First Nature Determinants in South American Industrial and Economic Development

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Summary

Following a recent line of research promoted by the Harvard Centre for International Development (and by Jeffrey Sachs in particular), the paper explores the relationship between first nature determinants (i.e.: natural geography) and economic as well as industrial development in South American countries before the implementation of the New Economic Model in the region. The historical and empirical analyses point to a significant influence of geographical characteristics on both the level of a country's economic development (particularly through climate and the degree of accessibility to the sea) and the level of a country's industrialisation (particularly through the population size and the ease of transportation) throughout the region. The results largely confirm the theoretical predictions and may bear significant policy implications for governments as well as for development actors.

Resumen**

Siguiendo una línea reciente de investigación, promovida por el Centro Internacional de Desarrollo de Harvard (y en particular por Jeffrey Sachs), el documento explora la relación entre los determinantes de primera naturaleza (i.e.: naturaleza de la geografía) y el desarrollo económico, así como el desarrollo industrial en los países de América del Sur antes de la implementación del Nuevo Modelo Económico en la

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región. Los análisis históricos y empíricos apuntan hacia una significativa influencia de las características geográficas (particularmente a través del clima y el acceso al mar) y de los niveles de industrialización del país (particularmente por el tamaño de la población y las facilidades de transporte) en los niveles de desarrollo económico de los países de la región. Los resultados confirman ampliamente las predicciones teóricas y podrían incluir significativas implicaciones de política tanto para gobiernos como para agentes de desarrollo.

1. Introduction

In recent years an increasingly more significant line of research, promoted in particular by the Harvard Centre for International Development, has highlighted the direct influence of a country's physical geography on its level of economic development (e.g.: Gallup, 1998; Gallup *et al.*, 1998 and 2000; Radelet and Sachs, 1998; Sachs, 2003). The basic idea is that the inherent features of the landscape (i.e.: climate, degree of accessibility, resource endowments and so on) affect the location of economic activity throughout countries. For instance the lack of access to the sea of a landlocked country may undermine its development by constraining internal trade and productivity as well as international trade. Indeed Gallup *et al.* (1998) calculated that the 29 landlocked non-European countries in the world have an average income significantly lower to the non-European coastal countries.[1] In the same line a tropical climate may negatively affect a country's growth via its adverse effects on agricultural productivity (Gallup, 1998).

Such features are inherently natural and are predetermined for any country; thus they represent *first nature* determinants of economic activity, as opposed to the concept of *second nature*, which concentrates on the efforts of the human's actions in trying to soften the constraints of first nature (Ottaviano and Thisse, 2004). This paper concentrates on the first nature determinants in order to assess their influence on the economic development of South America.

This focus on only one region of the world makes this work different from the majority of those ones in search for such influence, which usually test for the relationship between geography and economic development through cross-country regressions

1 Such difference is significant at the 1 percent level.

including all the regions of the world. While such one-region focus penalises the statistical significance of the empirical verification, on the other hand it guarantees more uniformity and homogeneity between countries. In this sense it serves as a sort of control for other countries' characteristics, such as history, culture and institutional quality, which may spoil the relationship between geography and economic development when a very heterogeneous sample of countries is considered.

Indeed South America is a land mass composed of countries situated mostly in the Southern hemisphere, with a similar history of colonisation and independence, a common culture, analogous patterns of trade policies and with fairly similar distances to core markets (United States and Europe).[2] The latter point is the main reason why this discussion concentrates only on South America and not on Latin America as a whole, as it is in much of the economic literature. As a matter of fact Central America, and Mexico in particular, are heavily influenced by the vicinity to United States, which has a significant impact on their economic development. For instance a free trade agreement such as NAFTA has made Mexico an important assembly centre for foreign producers wanting to export to North America. This geographic location therefore would thus spoil the relative homogeneity of conditions on which the analysis of the paper is based.

With respect to the traditional literature in the field, the present work also adds an analysis of the physical geography's influence on a country's industrial development. Despite the little attention the literature has dedicated to it, this relationship appears to be relevant in different respects. Firstly, in as much as industrialisation is crucial for long-run growth, as suggested by Zattler (1996),[3] such relationship could be used as a sort of robustness analysis for the more general one between geography and economic development. Secondly, industrial activity has always been particularly relevant in

2 It has to be noted though that, within such relative homogeneity, quite different geographic conditions among South American countries do exist, which make distances to core markets may differ significantly in economic terms.

3 This is for two main reasons: productivity growth and technical development are higher in manufacturing industry than in other sectors and industrialisation avoids the dependence of the country on primary exports, which are subject to a long-run deterioration of the terms of trade. As a matter of fact, a fairly large empirical evidence (Larraín, Sachs and Warner, 1999) supports the view that the existence of a large industrial sector seems to be a necessary condition to a steady growth path. I would add a third reason in that the manufacturing industry is also the sector of the economy with the highest density of backward-forward linkages, which, as first noted by Hirschmann (1958), are crucial to economic development through strategic complementarities and positive spillovers.

South America as compared to the rest of the world's periphery, and its promotion has been the object of the region's widespread import substitution industrialisation (ISI) strategy during the post-war period. Moreover, industrial development represents a more specific issue to investigate and on which basing policy recommendations than economic development as a whole. Indeed, the analysis of the geographical influence on a country's industrialisation could provide some useful insights for the elaboration of governmental industrial policies.

Maybe surprisingly the following discussion abstracts from one of the main features of South America's physical geography, namely the high land/labour ratio, whose prominent role in shaping the region's industrial and economic development has been well underlined by Wood (2002). However the use I have made of first nature determinants of location in the paper aims at explaining the differences in terms of industrial and economic development between South American countries rather than of the region as a whole. These differences do not seem to be influenced in a relevant way by the land/labour ratio, which is similar throughout the region: virtually all South American countries have a high value of this ratio.

The rest of the paper is organised as follows: Section 2 and 3 draw a brief historical excursus of economic and industrial development in the region trying to identify the channels through which geography has influenced the location of economic activity and industry in South America; Section 4 presents a simple econometric test for such channels using country-based South American data; Section 5 concludes, drawing some policy implications and indicating a few directions for future research.

2. The Role of Geography in South American Economic Development

The first relatively large scale productions in South America emerged with the Incas, who developed production of metals, textiles, clothing and pottery mainly in the Andes (Bakewell, 1984). This production location was a consequence of the geographical division of the Inca empire, whose main cities developed on the highlands, as they were more protected from external attacks and from tropical illnesses. Thus the more convenient geographic characteristics of the highlands contributed to determine the pattern of production and economic development of pre-colonial societies.

The spatial distribution of population and economic activity during the European domination remained that of the pre-Columbian times, with the major exception of areas where precious minerals were found (such as Potosí and Minas Gerais) and of coastal settlements, which acted as control centres for the economic exploitation of the sub-continent by Europeans (Newson, 1996). As a matter of fact, the Andean areas of South America[4] were the most densely populated regions, making them the most attractive zones to European colonists. That was probably due to the potential to exploit a large sedentary native population, by forcing it to work to extract natural resources or by taxing it by taking over existing tribute systems. Indeed, Acemoglu, Johnson and Robinson (2002) argue that high population density was the main driving force for colonists to develop the so-called "extractive institutions", which are likely to discourage investment and economic development by concentrating power in the hands of a small elite and by creating a high risk of expropriation for the native population. On the other hand, colonisation tended to introduce better institutions in previously sparsely settled and less prosperous areas, where Europeans could easily settle in large numbers, finding a more suitable disease environment and a more temperate climate. Such causality points to the reversal of levels of development between colonial and recent time (a point already made by Gunder Frank in his development of underdevelopment thesis). This pattern seems to have been followed throughout South America, where the least prosperous and populated parts of South America (i.e.: Argentina, Uruguay, Chile and temperate areas of Brazil) had larger European settlements that laid the bases for subsequent economic development and reversed the relative economic positions of pre-Columbian times. Instead the densely populated Andean areas were difficult environments (due to the altitude, the climate and the difficult terrain) for the colonists to settle and served mostly for plundering native treasures and extracting precious minerals. In line with this considerations, the Spanish developed the west-east roads based on the ports at the expenses of the north-south route along the Andes that served to integrate the Inca empire.

Following these arguments, some recent studies (Acemoglu *et al.*, 2002; Easterly and Levine, 2002; Rodrik *et al.*, 2002) claim that the indirect effect on institution quality constitutes the dominant influence of geography on economic development, with little

4 These areas comprise roughly the Inca empire, which extended throughout the actual Ecuador, Peru and parts of Bolivia, and other chiefdoms in the northern part of the South American Andean area, including parts of the actual Venezuela and Colombia.

or no direct effect of geography on income. I agree with Sachs (2003, pp. 2-3) that in fact "many of the reasons why geography seems to have affected institutional choices in the past (e.g. the suitability of locations for European technologies, the disease environment and risks to survival of immigrants, the productivity of agriculture, the transport costs between far-flung regions and major markets) are indeed based on *direct* effects of geography on production systems, human health, and environmental sustainability, and many of those very same channels would still be likely to apply today". Sachs himself, using cross-country regressions with malaria risk as the geographical variable, shows that geography has a direct effect on the level of *per capita* income, after controlling for institution quality. Thus I would then consider the direct and indirect effect of geography on economic development as complementary rather than alternative explanations. In any case, disentangling and quantifying the direct and indirect effects of geography on economic and industrial development is not within the scope of this paper, for the central idea is only to investigate the role played by geography in shaping economic differences among South American countries.

As we shall see below, other effects of geography, identified by the literature as affecting countries' economic development more directly, appear to have played a relevant role in South America. Such effects are based on an idea which goes back to Montesquieu (1750), whereby environment directly influences the quality of land, labour, and production technologies. For example, compared to temperate climates, tropical environments tend to have poor crop yields, more debilitating diseases, and endowments that cannot effectively employ production technologies developed in more temperate zones (Diamond, 1997). Gallup (1998) finds that tropical agriculture suffers a productivity decrement of between 30 and 50 percent compared with that of temperate zones. Similarly, Gallup *et al.* (1998) argue that coastal regions are strongly favoured in development relative to landlocked economies, which are constrained in their ability to access a large economic market, and thus to exploit economies of scale and increase their production efficiency.[5] Radelet and Sachs (1998) calculate that,

5 The authors also notice that landlocked economies tend to be particularly disadvantaged even when they are no farther than the interior parts of coastal economies for three main reasons. Firstly, infrastructure development across national borders is much more difficult to arrange than within a single country. Secondly, coastal economies may have military or economic incentives to impose costs on interior landlocked economies (a quite clear example in this respect is the case of Chile and Bolivia, which still lack diplomatic relation after the war at the end of 1800). Finally, cross-border migration of labour is more difficult than internal migration.

ceteris paribus, a landlocked country pays 63 percent more than a coastal economy in freight and insurance costs.[6] Moreover, the topography of a country may constitute barriers to internal trade as well (especially in the case of mountain areas), reducing specialisation and slowing the diffusion of technology and thus the progress of economic development (Wood, 2002). Finally, resource endowments like minerals or ecological conditions favouring cash crops may also influence income. According to this hypothesis, the environment shapes economic development directly by influencing the inputs into the production function and the production function itself (i.e. certain endowments could make production technologically more difficult).

3. The Role of Geography in the Rise of Industry in South America

Economic and industrial development are clearly much intertwined, with causality running in both directions. At a general level we can argue that the beginning of industrialisation is influenced by a country's relative level of economic development, while the successive economic development is significantly determined by a country's industrialisation pattern.

The earliest industries in South America were limited to the processing of primary products prior to export (thus linked to natural resource endowments), and to make the goods necessary to sustain the local population, as in the case of the textile industry. Consequently, industry developed in a limited number of locations: at the point of production of commodities, such as the sugar zones of North-East Brazil, and the mines of Upper Peru, Potosí and Minas Gerais; at the ports in Brazil, Argentina and Peru; and in the cities of the Central Andes. Economic activity and population distributions experienced major changes during the nineteenth century, when the temperate regions, which had remained fairly underdeveloped throughout the colonial period, received an influx of capital, technology and immigrants aimed at developing the production of temperate agricultural products for which demand had developed in Europe with the Industrial Revolution (Newson, 1996). Moreover, the improvement in transport, especially through an expansion of the railway network, allowed the exploitation of resources from the interior, confirming and strengthening the spatial pattern of

6 They calculate this value as the coefficient of the dummy variable for landlocked economies in a regression with shipping costs (measured by the CIF/FOB band) as dependent variable.

industrialisation that focused on existing hubs such as capitals and ports (e.g.: Lima-Callao, Rio de Janeiro, Sao Paulo, Buenos Aires, Montevideo, Santiago, Valparaiso). Moreover, around the beginning of the twentieth century the railway system encouraged the first factory-scale industries such as brewing, sugar-refining, sweet manufacturing and textiles. For instance Sao Paolo was the main town where the rail net was focused in Brazil. This development made it the principal industrial centre in Brazil, with a ten-fold increase in population between 1890 and 1920 and with 121 mechanised factories by 1895. In contrast, the construction of the railway was more difficult in the Andean areas, where the combination of extractive institutions and high transport costs (due to the scarcity of transport infrastructures) seem to have been the main causes for the decreasing attractiveness of the highlands as a production location.

On the other hand larger European settlements, better institutions and easy access to the sea have been important in attracting a larger population, especially relatively highly skilled immigrants, towards temperate areas of the Southern cone (in particular Argentina and Brazil), which soon became the most populated countries of the region (Table 1). This feature proved to be a further propellant for industrialisation, by allowing the exploitation of economies of scale and by attracting foreign investment, which although limited in scale, was important in the development of modern industries, such as vehicles, chemicals and pharmaceuticals.

Thus by the late 1940s, there were considerable contrasts in the level of industrialisation and its structure between countries (see Table 1). Three groups of countries have been identified by Dickenson (1996) on the basis of the level of industrialisation: the more industrialised countries including Brazil, Argentina and, to a lesser extent, Chile, characterised by easy access to the sea, a temperate climate in most of their areas and a smooth terrain, which eased internal transports; the intermediate group, including Peru, Colombia and Venezuela, characterised by limited industrial progress, medium size population, difficult terrain[7] and an undeveloped transport network; and the least industrialised group consisting of small countries with little population and a very limited industrial base. We find in this group the two landlocked countries of the region, Bolivia and Paraguay, two Andean countries, Bolivia and Ecuador (which also lays on the equator) and the smallest country in our analysis,

7 These countries share most northern part of the South American Andean range.

Uruguay. This pattern of industrial development was essentially perpetrated during the successive ISI period, when the success of nationalist policies in promoting domestic industries heavily depended on the market size and the level of industrialisation already reached by these countries.

Table 1
Employment in industry and population in about 1950

Country	Employed (000)a	Population (000)b
Argentina	1,457	17,150
Brazil	1,310	53,443
Colombia	461	12,568
Chile	410	6,082
Ecuador	234	3,387
Venezuela	178	5,094
Bolivia	151	2,713
Paraguay	69	1,488
Peru	no data	7,632
Uruguay	no data	2,238

Sources: a) Dickenson (1996); b) United Nations DESA

From this brief history, it seems clear that both economic development and the location of industrial activity in pre-liberalisation South America have been shaped by geographical factors in two ways: directly, mainly via access to the sea, endowment of natural resources, population size and climate; and indirectly, via the institution hypothesis. In particular, the direct influence did not take place in a time invariant mode: the colonial period and the beginning of the industrial revolution changed the effect of physical geography on countries' industrial and economic development as compared to pre-Columbian times. This confirms the idea of the changing nature of geographical advantage stressed by historians (Diamond, 1997 and Landes, 1998).[8]

8 Landes (1998), for instance, argues that in early civilisations when transport costs were too high to support inter-regional trade, geographical advantage came mainly from agriculture productivity rather than from access to markets. Thus early civilisations emerged in highly fertile river valley, such as the Nile, Indus, Tigris and Euphrates. By the same token, as the advantages of trade between Europe and Asia gave way to oceanic commerce in the 16th century, economic advantage shifted from the Middle East and eastern Mediterranean to the North Atlantic.

4. A Simple Empirical Test

In order to test more formally for the influence of physical geography on economic and industrial development in South America, I proceed to a simple econometric analysis based on the data of Gallup *et al.* (1998), World Bank (2002), Undesa (2001) and Summers and Heston (1994) (see Appendix I for details). Such analysis does not bear much statistical significance because of the very limited size of the sample (10 observations, namely the number of South American countries excluding Guyana, Suriname and French Guiana),[9] and thus of the degrees of freedom of the regressions. However, this test can provide some empirical support for the channels identified above, through which geography may have exerted its influence in the economic and industrial development of the region.

The test takes into account the period before the widespread implementation of the Washington Consensus induced New Economic Model (NEM) in South America, which emerged out of the debt crisis of the early eighties. A few important considerations justify the choice of this period. Firstly, the economic reforms within the NEM framework (including liberalisation of domestic markets, privatisation, trade liberalisation and opening to international financial flows) were so thoroughly and abruptly implemented that it is difficult to imagine that they would not severely bias the results of the analysis. Moreover, as it has become apparent,[10] the NEM has produced different responses (especially in terms of industrial development) throughout countries in the region. Therefore an analysis referred to the pre-NEM economic conditions might be helpful in identifying reasons of countries' relative successes and failures.

Because of the small size of the sample, I use only very simple specifications with a few variables testing the South American case against the theoretical predictions. So, for instance, I do not include the size of a country's population as explanatory variable for economic development (while I do include it for the level of industrialisation), since there is no clear theoretical relation between the two variables. Moreover, the more classical Hecksher-Ohlin type of variables (i.e.: land/labour ratio and resource

9 These countries have not been included in the regression, because both the data are not available and anyway they are not part of the analysis carried out by the paper for the negligible size of their economies.

10 See, for instance, Stallings and Peres (2000) and CEPAL (2001).

endowments) are not used in the regressions. The reason for not using land/labour ratios has been explained above, while resource endowment variables have not been used because their relations with both economic and industrial development is not theoretically clear (see Gallup *et al.*, 1998, among others). In any case, I have tried to incorporate in the regressions the only data I had on resource endowments "log Hydrocarbons *per cápita*" and it is significant in explaining neither industrial nor economic development of countries.[11]

Table 2
Summary statistics of the variables

	lgdp65	lgdp74	Tropicar	Pop100km	malfal66
Mean	7.8332	8.0896	0.6682	0.3902	0.1021
Median	7.6807	8.1000	0.9654	0.4340	0.0224
Maximum	8.9209	8.9083	1.0000	0.7245	0.4005
Minimum	7.1476	7.3877	0.0000	0.0000	0.0000
Std. Dev.	0.5916	0.4844	0.4403	0.2696	0.1422
Skewness	0.5352	0.2559	-0.6749	-2.8438	1.0994
Kurtosis	2.1100	2.2002	1.6411	1.6812	2.8077
Observations	10	10	10	10	10
	Manexp	**manVA**	**Landlock**	**lpop50**	**Andean**
Mean	19.2100	22.9000	0.2000	8.7316	0.5000
Median	13.1000	22.7500	0.0000	8.6245	0.5000
Maximum	53.9000	31.0000	1.0000	1.0886	1.0000
Minimum	0.4000	14.2000	0.0000	7.3052	0.0000
Std. Dev.	17.6245	5.0818	0.4216	1.0739	0.5300
Skewness	0.7953	-0.1167	1.5000	0.6311	0.0000
Kurtosis	2.4132	2.2841	3.2500	2.6635	1.0000
Observations	10	10	10	10	10

4.1 Influence of Geography on Economic Development

First I test for the influences of geography on the level of pre-liberalisation economic development, which is proxied by the log of GDP *per cápita* at constant prices in 1965 ad 1974 (Penn Tables). I use two different years to give some robustness to the analysis.

11 Results are available upon request.

1965 is the base year also used by Gallup *et al.*, while 1974 is the year before the implementation of the NEM in the region.[12] Table 3 presents the main results of these regressions. A parsimonious specification, using only tropical area and oil endowment (a dummy for Venezuela, which is the only large oil producer of the region) as independent variables, gives already a good explanation of the level of economic development in 1965 (regression 1). Other variables, such as the percentage of the population living near the coast (a proxy for access to the sea, regression 2), the incidence of malaria, the presence of mountains which constrain trade (proxied by an Andean dummy) and the lack of access to the sea (Landlock dummy) have the expected sign and are almost all significant over different specifications (regressions 2 to 7).

Table 3
Influence of Geography on the Level of Economic Development

	(1) lgdp65	(2) lgdp65	(3) lgdp65	(4) lgdp65	(5) lgdp74	(6) lgdp74	(7) lgdp74
Tropical Area (%)	-0.83** (4.31)	-0.76** (2.58)			-0.46* (2.44)		
Pop 100 km (%)		0.57 (1.09)					
Oil	1.51** (11.30)	1.30** (5.71)	0.99** (8.10)	1.18** (12.52)	0.94** (11.07)	0.72** (5.79)	0.93** (9.24)
Malaria Index 1966			-2.04** (2.82)	-1.86** (5.13)		-0.98 (1.23)	
Andean				-0.31* (2.46)			-0.32 (1.88)
Landlock			-0.90** (6.12)	-0.86** (4.51)	-0.62** (3.69)	-0.81** (5.13)	-0.68** (3.09)
Constant	8.24 (50.07)	7.99 (19.89)	8.12 (51.51)	8.23 (59.84)	8.43 (50.53)	8.28 (51.20)	8.29 (57.46)
Observations	10	10	10	10	10	10	10
Adj. R^2	0.71	0.74	0.81	0.89	0.82	0.69	0.73

Absolute values of t-statistics in parenthesis

* Significant at 10%level; ** Significant at 5% level

All regressions corrected for White heteroskedasticity-consistent standard errors and covariance

12 The NEM started in 1975 in Chile, Argentina and Uruguay (but the latter two reversed it after a few years). Then I could have used GDP in 1975, but it would have been biased by the heavy economic crisis that faced Chile in that year.

In particular, being landlocked and having a high influence of malaria appear to exert a highly negative influence on economic development, as predicted by the theory. Note that the percentage of tropical area and the malaria index have a high degree of collinearity, since the former tends to determine the latter.[13]

4.2 Influence of Geography on Industrialisation

The second part of the analysis tests for the influence of geography on the level of industrial development. I use again two dependent variables: the percentage of manufactures exports over total merchandise exports (*Manexp*) and the manufacturing value added as percentage of GDP (*ManVA*).[14] The former is a proxy for industrialisation in that the more industrialised a country is, the more its manufacturing sectors will weigh in the country's total exports. Indeed an economy with a small backward industry will tend to export mainly primary products. By the same token, the more developed a country's industrial base is, the higher its manufacturing value added (more capital and intermediate goods will be produced within the country).

As it is clear from table 4, the relevant explanatory variables in this test are quite different from those in the previous one. In particular, the most significant variable appears to be the size of the country's population, which is referred to the year 1950 to try to minimise reverse causation.[15] Such result stresses the importance of a large population in the development of a national industry, especially during a period of little openness to international trade as it was during the ISI. A large internal market is likely to guarantee more efficient levels of plants' capacity utilisation, the development of capital intensive industries (characterised by high fixed costs) and the presence of competition within the domestic industry, thus creating some incentive for local firms toward modernising investments. As a matter of fact, Brazil and Argentina, the two most populous (in 1950) countries of the region, have the highest values of *ManVA*, while Paraguay and Bolivia, two of the three least populated countries of South America (and with no access to the sea) have the lowest values. Andean countries, which tend to be characterised by a more difficult terrain and by a less developed transport

13 In fact in the regressions (not included here) I run with both variables, one of them was always insignificant.

14 These variables are referred to different years for several countries. See Appendix 2 for the ratio of this choice.

15 In this case a high level of industrial development could be the cause of higher population. Taking 1950 as the base year for the population and the 1985-90 period for the level of industrial development should reduce this problem.

network (as we have seen above), appear to be significantly penalised. This could be a sign of the importance of internal as well as external trade (to better exploit economies of scale) in the development of an industry. Further support to this theory is given by the negative coefficients of both the *landlock* dummy and the percentage of the population living near the coast (*Pop 100km percent*). The latter, unlike in the previous test, seems to have more explanatory power than the *landlock* dummy, indicating a possible problem of reverse causation (industrial centres tend to be located near the coasts, attracting population from the interiors). The main predictions of the theory are largely confirmed in this analysis as well.

Table 4
Influence of Geography on the Level of Industrialisation

	(1) Manexp	(2) Manexp	(3) ManVA	(4) ManVA	(5) ManVA
Log Pop 1950	8.087	10.00**	3.51**	3.27**	1.87
	(1.49)	(3.61)	(3.72)	(4.61)	(1.79)
Pop 100 km (%)		16.38	7.88*	8.78*	
		(1.17)	(2.10)	(2.36)	
Andean	-16.28*	-16.85*		-3.51*	-3.31
	(1.95)	(2.07)		(2.09)	(1.84)
Landlock	-8.94				-6.50*
	(0.79)				(2.14)
Constant	-41.48	-66.11	-10.82	-7.33	9.56
	(0.76)	(2.69)	(1.29)	(1.02)	(0.91)
Observations	10	10	10	10	10
Adj. R^2	0.56	0.61	0.64	0.77	0.76

Absolute values of t-statistics in parenthesis
* Significant at 10%level; ** Significant at 5% level
All regressions corrected for White heteroskedasticity-consistent standard errors and covariance

A more qualitative confirmation of the above analysis comes from the data gathered by Alcorta and Peres (1995) on R&D expenditure as percentage of GDP in the early 1980s (Table 5)[16], which is usually strongly correlated with a country's level of industrial development. Again, Brazil and Argentina are on top of the list, together with Chile, the country with the highest coast/land ratio in the region, while Bolivia and Paraguay have the lowest ratio of R&D/GDP.

16 These data have not been utilised as a dependent variable due to their unavailability for a number of country.

Of course, these associations are hardly a proof of causality. Apart from the small sample size, the explanatory variables may be proxies for left out variables, such as the quality of institutions and policies which are influenced by geography as we have seen. Thus they may suffer from an upward bias. Moreover, as noted by Gallup *et al.* (1998), there could also be a reverse causation problem for the malaria variable, by which high incomes lead to the control of malaria. However, as stressed above, this analysis may be useful to provide a more formal empirical confirmation to a relation between geography and South American development, which has been presented from theoretical and historical angles.

Table 5
R&D expenditure (% GDP) in the early 80s

Country	Percentage
Argentina	0.47
Bolivia	0.07
Brazil	0.72
Chile	0.41
Colombia	0.10
Ecuador	0.10
Paraguay	0.10
Peru	0.22
Uruguay	NA
Venezuela	NA

Source: Alcorta and Peres (1995)

5. Policy Implications and Directions for Future Research

The paper has presented a country based analysis of the possible effects of first nature determinants on South America's economic and industrial development, a relationship often overlooked by the traditional literature. The results appear to confirm the relevance of geography in determining both the level of national income and the location of industrial activity in the region.

To the extent that such geographical influence is correct, this should yield important implications for national policies as well as for the development agenda, which shall give particular attention to the special problems imposed by geography in the

elaboration of their policies. So, for instance, in as much as tropical areas appear to be economically penalised by low agriculture productivity and by a difficult disease environment, more significant efforts should be placed in the diffusion of more efficient technology for tropical agriculture and in making medicine to fight tropical diseases more accessible. Furthermore, the constraints to development imposed by the lack of access to the sea (as emerged in the analysis) call for better transport infrastructures linking landlocked countries' production sites to ports.[17]

The above analysis has also stressed the importance of market size and transport costs for industrial development in pre-NEM South America. A large market allows domestic firms to exploit increasing returns to scale, thus creating the conditions for the development of a more consistent industrial base, as the experiences of Brazil, Argentina and Chile confirm. This argument may provide a rationale for the creation of a South American common market.[18] Given its significant size (around 340 million people), such market could give the possibility to develop competitive South American industries, as long as they would enjoy a preferential treatment relatively to competition from outside the region. In order for countries to reach efficient levels of capacity utilisation, a degree of specialisation may also be promoted within the region on the basis of natural resources and accumulated technological and human capital. Small countries like Bolivia, Paraguay and Uruguay cannot clearly develop a wide variety of efficient industries, but even a large economy like Brazil seems to have gone too far in sector diversification during the ISI period (Moreira and Correa, 1998). In this respect, the importance of coordinated national industrial policies needs to be highlighted.

A central role in such integration should be played by efficient national and transnational transport networks, which are still lacking in many parts of South America. The analysis has highlighted that especially for Andean and landlocked countries high transport costs seem to represent a significant constraint to industrial development. A

17 In fact the high penalty of being landlocked has long been recognised by Bolivian governments, that still lack diplomatic relations with Chile for this reason. However such recognition has not been turned into an effective strategy to improve the country's access to the sea. As a matter of fact the Santa Cruz region, the highest contributor to the national production, still lacks good transport infrastructures to connect it to a port.

18 The exclusion of Central America would be determined by its already prominent integration with North American markets.

case in point is the poor land connection of Bolivia with its main export market (Brazil), which causes the loss of significant market opportunities due to high transport costs.

The paper has only sketched a preliminary roadmap to analyse the relationship between geography and development in South America. Further research is then needed to carry out more consistent empirical analyses possibly using data at regional level, which may provide a quantitatively significant verification of the influence exerted by geography on development. Moreover, it would be interesting to combine such analysis based on first nature determinants with one based on second nature to investigate whether the eventual geography induced inter-country (or inter-region) differences in economic and industrial development have been magnified by the agglomeration forces described by the new economic geography approach.[19] This analysis could be used for instance to investigate the possible relation between the different industrial responses to the NEM by South American economies and the differences in the pre-NEM level of industrialisation and in the physical geography of countries (such as the degree of accessibility to international markets).

19 Or, using a Krugman's (1998, p. 30) metaphor, whether aspects of natural geography have the role of establishing "seeds around which self-reinforcing agglomerations crystallize".

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Appendix 1: Variables' Description for Regressions

Most of the data for the regressions are taken from Gallup, Sachs and Mellinger (1998) –henceforth GSM– available at http://www.cid.harvard.edu/ciddata/ciddata.html

Variable	Description	Creation/Source of Data & notes
Gdp65	Real GDP *per cápita* 1965 at constant prices (Laspeyres index)	Penn World Tables 5.6 (GSM)
Gdp74	Real GDP *per cápita* 1974 at constant prices (Laspeyres index)	Penn World Tables 5.6 (Summers and Heston 1994)
Manexp	Manufactures exports (as % of total merchandise exports)a	World Development Indicators 2002
ManVA	Manufacturing value added (as % of GDP)a	World Development Indicators 2002
Tropical Area (%) (tropicar)	% of land in geographical tropics	GSM
Pop 100 km (%) (pop100 km)	% of the population within 100 Km from the coast	GSM
Pop 1950	Population in 1950 (in 000)	Undesa Statistics Http://www.un.org/esa/population/publications/worldageing19502050/pdf/
Malaria Index 1966 (malfal66)	Falciparam malaria index, 1966 – index 0-1	GSM
Oil	dummy for Venezuela	Created to account for a large effect of oil revenues on income
Andean	dummy for Andean countries	Applied to the members of the Comunidad Andina de Naciones (CAN)
Landlock	dummy for landlocked countries	

[a] The years which these variables are referred to vary from country to country (see Appendix 2).

Appendix 2

Years to which Proxy Variables for Industrialisation are referred to by Country

	manexp	ManVA
Argentina	1989	1988
Bolivia	1985	1990
Brazil	1989	1988
Chile	1975	1976
Colombia	1986	1988
Ecuador	1989	1988
Peru	1989	1988
Paraguay	1985	1985
Uruguay	1988	1988
Venezuela	1989	1988

The reasons for a variables' dataset not referred to the same year are related to the conditions that the choice of the years should fulfil. Indeed for each country, the year should have been:

- the last year before the implementation of the NEM in the country.
- as close as possible to the other countries' years.
- a year with data not very distant from those of the years nearby, to give some robustness to the data.
- available in the World Development Indicators database.

For instance all countries except Chile have data referred to the 1985-90 period, when the wave of TL process started in the whole region. Bolivia has two very different years (1985 and 1990) because of the unavailability of earlier data for *ManVA*.

In any case, even using different years in the regressions the main results do not change much (data available upon request).