved and fruit preparations	0.0068	
61	Sugar and honey	0.006284	
62	Sugar confectionery, sugar preps.	0.000662	Yes
81	Feed stuff for animals	0.000483	
112	Alcoholic beverages	0.000168	
122	Tobacco manufactures	4.13E-05	
211	Hides and skins, excluding fur skins	1.46E-05	
231	Crude rubber including synthetic and recycled	0.005775	Yes
273	Stone, sand and gravel	8.17E-05	Yes
276	Other crude minerals	0.002225	
283	Non-ferrous ores and concentrates	0.00366	
284	Non-ferrous metal scrap	0.000293	
291	Crude animal materials, n.e.s.	0.001894	
292	Crude vegetable materials, n.e.s.	0.000851	Yes

2. The data on price levels (measured by PPI for both countries), the exchange rate, and U.S. GDP are from the International Financial Statistics published by the International Monetary Fund. The industry-level trade data are from World Bank's WITS system (which in turn receives the data from the United Nations' COMTRADE database). All data are annual over the 1971-2010 period.

Table 1. (continued)

Code	Industry name	Trade share	Support
422	Other fixed vegetable oils	0.000139	
431	Animal/vegetable oils and fats, processed	0.000784	
512	Organic chemicals	0.057495	Yes
513	Inorganic chemicals elements, oxides	0.013377	Yes
531	Synthetic organic dyestuffs, natural	0.002277	
532	Dyeing and tanning extracts	9.46E-05	
541	Medicinal & pharmaceutical products	0.02464	Yes
571	Explosives and pyrotechnic products	0.000178	Yes
581	Plastic materials, regenerated	0.032407	Yes
599	Chemical materials and products	0.017733	Yes
611	Leather	0.001583	
612	Manuf. of leather	8.83E-05	Yes
629	Articles of rubber, n.e.s.	0.010798	
631	Veneers, plywood boards and other wood	0.001198	Yes
632	Wood manufactures, n.e.s.	0.003398	Yes
641	Paper and paperboard	0.007375	Yes
642	Articles of paper, pulp, paperboard	0.001065	Yes
651	Textile yarn and thread	0.000954	Yes
652	Cotton fabrics, woven excluding narrow	0.000308	
653	Text fabrics woven excluding narrow	0.000555	Yes
654	Tulle, lace, embroidery, ribbons	4.68E-05	Yes
655	Special textile fabrics and related	0.003323	
656	Made up articles, wholly or chiefly	0.002021	Yes
657	Floor coverings, tapestries, etc.	0.000257	Yes
661	Lime, cement and fabr. bldg.mat.	0.010213	Yes
662	Clay and refractory construction materials	0.001563	Yes
663	Mineral manufactures, n.e.s.	0.00244	
664	Glass	0.00133	Yes
665	Glassware	0.000458	Yes
666	Pottery	3.53E-05	Yes
667	Pearls and precious and semi-precious stones	0.000872	
671	Pig iron, spiegeleisen, sponge iron	0.016903	
672	Ingots and other primary forms of iron	0.007023	
673	Iron and steel bars, rods, angles,	0.002921	
677	Iron and steel wire	0.000471	Yes
678	Tubes, pipes and fittings of iron ore	0.003005	
682	Copper	0.001139	
689	Misc. non-ferrous base metals	0.001535	
692	Metal containers for storage	0.001821	Yes
693	Wire products ex electric and fence	0.000451	

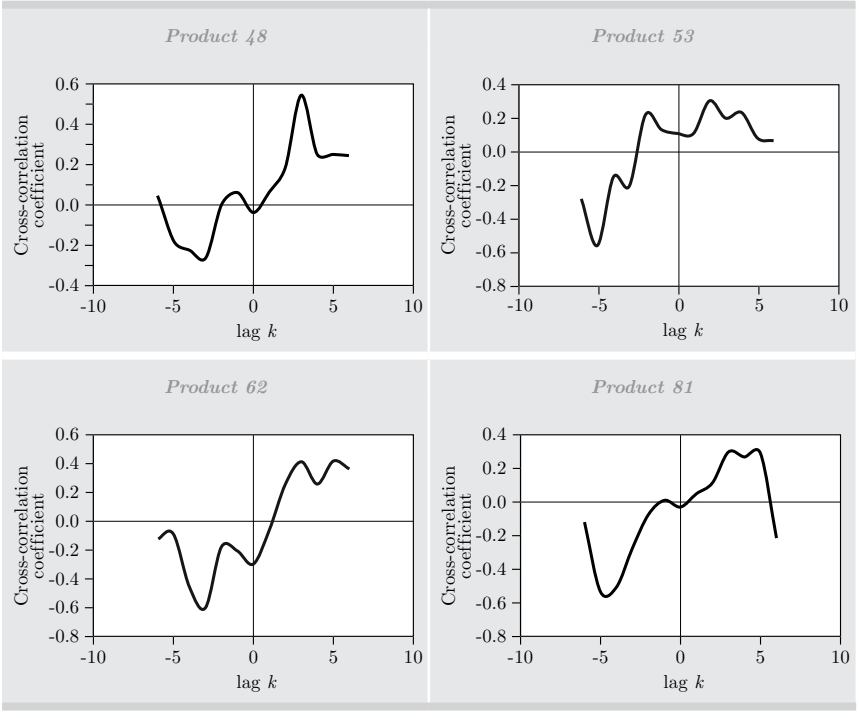
Table 1. (continued)

Code	Industry name	Trade share	Support
694	Nails, screws, nuts, bolts, rivets	0.001425	Yes
695	Tools for use in the hand or in machine	0.002828	
696	Cutlery	0.000824	Yes
697	Household equipment of base metals	0.000612	Yes
698	Manufactures of metal, n.e.s.	0.003871	Yes
711	Power generating machinery	0.02137	
712	Agricultural machinery	0.00546	Yes
714	Office machines	0.016514	Yes
715	Metalworking machinery	0.001971	
717	Textile and leather machinery	0.000671	Yes
718	Machines for special industries	0.032678	Yes
719	Machinery and appliances non electrical	0.059249	Yes
722	Electric power machinery and switch	0.01633	Yes
723	Equipment for distributing electricity	0.002378	Yes
724	Telecommunications apparatus	0.015917	Yes
725	Domestic electrical equipment	0.000535	Yes
729	Other electrical machinery and appliances	0.015454	Yes
731	Railway vehicles	0.003438	
732	Road motor vehicles	0.022861	Yes
734	Aircraft	0.013807	
812	Sanitary, plumbing, heating & light	0.000504	Yes
821	Travel goods, handbags and similar	0.00018	Yes
841	Clothing except fur clothing	0.000653	Yes
851	Footwear	0.006768	
861	Scientific, medical, optical, meas.	0.021344	Yes
862	Photographic and cinematographic su	0.002191	
863	Developed cinematographic film	1.54E-06	
864	Watches and clocks	0.000206	
891	Musical instruments, sound recorder	0.002976	
892	Printed matter	0.002153	
893	Articles of artificial plastic mater.	0.003287	Yes
894	Perambulators, toys, games and sporting	0.001879	Yes
895	Office and stationery supplies, n.e.s.	0.000638	
896	Works of art, collector pieces	0.000601	
897	Jewelry and gold/silver watches	0.001288	Yes
899	Manufactured articles, n.e.s.	0.003152	Yes
931	Special transactions & goods not classified	0.100907	Yes

Source: ??
Note: n.e.s. stands for "not specified elsewhere."

From the last column of the table, we gather that the S-curve is supported in 52 out of 95 industries, which is a much stronger level of support than for the J-curve concept investigated by Bahmani-Oskooee *et al.* (2012), who find that the same data set supports the J-curve in only 31 cases. It appears that neither industry size nor industry classification (e.g., durable versus non-durable) play any role in the outcome.[3] While many of the industries are small as measured by the size of their trade shares, the four largest industries are also among those that support the S-curve. These include industry code 718 with 3.26%, 719 with 5.92%, 732 with 2.28%, and 931 with 10.09%. For brevity, in Figure 1 we report only the plots of the curves for industries that support the S-pattern.

Figure 1. S-curves in industries that support the pattern



3. This finding is consistent with Bahmani-Oskooee and Xu (2013) who conduct a similar analysis for U.S.-Mexico industry-level data. It is also consistent with Bahmani-Oskooee and Ratha (2010) who do the same for U.S.-China trade.

Figure 1. (continued)

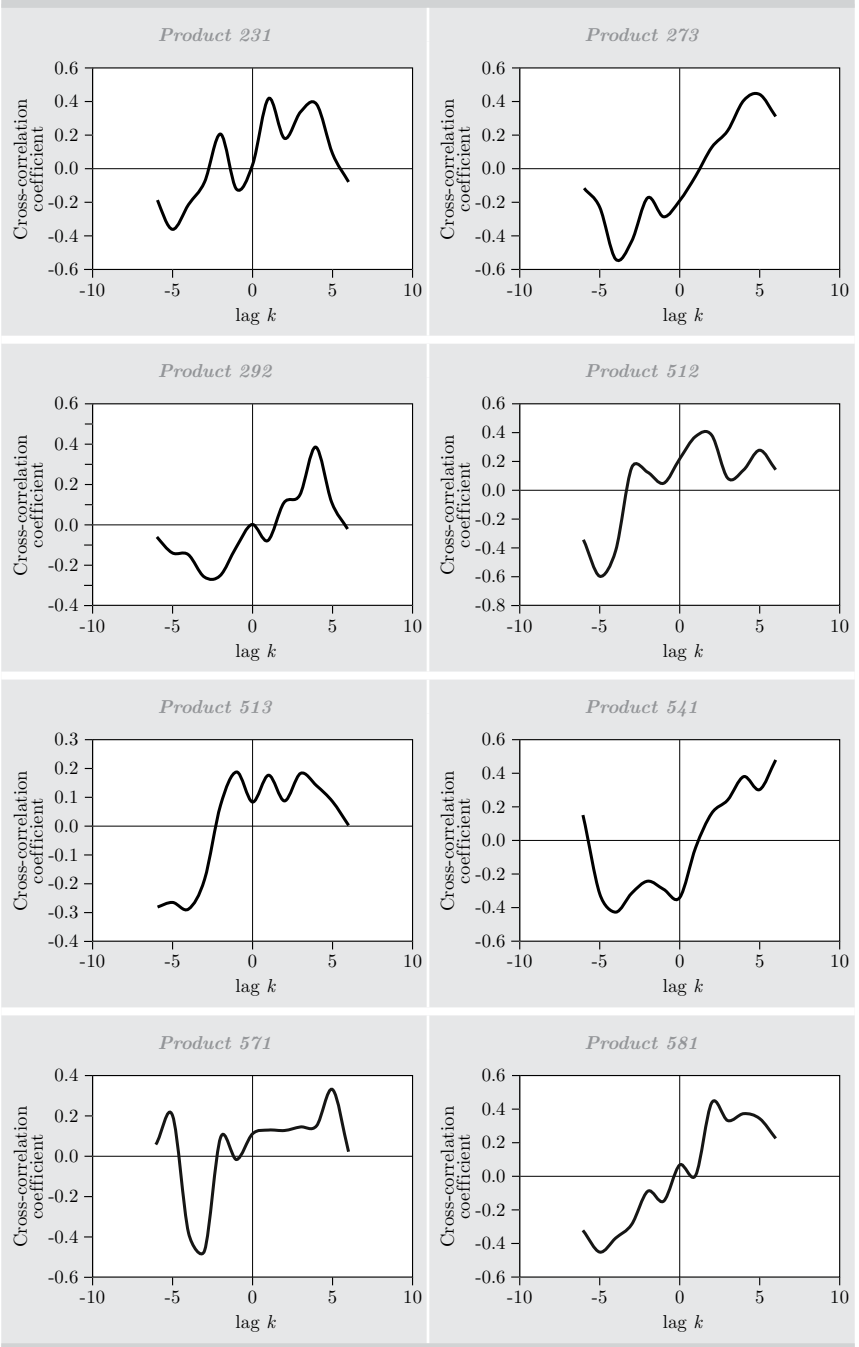


Figure 1. (continued)

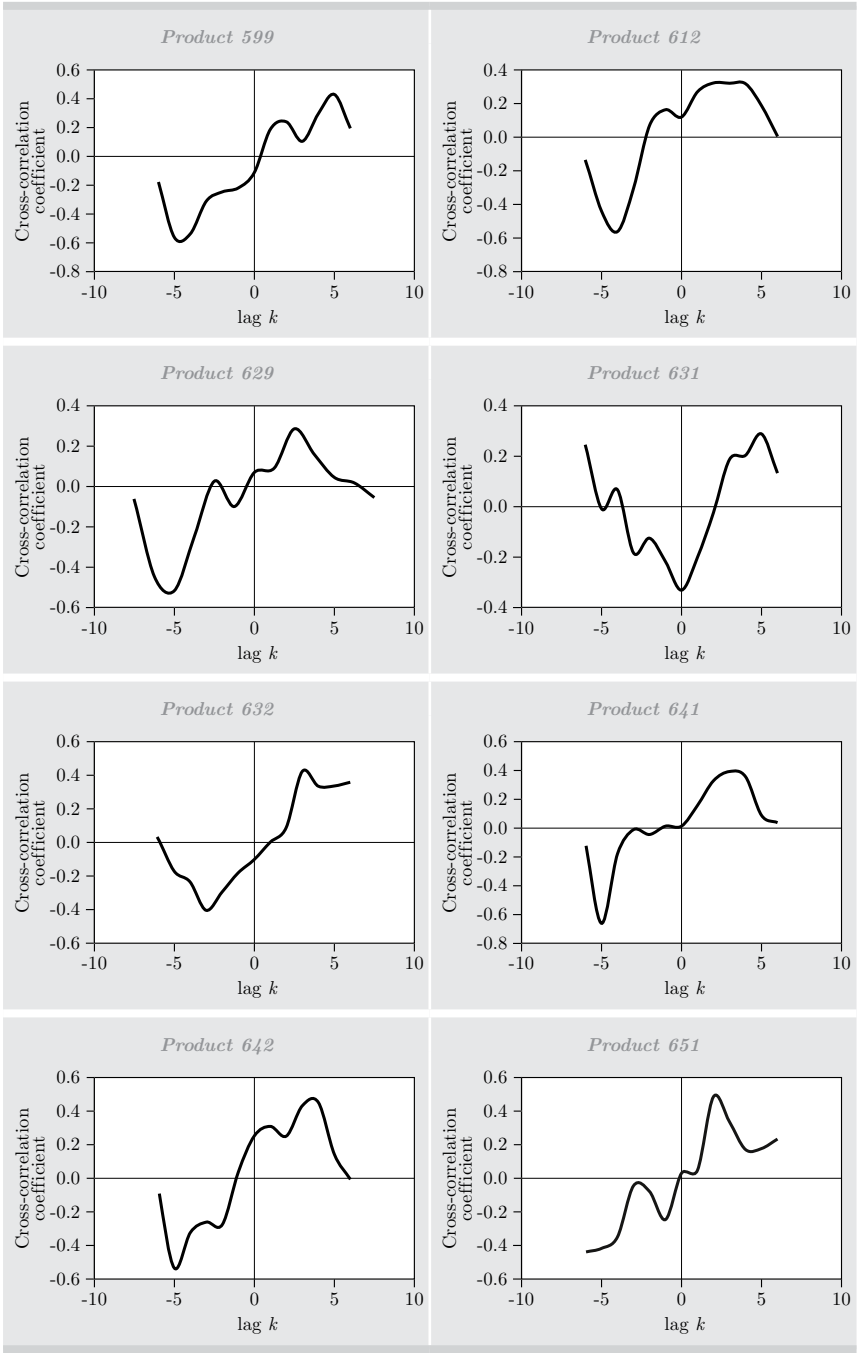


Figure 1. (continued)

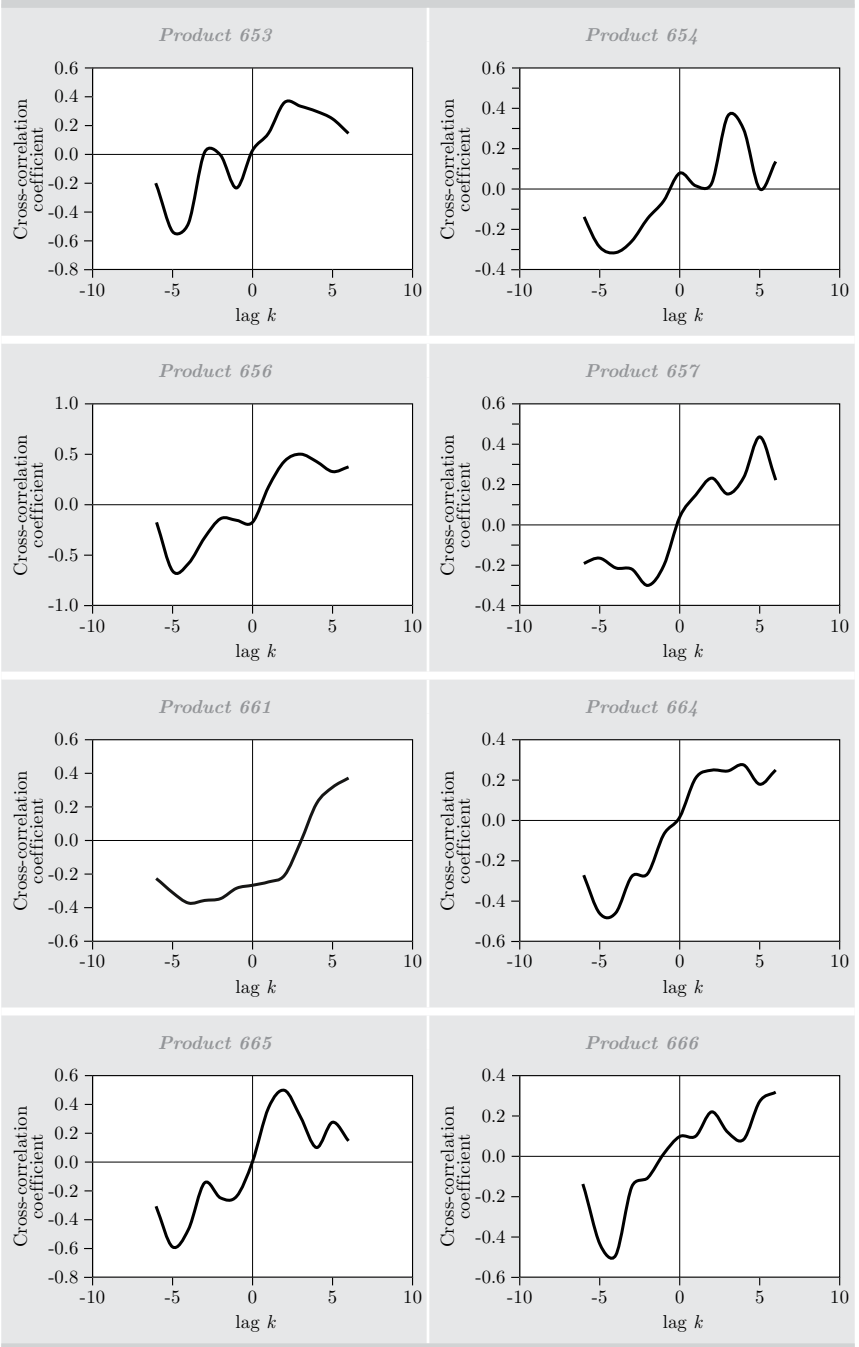


Figure 1. (continued)

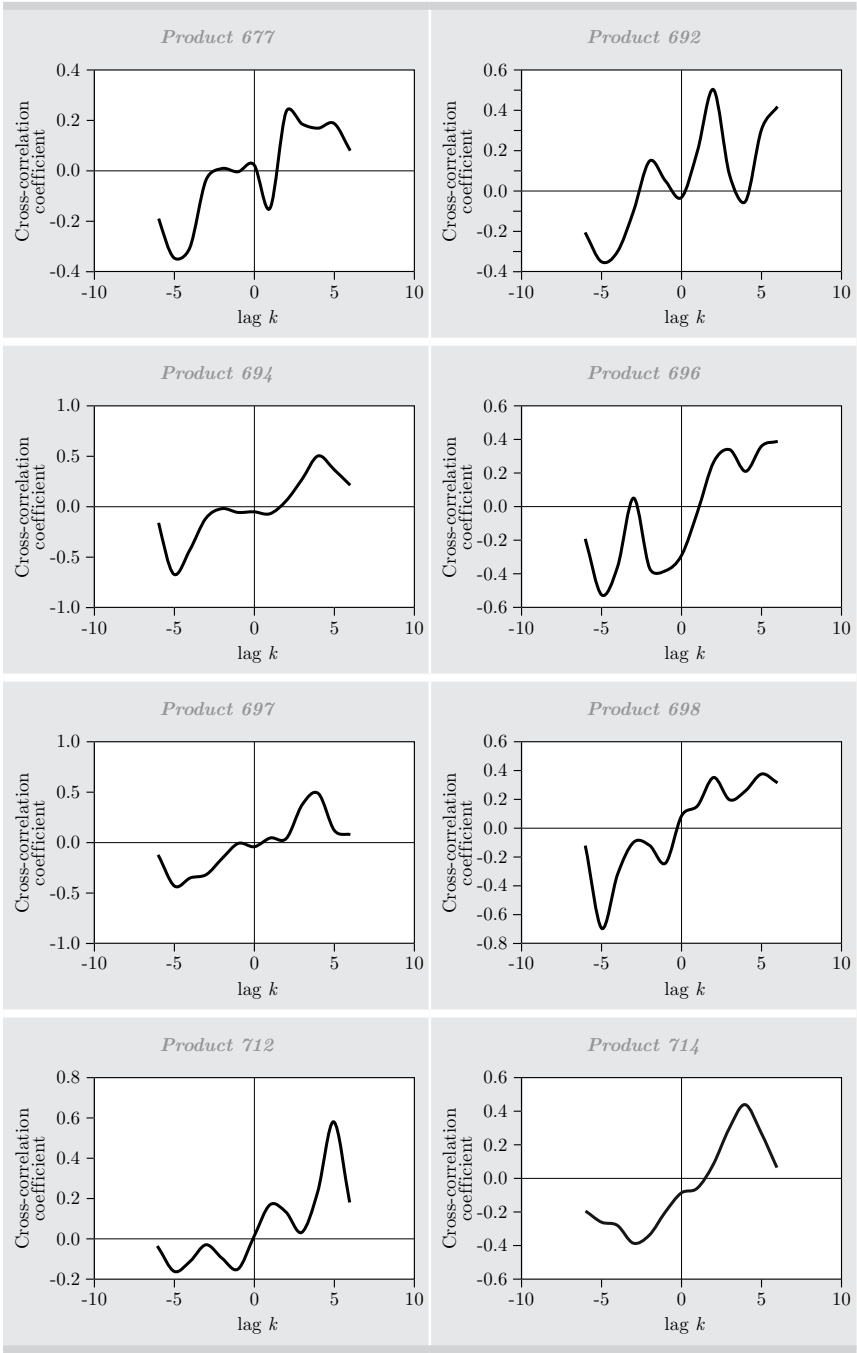


Figure 1. (continued)

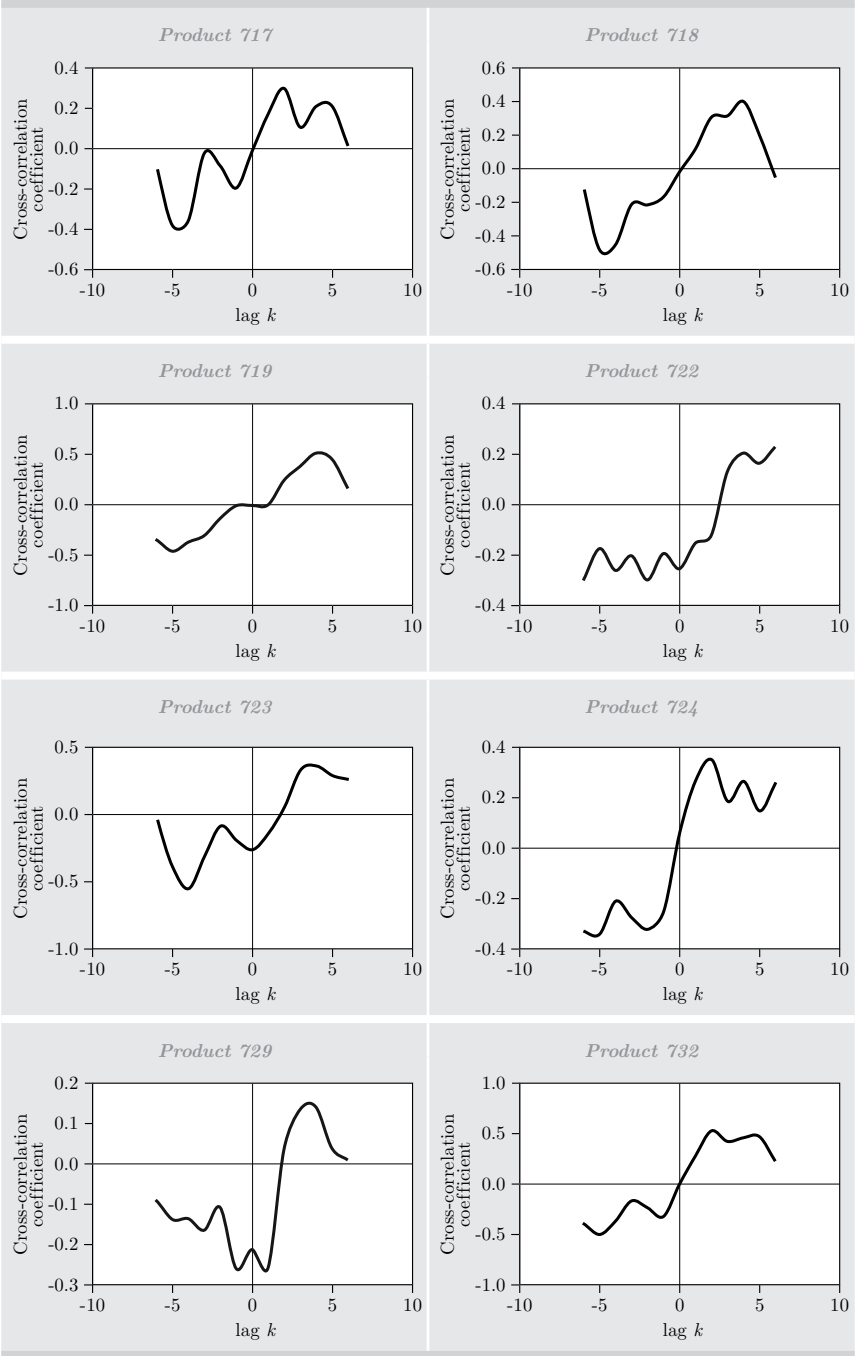


Figure 1. (continued)

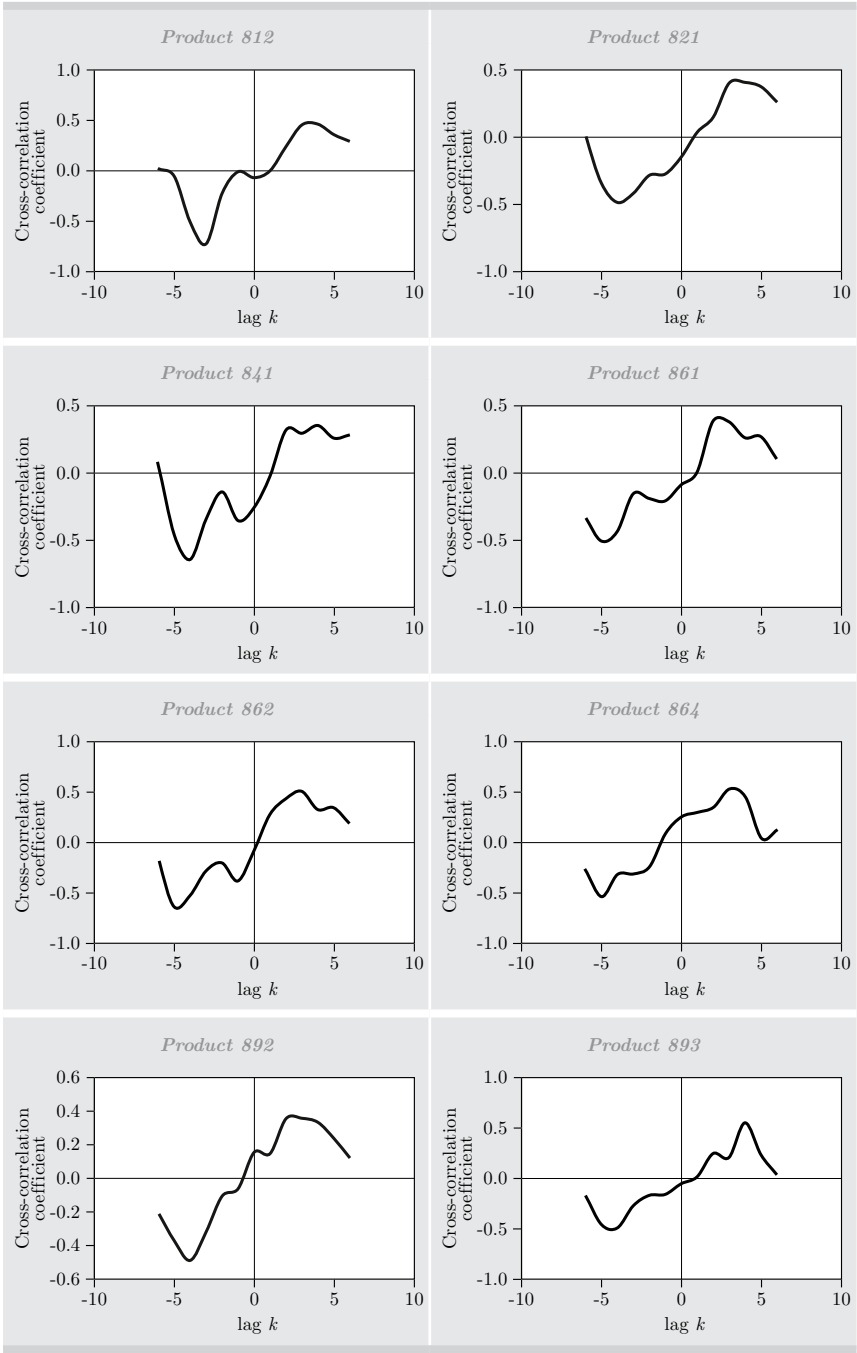
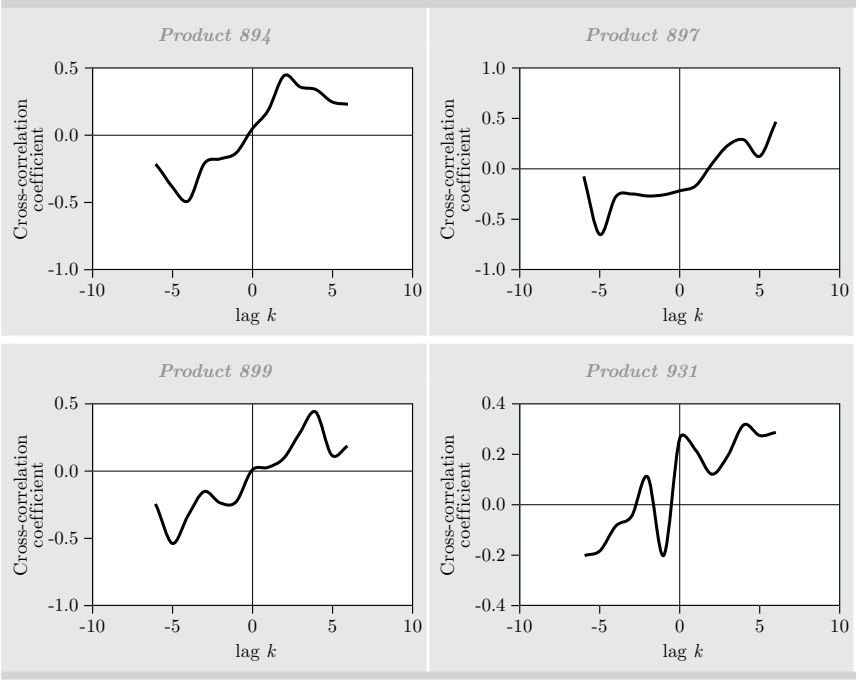


Figure 1. (continued)



Source: Authors' construction.

4. Summary

A country that is experiencing a decline in net exports or deterioration in its trade balance may adhere to currency devaluation or allow its currency to depreciate. Due to lags such as recognition, production, replacement, delivery, etc. the impact of devaluation is not instantaneous. The trade balance continues to deteriorate after devaluation and improvement comes only after the adjustment lags are realized. This short-run deterioration followed by an improvement can be tested using either the J-curve or the S-curve concept.

These curves are tested empirically by using the aggregate trade flows of one country with the rest of the world or between two countries using bilateral trade flows. In this paper we consider the experience of Brazil with the S-curve phenomenon. A previous study that includes Brazil among many other developing countries and tests the S-curve using aggregate trade flows between Brazil with the rest of the world finds weak support for the S-curve. However, in our study, we consider

not only the trade flows between Brazil and one of its major trading partners, the U.S., but we take an additional step to disaggregate the trade flows between the two countries by industry and investigate the experience of each of the 95 industries involved in that trade between the two countries. At this disaggregated level, we find support for the S-curve in 52 cases, a result that had been masked by aggregate data. Further analysis reveals that the S-pattern emerges for small as well as large industries and in durable as well as non-durable commodities, identifying industries that will reap the benefits of currency devaluation.

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U.S. MONETARY POLICY'S IMPACT ON LATIN AMERICA'S STRUCTURE OF PRODUCTION (1960-2010)

Nicolás Cachanosky*

This paper examines the effects of U.S. monetary policy on Latin America's production structure before two economic crises, specifically the effects of monetary policy on the real economy at the industrial level. Changes in the federal funds rate produce uneven effects on output trends across sectors and industries that are more capital-intensive and involved in relatively long-term projects are more sensitive to changes in the federal funds rate. Periods of loose monetary policy result in resource misallocation that is costly to correct during a bust if investment is irreversible, with a particular pattern of economic distortion during an unsustainable boom.

JEL classification: E32, E52, F44

Keywords: monetary policy, Latin America, international business cycles, structure of production

1. Introduction

The two deepest economic crises in Latin America in the last 50 years occurred in the early 1980s and in 2009; both of these episodes followed the two longest periods of deviation from the Taylor rule by the Federal Reserve. Previous research has shown that commodity prices and U.S. interest rates are among the variables that significantly impact the economic performance of Latin America (Canova, 2005; Corbo and Tokman, 2007; Gallego, Gardó, Martin, Molina, and Serena, 2010; Izquierdo and Talvi, 2008; Jara, Moreno, and Tovar, 2009; Ocampo, 2010).[1]

After the 2008 subprime crisis, some authors turned to Wicksell effects as embedded in the Mises-Hayek business cycle theory to explain what went wrong. This theory suggests that, all else being equal, loose monetary policy will have a greater effect on industries that are more capital-intensive and forward-looking than industries that are less capital-intensive and forward-looking (Borio and Disyatat, 2011; Cachanosky, 2014c; Calvo, Leiderman, and Reinhart, 1993; Calvo, 2013;

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1. Although China has increased its economic integration with Latin America in recent years, the latter remains highly integrated with the U.S. economy (Cesa-Bianchi *et al.*, 2011).

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Diamond and Rajan, 2012; Garrison, 2001; Lal, 2010; Leijonhufvud, 2009; Ohanian, 2010; Young, 2012). In this article, I study whether U.S. monetary policy produces uneven Wicksell effects at the industrial level. Young (2012) finds evidence of this relationship with respect to the U.S. economy during the period 2002-2007. Because Latin America has been found to be sensitive to U.S. monetary policy, this begs the question of whether a similar relationship exists between the Federal Reserve and Latin America. I find evidence suggesting that loose U.S. monetary policy contributes to Latin American countries' bias towards activities that are more capital-intensive and forward-looking.

Contrary to most studies that analyze the problems of international monetary shocks by focusing on the monetary transmission mechanism, this paper evaluates the impact that Federal Reserve monetary policy has on the real economy at the industrial level in Latin American countries. I find that Wicksell effects are correlated with the Federal Reserve funds as a proxy for U.S. monetary policy. This has policy implications, since a country that decides to fix its exchange rate to avoid movements in the prices of tradable to non-tradable goods through the exchange rate is more prone to importing Wicksell effects when the U.S. follows an expansionary monetary policy. As I discuss below, it may not be an accident that the two largest Latin America crises followed the Federal Reserve's two largest deviations from the interest rate prescribed by the Taylor rule.

The rest of this paper is organized as follows: Section 2 describes the data and methodology used to analyze the impact of U.S. monetary policy on Latin America's production structure. Section 3 presents and explains the results, Section 4 discusses the policy implications, and Section 5 concludes.

2. Data and Methodology

2.1 Methodology

Building on Cachanosky and Lewin (2014b), Hayek (1931), and Kirzner (2010), I refer to the combination of capital intensity and time horizon as the "roundaboutness" of economic activity. Activities that are relatively more capital-intensive and forward-looking are more roundabout than activities that are less capital-intensive and forward-looking. I divide the sector-level output of eight Latin American countries into three groups: high roundaboutness (HR), medium roundaboutness (MR) and

low roundaboutness (LR). The rationale for this categorization is that activities that are more roundabout are expected to be more sensitive to changes in discount rates than activities that are less capital-intensive and forward-looking (Cachanosky and Lewin, 2014b). If we assume that investment is irreversible, then it becomes costly to reallocate resources once they are invested in the wrong group (Dixit, 1991). In addition, capital goods and resources that are misallocated may become wasted if their re-allocation is too costly, thus reducing total factor productivity (Hsieh and Klenow, 2009; Restuccia and Rogerson, 2008). Therefore, monetary policy can contribute to producing macroeconomic cycles through accumulated distortions in real markets.

Because the present value (PV) of longer free cash flows (FCFs) is more sensitive to changes in discount rates than the present value of shorter FCFs, changes in discount rates affect the relative price of investment projects. Namely, the downward movement of a given discount rate increases the PV_{HR}/PV_{LR} ratio. In other words, the relationship between roundaboutness and interest rates is captured by the Hicks-Macaulay duration.[2] In addition, if the FCF is rewritten in terms of capital invested, as is usually the case in the economic value added (EVA®) literature, then FCFs from larger projects, in terms of capital invested, are also more sensitive to changes in the discount rate (Cachanosky and Lewin, 2014b; Lewin and Cachanosky, 2014).[3] Like Bernanke and Blinder (1992), I use the federal funds rate as a proxy for U.S. monetary policy in my analysis of whether changes in U.S. monetary policy produced uneven economic effects in different sectors of Latin America's economy.

Although the relationship examined is between investment and discount rates, investment information at the industry level is lacking for the sample period and therefore I use output as a proxy for the effects of monetary policy on economic activities, since investment is usually intended to increase output.[4] The lags included in the interest rate variable account for the delayed effects of monetary policy on output changes.

I use yearly data from 1960 to 2010 for (1) Argentina (ARG), (2) Colombia (COL), (3) Costa Rica (COS), (4) Mexico (MEX), (5) Panama (PAN), (6) Paraguay (PAR), (7) Peru (PER) and (8) Venezuela (VEN). The

2. Macaulay develops the concept of duration to analyze bonds. Hicks uses elasticity operators to analize Bhöm-Bawerk's average period of production and reaches the same analysis as Hicks.

3. For EVA®, see Rappaport (1986) and Stewart III (1991, 2002). For an application of EVA® business cycles, see Cachanosky and Lewin (2014a), and Cachanosky (2014a).

4. If $Y_i = A \times F(K_i, L_i)$ where $i = \{LR, MR, HR\}$, Y is output, A is technology, K is capital, and L is labor, then investment that increases K also increases output.

sample of countries is constrained by the availability of data. Brazil, a large country that is representative of the region, has an incomplete series. Also, the analysis requires information at the industrial level, which may be either incomplete or lacking for certain countries. Finally, although GDP numbers are usually reported on a quarterly basis, information at the industrial level is usually available only on a yearly basis.

In this analysis:

1) The Taylor rule is used as a federal funds rate benchmark to identify periods when the monetary authority clearly deviated from equilibrium values. This yields two periods of interest for the study of whether changes in U.S. monetary policy produce uneven reactions in Latin American countries' production structures.[5]

2) Economic sectors are divided into three roundabout groups: HR, MR, and LR.

3) A VAR model is estimated for each country with one equation for each activity group (HR, MR, and LR), where the output of each sector is on the left-hand-side of the regression and the federal funds rate and control variables are on the right-hand-side.

4) Hypothetical output values are estimated for each activity group in the event of a 0.5% downward deviation in the federal funds rate only for the periods identified as deviating from the Taylor rule, to avoid dragging the shock effects for the rest of the series. For example, if the federal funds rate in period t is 4%, I estimate new output values for a federal funds value of 3.5%. As is shown below, this is significantly below observed deviations from the Taylor rule.

5) The new set of hypothetical output values is used to estimate output/federal funds rate elasticities. If elasticities for each group are different, then U.S. monetary policy is correlated with non-neutral effects at the industrial level in Latin America.

I calculate classic Taylor rule interest rates between 1960 and 2010 with the following equation:[6]

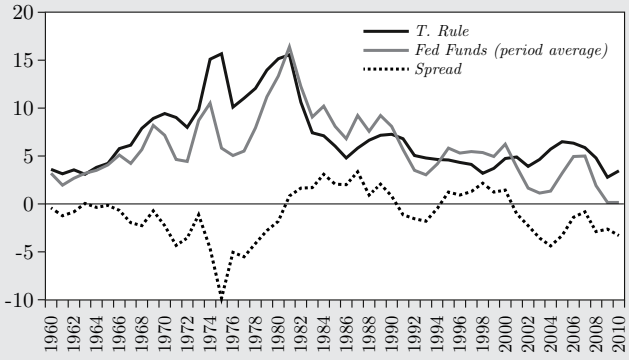
$$i_t = r_t^* + \pi_t + 0.5(\pi_t - \pi_t^*) + 0.5(y_t - \overline{y}_t) \tag{1}$$

5. The Taylor rule is used as a benchmark because it is a well-known rule. Other approaches that pay more attention to real interest rates and changes in productivity, e.g., Selgin *et al.* (2011), yield similar monetary policy deviation periods.

6. I use the same equation as Taylor (1993). For a more general treatment of Taylor rules, see Martins (2000) and Orphanides (2007).

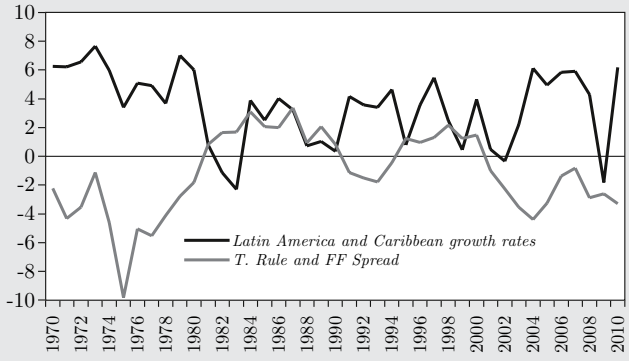
Where i_t is the target federal funds rate for year t, r_t^* is the estimated equilibrium value for the real interest rate, π_t is yearly inflation as measured by the GDP deflator, π_t^* is the inflation target (assumed to be 2%), y_t is the log of real output, and $\overline{y}_t$ is the log of potential output. The first plot in Figure 1 shows the federal funds rate, the Taylor rule rate, and the spread between both series, while the second plot contrasts Latin American and Caribbean growth rates with the Taylor rule spread.

Figure 1. Taylor rule, federal funds and LAC growth



Source: Author's calculations using data from the St. Louis FRED® Economic Data and ECLAC.

Figure 2. LAC growth rates and Taylor rule spread



Source: Author's calculations using data from the St. Louis FRED® Economic Data and ECLAC.

The first plot shows two periods with deviations from the Taylor rule: 1971-1980 and 2002-2007. The second plot shows that the two largest drops in Latin American output occurred after the two largest deviations from the Taylor rule. This invites consideration of the possibility that structural distortions accumulated during these loose monetary periods may have played a role in the two Latin American crises. Table 1 shows the spread between the Taylor rule rate and federal funds rate for both periods.

Table 1. Taylor rule and federal funds rate spread, 1971-1980 and 2002-2007

Year	T. rule	Federal fund	Spread	Year	T. rule	Federal fund	Spread
1971	9.0	4.7	-4.3	2002	3.9	1.7	-2.3
1972	8.0	4.4	-3.5	2003	4.6	1.1	-3.5
1973	9.8	8.7	-1.1	2004	5.7	1.3	-4.4
1974	15.1	10.5	-4.6	2005	6.5	3.2	-3.3
1975	15.7	5.8	-9.8	2006	6.4	5.0	-1.4
1976	10.1	5.0	-5.1	2007	5.9	5.0	-0.8
1977	11.1	5.5	-5.5				
1978	12.0	7.9	-4.1				
1979	14.0	11.2	-2.8				
1980	15.2	13.4	-1.8				

Source: Author's calculations.

As Table 1 shows, the values of the spread between the federal funds rate and the Taylor rule rate are not insignificant. In 1971, for example, the spread value is almost as high as the value of the federal funds rate itself. This means that a linear estimation of output values based on a model using Taylor rule values instead of federal funds rates might be inaccurate; using Taylor rule values rather than federal funds rates to estimate new output levels for each group is more than a minor change. For this reason, I estimate alternative output values with a 0.5% deviation from the federal funds rates rather than the Taylor rule values. Therefore, the hypothetical output values provide linear estimations of the direction and intensity of the correlation between each group's output and movements in the federal funds rate but do not provide estimates of the total deviation from what output would have been if the federal funds rate had not deviated from the Taylor rule.

2.2 Transmission mechanism

It should be noted that the sample comprises two different scenarios. Before 1980, Latin American countries had closed economies and capital controls; after 1980, some countries started to deregulate and open their economies. Exceptions to this are Venezuela and Argentina after its 2001 crisis. A comment, therefore, on the transmission mechanism is needed.

The first thing to note is that even though Latin American countries can be described as closed and with capital controls in the pre-1980 period, capital inflows were not absent. According to Calvo, Leiderman, and Reinhart (1994), capital inflows in the late 1970s exceeded capital inflows in the early 1990s, when measured as a percentage of GDP rather than in absolute values. That study also shows that during the late 1970s, bank loans and bonds were more common than foreign direct investment in the early 1990s. These authors conclude that although economic reforms took place in many countries from the 1970s to the early 1990s, the U.S. may have played an important role in determining the inflow of capital to the region.

It is also notable that the region shows signs of fear to float (Calvo and Reinhart, 2002; Hausmann, Panizza, and Stein, 2001). Fear to float occurs when countries state that they have a floating exchange rate but in fact they intervene in their foreign exchange market, importing U.S. monetary policy. Frankel, Schmukler, and Servén (2004) find a global transmission of interest rates from the U.S. to other countries, including Latin America, for the 1970s, 1980s, and 1990s.[7] While floating exchange rates do protect the domestic economy from external shocks, the effects on interest rates might be temporary.

Third, I use Levy-Yeyati and Sturzenegger's (2003) *de facto* categorization of exchange rates. Excluding Panama, none of the countries had a floating exchange rate for more than 40% of the time between 1974 and 2000 scattered throughout the period. The years and percentage of time (in parenthesis) with floating exchange rate in the Yeyati-Sturzenegger classification are as follows: ARG: 5 (19%), COL: 12 (44%), COS: 5 (19%), MEX: 6 (22%), PAR: 6 (22%), PER: 11 (41%), VEN: 3 (11%).[8] This means that together, these countries were under a floating exchange

7. The two countries not included in their sample that are studied in this paper are Panama and Peru.

8. The years logged as floating are ARG: 1977-1980, 1986; COL: 1974, 1984, 1988-1991, 1995-2000, COS: 1974, 1988, 1990-1992, MEX: 1977, 1984, 1992-2000, PAR: 1990, 1992-1993, 1998-2000, PER: 1975, 1978-1982, 1993, 1995-1996, 1998-1999; VEN: 1992-1993, 1990.

rate 25% of the time; this regime was scattered along the sample rather than there being a long period of floating exchange rates.

The aforementioned studies do not cover the same sample used in this paper; rather, they usually start their analysis in the 1970s and end it sometime in the 1990s. If there is less transmission in the years in my sample than the levels suggested by previous studies, that fact should counter the expected results, as the link between U.S. monetary policy and Latin American industrial output values should be less robust.

Domestic interest rates for the sample period are lacking. However, U.S. monetary policy has been found to affect Latin America's economy at different points in time, suggesting a connection with the region. Certainly the inclusion of domestic interest rates would provide a more robust result. But again, the lack of domestic interest rates and other economic variables plays against the expected results by underestimating them. The relationship pattern under observation is very distinctive of discount rate movements.

2.3 Economic activities categorization

Because there is no available measure of industrial roundaboutness, activities are grouped according to a mix of assumptions relating to their relative roundaboutness and a proxy of roundaboutness taken from Young's (2012) study of U.S. activities (discussed below.) For example, mining and quarrying are assumed to be more roundabout than manufacturing, which in turn is assumed to be more roundabout than real estate brokerage. Table 2 shows the categorization of each activity into one of the three groups. The objective is not to place all activities in a particular group but to construct representative groups according to relative roundaboutness. Therefore, activities for which relative roundaboutness is unclear or activities in which there is heavy regulation or a strong presence of state-run companies (i.e., public services and public administration) are dropped from the sample.[9]

This classification is not without some shortcomings. For example, the least roundabout activity in the most roundabout group may be less roundabout than the most roundabout activity in the medium roundabout group. It may also be the case that, between 1960 and 2010, some activities

9. Powell (2002) and Robbins (1934) use a similar approach to study Japan's recession in the 1990s and the Great Depression, respectively.

increased in their roundaboutness while others decreased, to the point that they should be re-categorized. In addition, some activities may have different relative roundaboutness in different countries. A sensitivity analysis could be performed by changing some of the sub-activities of each group. For instance, a manufacturing industry may be moved to the HR or LR group. However, data for this level of disaggregation is not available for the time frame in observation and therefore this exercise is not feasible. Manufacturing, which is the only sector representing the MR group, is composed of seven sub-sectors without data for the sample period.[10] However, as long as it is plausible to assume that this grouping captures relative roundaboutness, the result will shed some light on the correlation between interest rates and roundaboutness.[11]

Table 2. Economic activity classification

(roundaboutness)

Economic activity	Roundaboutness
Mining and quarrying	High
Construction	High
Transport, storage and communications	High
Manufacturing	Medium
Wholesale and retail trade, repair of goods, and hotels and restaurants	Low
Financial services, real estate intermediation, and business activities	Low
Agriculture, hunting, forestry and fishing	Omitted
Electricity, gas and water supply	Omitted
Public administration, defense, compulsory social security, education, health and social work, and other community, social and personal service activities	Omitted

Source: ECLAC.

Young (2012) estimates yearly roundabout values for different U.S. industries between 1998 and 2009 and builds a measure called TIOR (total industry-output requirement) that is "the amount of gross output from other industries that must be produced per dollar of a given industry's output: *the ratio of total gross output to final output for an*

10. Cachanosky (2014c) offers an analysis of this lower aggregation for Colombia and Panama for the 2002-2007 period.

11. Due to missing data, "mining and quarrying" is not part of Costa Rica's HR group and "transport, storage and communications," "wholesale and retail trade...," and "financial intermediation..." are not part of Peru's sample.

industry." The idea is that roundaboutness is correlated with TIOR. In this approach, the larger the ratio of total gross output to final output, the more previous work is required by a particular industry and, therefore, the more roundabout it is.

Even though the industrial classification used by Young does not exactly match the one used by the United Nation's Economic Commission for Latin America and the Caribbean (ECLAC), it is nonetheless a useful guideline for constructing the classification proposed in Table 2. As a reference, I use Young's calculations for 1998. For example, "primary metals" and "other transportation equipment" are among the more roundabout U.S. activities. Other activities such as "retail trade," "rental and leasing services and lessors of intangible assets" and "real estate" are among the less roundabout. Finally, activities such as "miscellaneous manufacturing," "fabricated metal products" and "non-metallic products" are ranked around the middle of Young's roundabout index. However, there are a few differences. If I divide Young's ranking of roundaboutness into three groups, sorting them by more to less roundabout, construction appears in the upper section of the middle group rather than in the most roundabout group. Nonetheless, construction shows a higher degree of roundaboutness than a number of manufacturing activities, such as support activities for mining and publishing industries. Although there may be some overlap between activities in the HR, MR and LR groups, the classification in Table 2 follows a pattern similar to Young's classification.[12]

2.4 The VAR model

To estimate the effects of changes in the federal funds rate on Latin American countries, I run a vector autoregressive (VAR) model where the dependent variables are the cyclical component of the HP filtered log of real output of each group. The independent variables are (1) the federal funds rate (period average) with two lags in addition to the contemporaneous value, (2) the cyclical component of the HP filtered log of U.S. real output, (3) the ratio of exports to imports as a trade variable and (4) the cyclical component of the HP filtered prices of commodities.[13] Because Latin American countries do not affect the

12. I would like to thank Andrew T. Young for sharing his database and calculations. His methodology cannot be replicated for Latin American countries due to the lack of data.

13. The price of commodities is an average of the real prices of the Energy price index, the Non-energy price index and the Precious Metals price index in the World Bank Commodity Price Data (Pink Sheet).

U.S. economy, it is unlikely that the effects of U.S. monetary policy in Latin America will produce a feedback effect into the U.S. economy that would trigger a revision of its own policy.[14]

Independent variables (1) and (2) capture the relationship between the U.S. and Latin American countries (i.e., monetary and real shocks.) Independent variable (3) captures the effects of terms of trade between Latin American countries and the rest of the world. Variable (4) captures independent external commodity price shocks, which is an important variable for Latin American countries. This variable also captures external shocks other than those generated by the U.S. Although the United States remains Latin America's largest trading partner, the impact of other economies has grown significantly. Cesa-Bianchi, Pesaran, Rebucci, and Xu (2011) find that the importance of China in Latin America's trade increased from 1% in 1980 to 12% in 2009. These authors also find that China has direct and indirect effects (through its effect on other countries) on Latin America. In particular, a significant characteristic in the emergence of economies in Asia is the effect on the price of commodities. Given the importance of commodities prices for Latin American countries, and the effect of the rest of the world on such prices, this variable captures non-U.S. shocks that might be relevant.

Due to missing values, Peru's regression starts in 1970. In addition, because the model must work with the direct relationship between the federal funds rate and each country, and not with the behavior of domestic authorities, movements by domestic monetary authorities that are independent of the Federal Reserve are not captured in these regressions. Furthermore, potential cross-correlation between the outputs of each country is not captured in the model due to the lack of degrees of freedom to add the output of all countries in all equations.

The number of lags used is that which yields the best information criteria values constrained by the presence of inverse unit roots inside the unit circle. This is because the estimated coefficients will be used to estimate a series of hypothetical output values that depend on lag values, and the presence of inverse roots outside the unit circle would produce unstable and unreliable results.[15]

14. Data sources are as follows: (1) Economic Comission for Latin America and the Caribbean (ECLAC) (GDP, exports and imports for Latin American countries); (2) FRED® Economic Data (federal funds rate, U.S. real GDP); (3) World Bank Commodity Price Data, Pink Sheet (commodity prices).

15. Lags: ARG = 2, COL = 1, COS = 6, MEX = 1, PAN = 3, PAN = 6, PAR = 3, PER = 2 and VEN = 2.

Using the coefficients from each model, hypothetical output values are estimated for each group (LR, MR, and HR) for each country for the 1971-1980 and 2002-2007 periods with a permanent downward deviation of 0.5% from the federal funds rate. Hypothetical output values are calculated with a deviation from the federal funds rate rather than the Taylor rule rate because the spread between these two series is too large for a linear estimation to yield reliable numbers. To avoid carrying differences throughout the entire sample, the hypothetical output value with deviated federal funds rates is calculated only for periods in which deviations from the Taylor rule are identified, namely, 1971-1980 and 2002-2007.

Model 1 shows the VAR(p) specification used to estimate the coefficients. The y vector includes the cyclical component of the three groups (HR, MR, and LR). Each model has three equations: one per activity group (HR, MR, and LR). The FF variable is the federal funds rate trend, and the X vector contains the other variables of the model, as specified above. Once Model 1 is calculated, Model 2 is used to estimate a new y series for each group using $d = 0.5$ as the deviation from the observed federal funds rate in the periods 1971-1980 and 2002-2007. Each country has its own Model 1 and Model 2.

$$\begin{aligned}
\text{Model 1} \quad \left[y_t\right] &= C + A_1 y_{t-1} + \cdots + A_p y_{t-p} + B_1 FF_t + B_2 FF_{t-1} \\
&\quad + B_3 FF_{t-2} + EX_t + e_t \\
\text{Model 2} \quad \left[\widehat{y}_t\right] &= C + A_1 y_{t-1} + \cdots + A_p y_{t-p} + B_1 (FF_t - d) \\
&\quad + B_2 (FF_{t-1} - d) + B_3 (FF_{t-2} - d) + EX_t + e_t
\end{aligned}$$

3. Results

3.1 Monetary policy effects at the industrial level

Table 3 shows which output ratios changed during the periods 1971-1980 and 2002-2007, and in which direction–up or down–according to the observed data. There are a total of 24 output ratios, for eight countries with three output ratios each: (1) HR/LR, (2) HR/MR and (3) MR/LR. If the output ratios increase, then activities that are relatively more roundabout increase their output more than the relatively less roundabout industries. I use a change of 2.5%, 5.0%, 7.5%, and 10%

for each period as a threshold to determine whether a change in the output ratio should be considered economically relevant. Any output ratio that changes more than the threshold value is marked "Up" or "Down" according to the direction of movement. If the change is less than the threshold value, then the output ratio shows "No change." For example, with respect to a threshold level of 5%, there were a total of 13 output ratios that increased by more than the threshold level between 1971 and 1980 and a total of 11 output ratios that did the same between 2002 and 2007. A total of 6 output ratios decreased more than 5% for the first period and 5 output ratios did the same for the second period. Finally, 5 and 8 output ratios show no change at the 5% threshold level for the respective periods. The table shows that, for all threshold levels, more output ratios move upward than downward in both periods with the exception being the 10% threshold level for the 2002-2007 period.

Table 3. Total output ratio changes above threshold levels

(1980 and 2007)

Threshold level	1980	2007	1980	2007	1980	2007	1980	2007
	2.5%		5.0%		7.5%		10.0%	
Output ratio increase	15	13	13	11	12	10	11	8
No change	7	5	6	5	5	4	5	4
Output ratio decrease	2	6	5	8	7	10	8	12

Source: Author's calculations.

Table 4 shows the estimated output/federal funds rate elasticities between 1971-1980 and 2002-2007 when the federal funds rate is deviated downward by 50 basis points.[16] The first notable result is that each sector shows different elasticity values, while the second notable result is that the elasticity values for each sector for 1971-1980 differ from the elasticity values for the same sectors for 2002-2007. Third, the relatively more roundabout sectors do not always have a higher elasticity than less roundabout sectors. This may be due to a combination of the following factors: activities being misclassified, too much overlap between the LR and MR groups, a specific regulatory framework in the region that affects the manufacturing sector differently

16. To calculate the elasticity, the average federal funds value is used as a reference for each period.

than the rest of the economy, changes in relative roundaboutness that occurred during the time sample that are not captured in the regression, varying behavior by domestic monetary authorities, and greater isolation from U.S. monetary policy.

Table 4. Output/fed fund elasticity with 100bp downward deviation

Country	Group	1971-1980	2002-2007	Country	Group	1971-1980	2002-2007
ARG	HR	0.69	0.03	PAN	HR	-2.36	-0.46
	MR	-2.01	-2.21		MR	-0.62	-0.41
	LR	-1.99	-1.36		LR	-0.02	-0.37
COL	HR	-0.22	-0.28	PAR	HR	-2.13	-0.69
	MR	-0.93	-0.21		MR	-1.50	-0.41
	LR	-0.22	-0.37		LR	-1.22	-0.65
COS	HR	-2.99	0.43	PER	HR	-1.74	-0.34
	MR	-1.25	-0.18		MR	-1.33	-0.17
	LR	-1.17	0.12		LR	-1.30	-0.11
MEX	HR	-1.56	0.01	VEN	HR	-0.88	-0.26
	MR	-1.05	0.01		MR	-1.20	-0.28
	LR	-1.21	0.11		LR	-1.49	-0.50

Source: Author's calculations.

Finally, I use the same threshold levels of 2.5%, 5%, 7.5%, and 10% to determine how many HR elasticities are larger (in absolute values) than LR output/fed funds rate elasticities. For instance, if the HR output/fed funds rate elasticity is 5% larger (smaller) than the LR output/fed funds rate elasticity, then it is categorized as "HR > LR" ("HR < LR"). If the difference between both elasticities is less than the threshold level, then the table shows the label "HR = LR." Table 5 shows that HR group output is consistently more sensitive to changes in the federal funds rates than LR group output and that significant differences at the threshold level are persistent.

The results shown in the tables above indicate the presence of uneven effects on the production structure of Latin American countries as captured in different elasticities; for all thresholds, the number of different elasticities is less than the total number of different elasticities. Also, the table suggests that more roundabout sectors are more sensitive to changes in interest rates.

Table 5. Are HR and LR output elasticities different?

	1980	2007	1980	2007	1980	2007	1980	2007
	2.5%		5.0%		7.5%		10.0%	
ARG	HR < LR	HR < LR	HR < LR	HR < LR	HR < LR	HR < LR	HR < LR	HR < LR
COL	HR = LR	HR < LR	HR = LR	HR < LR	HR = LR	HR = LR	HR = LR	HR = LR
COS	HR > LR	HR > LR	HR > LR	HR > LR	HR > LR	HR > LR	HR > LR	HR > LR
MEX	HR > LR	HR < LR	HR > LR	HR < LT	HR = LR	HR < LR	HR = LR	HR < LR
PAN	HR > LR	HR > LR	HR > LR	HR > LR	HR > LR	HR = LR	HR > LR	HR = LR
PAR	HR > LR	HR = LR	HR > LR	HR = LR	HR > LR	HR = LR	HR > LR	HR = LR
PER	HR > LR	HR > LR	HR > LR	HR > LR	HR = LR	HR > LR	HR = LR	HR > LR
VEN	HR < LR	HR < LR	HR < LR	HR < LR	HR < LR	HR < LR	HR < LR	HR < LR
HR > LR	5	3	5	3	3	2	3	2
HR = LR	1	1	1	1	3	3	3	3
HR < LR	2	4	2	4	2	3	2	3

Source: Author's calculations.

3.2 Floaters and non-floaters

To determine if floaters and non-floaters behave differently during a boom and bust cycle, I rank the countries according to nominal exchange rate variability, which is calculated as the coefficient of variation (CV) of their nominal exchange rates. A country with a fixed exchange rate will have a value of zero for the standard deviation of the nominal exchange rate and therefore a value of zero for the CV. In contrast, a country with a high standard deviation of the nominal exchange rate with respect to the mean will be a floater. I calculate the CV of the nominal exchange rate for each country for the periods 1971-1980 and 2002-2007. Panama, a dollarized economy, has the same position as a fixed exchange rate economy in both periods, whereas other countries demonstrate different exchange rate behaviors in each period. Argentina, for example, is a floater in the first period but behaves like a fixed exchange rate economy in the second period due to its managed float policy.

Table 6 shows the CV for each country and for each group. Note that the nominal exchange rate variability for each of the eight countries decreased in the second period relative to the first period. Figure 3 shows the yearly growth rate for each country in each group in both periods, plus/minus one standard deviation. The reason the periods of analysis were extended by five years and three years, respectively, is to account for the effect of the crises on these two measures of output for each group. The graph shows no discernible pattern in either the yearly growth rates or the standard deviations. Specifically, neither floaters nor non-floaters have a higher yearly growth rate or demonstrate less output level volatility. Namely, at the industrial level, exchange rate regimes do not seem to protect against an exogenous loose monetary policy.

Table 6. Nominal exchange rate coefficient of variability (CV)

1971 – 1980	CV	2002 – 2007	CV
ARG	1.54	VEN	0.21
PER	0.84	COS	0.14
MEX	0.31	COL	0.11
COL	0.27	PAR	0.08
COS	0.12	MEX	0.05
VEN	0.01	PER	0.04
PAR	0.00	ARG	0.03
PAN	0.00	PAN	0.00

Source: Author's calculations based on the International Monetary Fund's IFS database.

Comparing with Table 4, the predicted effects show up unambiguously in the fixed exchange cases: Panama for both periods and Paraguay between 1971 and 1980. The expectation is that the lower the CV of the exchange rate, the more direct the transmission from U.S. monetary policy and the more clearly the Wicksell effects show up. In the opposite case, a pure or perfect floating exchange rate would show less Wicksell effects but, on the other hand, would show a larger effect between tradable and non-tradable sectors since the exchange rate moves freely. However, because the region is not completely isolated from U.S. monetary policy, these effects also appear in the other countries, even if they are not as unambiguous as the fixed exchange rate cases. This means that in the presence of an expansionary monetary policy of a large economy there is a trade-off between exchange rate appreciation and the import of Wicksell effects (Cachanosky, 2014d).

Figure 3. Yearly output growth rate +/- one standard deviation

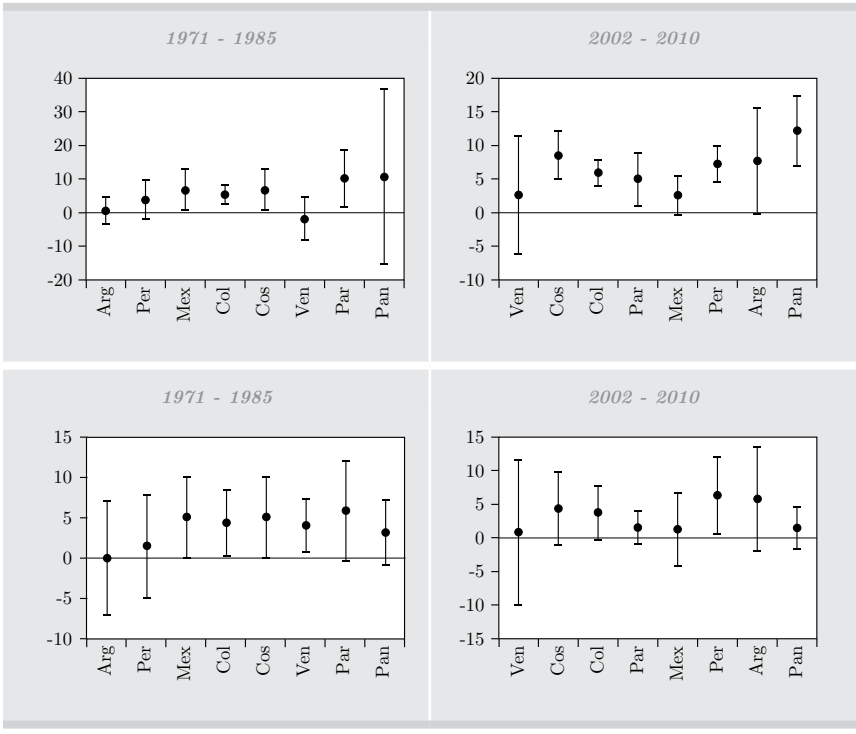
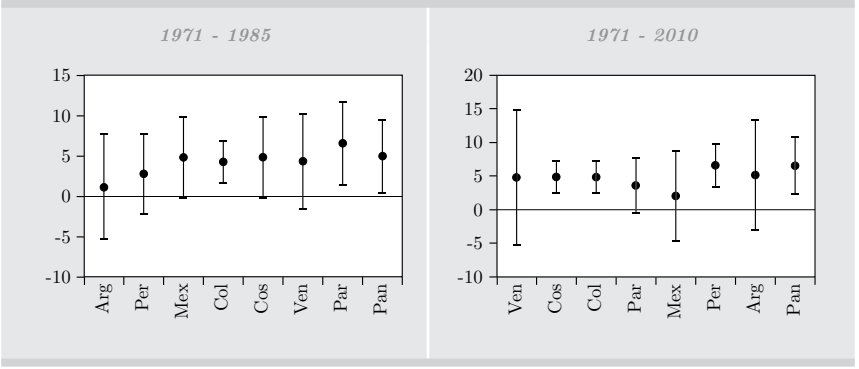


Figure 3. (continued)



Source: Author's calculations based on the IMF's IFS database and ECLAC.

4. Policy Implications

The results presented in this paper have two important policy implications. The first one is that because the exchange rate can either magnify or absorb an external shock, countries that have different exchange rate regimes are expected to react differently to a similar shock. In the presence of a monetary shock, a fixed exchange rate regime avoids changes in the relative price of tradable and non-tradable goods, while a floating exchange rate distorts the relative price between these two sectors. Conversely, in the presence of a productivity shock, a flexible exchange rate allows for faster accommodation in the relative price of tradable and non-tradable goods if necessary, but carries foreign exchange rate risk (Calvo and Mishkin, 2003; Corsetti and Pesenti, 2005). However, studies have found that Latin American countries that follow different exchange rate regimes show similar rather than divergent output behavior (Canova, 2005). This paper helps to solve this puzzle. If excess liquidity in the years prior to a crisis can explain a common set of economic distortions in Latin America, then U.S. monetary policy prior to an economic crisis can explain part of the unexpected co-movement in the business cycles of Latin American countries with different exchange rates.

The second implication is the fact that economic imbalances caused by a loose monetary policy can occur in the absence of inflation, as the 2008 subprime crisis shows. Borio and Disyatat (2011), Leijonhufvud (2009) and Selgin, Beckworth, and Bahadir (2011) argue that the Federal Reserve was misled into keeping interest rates too low for too long by the use of price level stability as a proxy for monetary

stability. The problem is that price level stability can be an unreliable measure of monetary stability in the presence of productivity gains. A monetary policy that keeps interest rates too low for too long in order to keep price levels stable in the presence of productivity gains does not cause observable inflation but does produce implicit inflation by preventing the price level from falling. There is an excess of money supply which eventually affects the allocation of resources in the market. Because of this problem, some authors have recently suggested that a productivity-norm policy that stabilizes a measure of nominal income, such as NGDP, is a better monetary policy than price level stability (Selgin, 1997; Sumner, 2012; White, 2007).[17]

5. Concluding Remarks

The effects studied in this paper suggest that the fact that both of the two largest economic crises in Latin America occurred after a period of monetary deviation by the Federal Reserve is not a coincidence. Young (2012) identifies an increase in the roundaboutness of the U.S. economy during the period 2002-2007; this paper shows a correlation between the roundaboutness of Latin American and U.S. monetary policy. Some scholars have shown an interest in whether Wicksell effects as embedded in the Mises-Hayek business cycle theory can contribute to an explanation of what went wrong in the 2008 financial crisis. This paper offers an analysis of how particular concepts of the Austrian theory can contribute to our understanding of international business cycles.

Studies on the international transmission of Wicksell effects are lacking. This paper sheds some light on the presence of these effects and points out some potential transmission mechanisms. But the paper also reveals the need for more detailed research about how this effect materializes in the case of dirty floats. Following previous findings, fear to float seems to be a good candidate, but this may not apply to other countries or regions and may not be the only transmission mechanism.

These results also invite further research. For example, have these problems been present in other regions and business cycle periods? What are the effects on labor markets and production factors? Taking the international context into consideration, what type of monetary policy would minimize imbalances in domestic and international economies?

17. For a historical account of the productivity norm, see Selgin (1996, Chapter 8). For a discussion of different approaches to and applications of this problem, see Cachanosky (2014b).

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