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GROWTH DIAGNOSTIC: PARAGUAY

BY

RICARDO HAUSMANN*
BAILEY KLINGER*

*** HARVARD UNIVERSITY**

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Growth Diagnostic: Paraguay

Ricardo Hausmann
Bailey Klinger

with

Felipe Kast, Reinier Schliesser, Alfie Ulloa, Rodrigo Wagner, and Andres Zahler

Center for International Development
Harvard University

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Abstract: Paraguay's growth history is characterized by prolonged periods of stagnation, interrupted by a few small recessions and growth accelerations. These dynamics reveal that growth in Paraguay has been dependent on latching on to particular export goods enjoying favorable external conditions, rather than driven by macroeconomic or political cycles. Moreover, the country currently has significant room for further export growth in existing products, as well as many new export products that are nearby and have high potential. But these available channels to generate sustained growth have all gone unexploited. Our growth diagnostic indicates that the underlying obstacles that have prevented the country from developing many of the available opportunities are related to two constraints: the provision of infrastructure and a lack of appropriability due to corruption and a poor regulatory environment. The current environment is one where the only activities that can survive have to be un-intensive in infrastructure, and either un-intensive in transactions requiring an efficient business environment or at least at a scale where informality and corruption is a viable alternative to institutional blockages. We provide policy recommendations that will help alleviate these problems, focusing on not only on institutional and infrastructure reforms in the abstract, but outlining a process of learning from the relevant private sector actors what sector-specific needs in the areas of regulations and infrastructure are the most important for achieving accelerated growth in Paraguay.

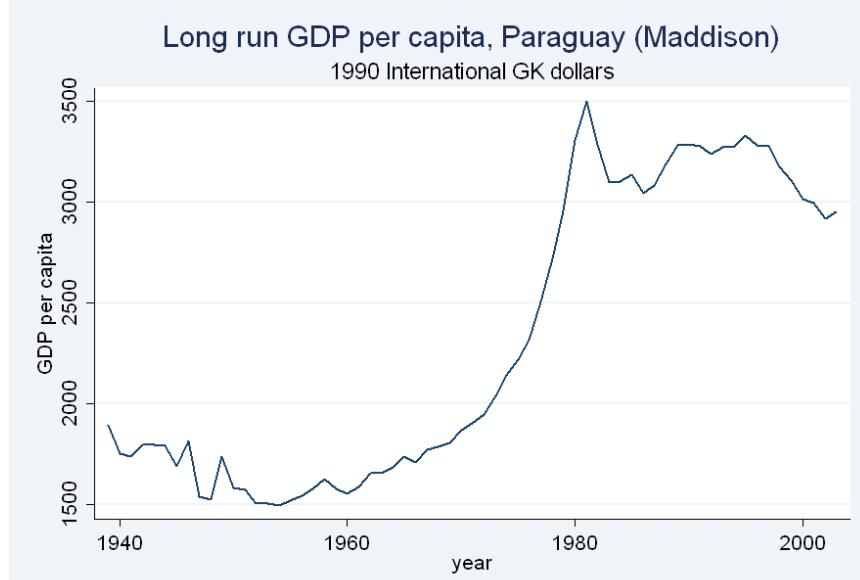
INTRODUCTION

Paraguay has undergone a major turnaround since 2003 as the economy emerged from a serious macroeconomic crisis that required an IMF supported adjustment program based on fiscal and financial reforms. Since 2003 the economy has been growing more rapidly than at any time since the 1970s. In this paper we will put the growth dynamics in a historical context, try to identify the drivers of long run economic performance, carry out a growth diagnostic of the country and discuss a policy agenda to sustain and accelerate the development of the country.

LESSONS FROM THE PAST SIX DECADES

Paraguay is a country of great promise but has yet to consistently realize this potential. The past 65 years have been marked by economic stagnation. After the Chaco war, during the 1940s and 1950s and even until the mid 1960s, output per capita was either stagnant or declining in Paraguay while the rest of Latin America enjoyed high growth. During the mid to late 1960s, and particularly in the 1970s, there was a significant growth acceleration. After this episode, the country entered another long period of economic stagnation that in broad outlines lasted for the last quarter century. If we look in more detail over this more recent period we find that there were two shorter growth accelerations: one in the late 1980s and another one initiated around 2003, but these have been recoveries from previous recessions of roughly the equivalent size, meaning that output per capita today remains below the peak level in 1981.

Figure 1

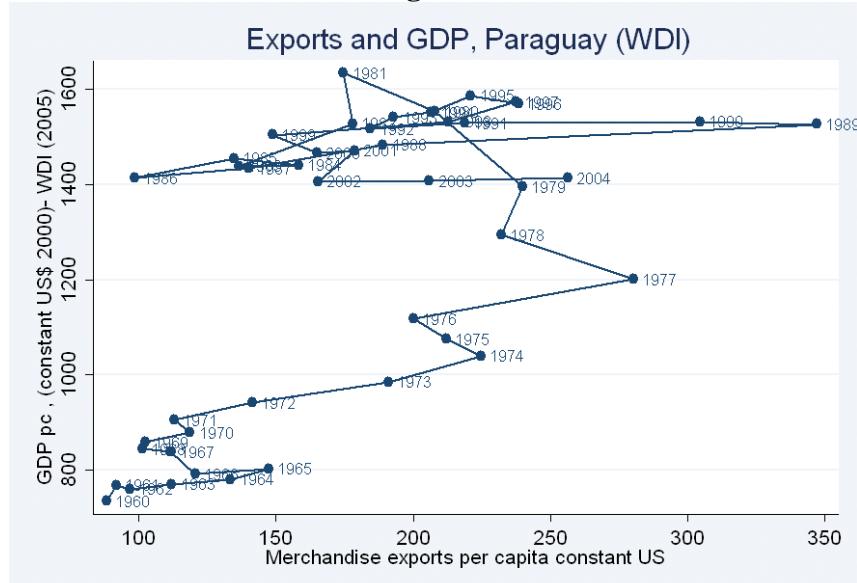


Source: Maddison

The growth acceleration in the 1970s was due to two factors: an export boom in the early to mid-1970s accompanied in the late 1970's by the construction boom for the Itaipu hydroelectric dam. Between 1969 and 1977, exports per capita more than doubled, as

shown in the figure below. This export boom was fueled by a basket of agricultural exports, such as soybeans and cotton, along with coffee and wood exports, which increased 10-fold. The export expansion, shown by movements to the right in this figure, reversed in 1977, yet growth in output per capita continued until 1981. When construction of Itaipu (which we could interpret as a boom in the export of construction services), wound up and Latin America fell into the 1982 debt crisis, Paraguay entered a recession.

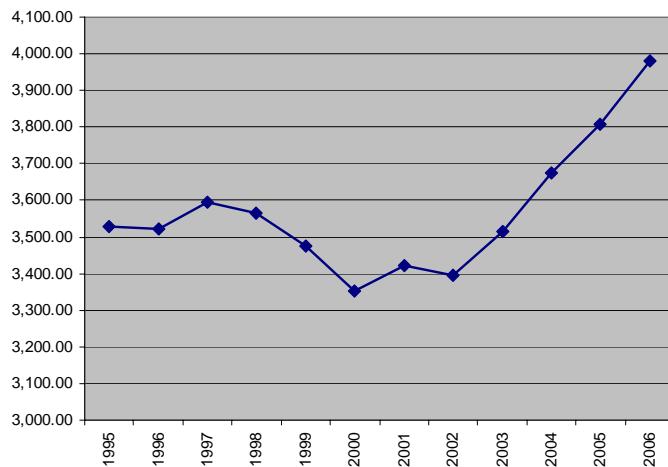
Figure 2



Source: WDI

There was another export boom from 1986 to 1989, almost entirely due to soybean and cotton exports, which enjoyed surging international prices and a significant positive supply response. A reversal in international prices, as well as production problems in cotton led to the end of the export and GDP with output per capita roughly on par with levels of the late 1970s before the Itaipu output spike. Growth picked up more modestly in the 1992-95 period buoyed by capital inflows, a credit boom and a widening current account deficit. In 1997 the country entered a prolonged 6 year period of decline associated first with a banking crisis, followed by the turmoil surrounding the East Asian, Russian, Brazil and Argentine crisis and the 2001 global recession. Since 2003 the economy has been recovering, achieving five years of positive growth in output per capita, buoyed by booming export volumes and prices.

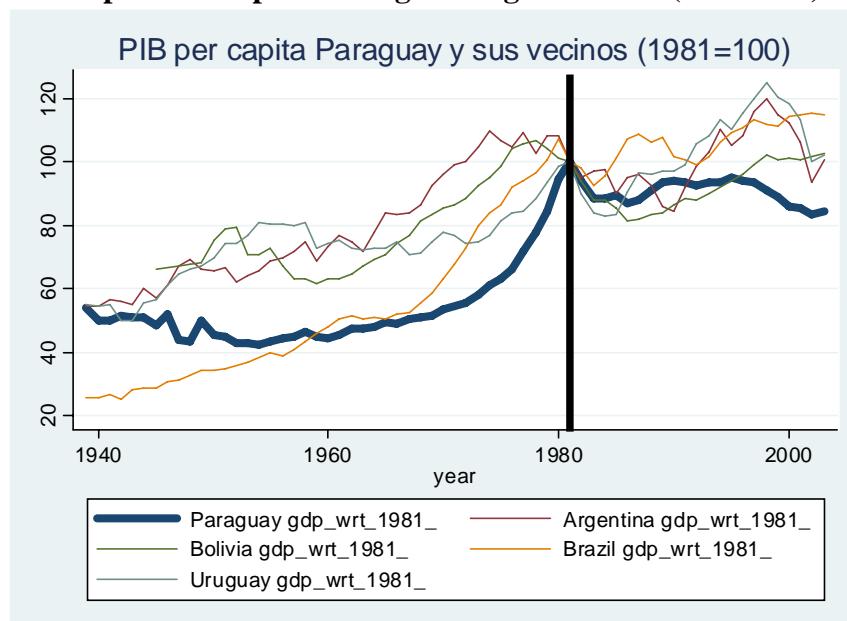
Figure 3
Recent Paraguay GDP per capita, PPP



Source: EIU. 2006 value is a projection

While the stagnation of the 1980s was a general phenomenon in Latin America, Paraguay's relative performance in the 1990s was quite poor. The following figure shows output per capita in Paraguay and neighboring countries, with the levels in 1981 (Paraguay's peak year) equal to 100. Paraguay underperformed from 1940 to the mid 1960s. Afterwards, it had a very rapid rate of growth relative to its neighbors until its peak in 1981. Paraguay kept in-step with its neighbors during the “lost decade” of the 1980s, but in the 1990s it fell behind.

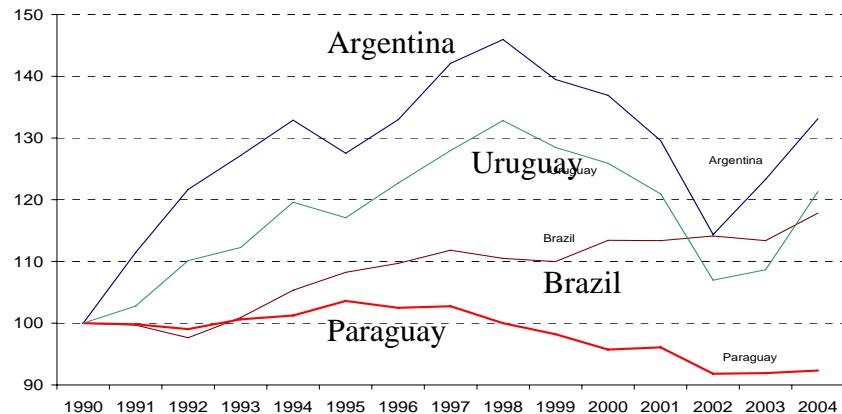
Figure 4
Output Per Capita in Neighboring Countries (1981=100)



Source: Author's calculations using WDI

The following figure focuses in on the 1990s and early 2000 in Mercosur. Although Argentina and Uruguay suffered severe crises in 2001, their cumulative growth since 1990 was always greater than that of Paraguay and their recovery was very steep, while Paraguay spent the decade in relative stagnation and decline.

Figure 5
Output Per Capita in Mercosur (1990=100)



Source: Author's calculations using WDI

It is possible that this recession was due to localized factors that large neighbors like Argentina and Brazil were able to absorb more easily because they have larger more diversified economies. But even if we isolate the provinces in Brazil and Argentina that border Paraguay, we see that neighboring provinces in other countries did much better than Paraguay during the 1990s.

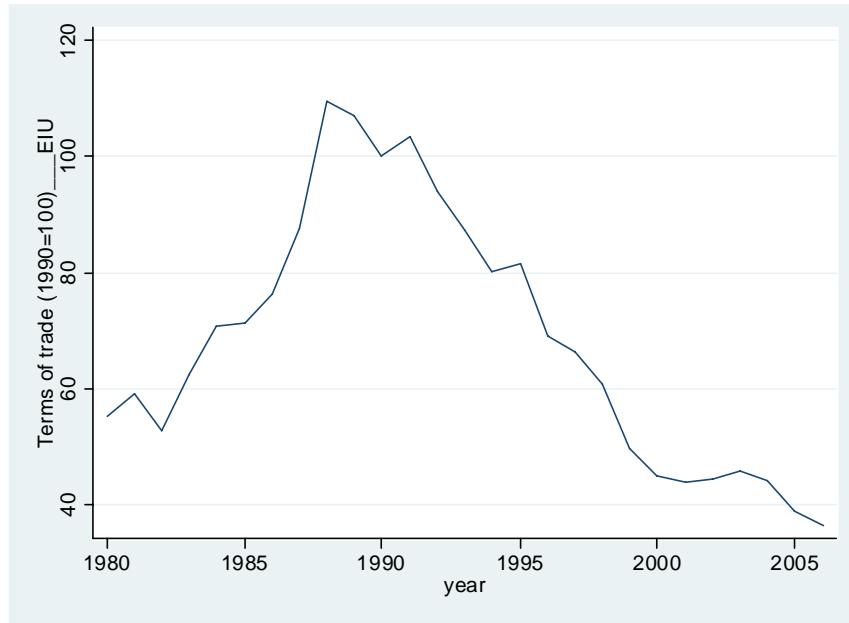
Table 1
Paraguay and Neighboring Provinces

Country / Province	Growth 90-00	Ranking
Mato Grosso do Sul	2.1%	34
Misiones	1.9%	38
Formosa	1.0%	52
Paraná	0.8%	55
Salta	0.5%	57
Corrientes	0.3%	60
Chaco	-0.3%	64
Paraguay Total	-0.5%	65

Out of a total of 72 states & provinces in Argentina, Brazil and Uruguay. Source: Inter-American Development Bank and authors' calculations.

Why did Paraguay do so poorly relative to its neighbors in the 1990s? We attribute this outcome to the fact that the country suffered a significant deterioration in its terms of trade after the export boom in the late 1980s. This downward trend has continued until today, as shown in the following figure.

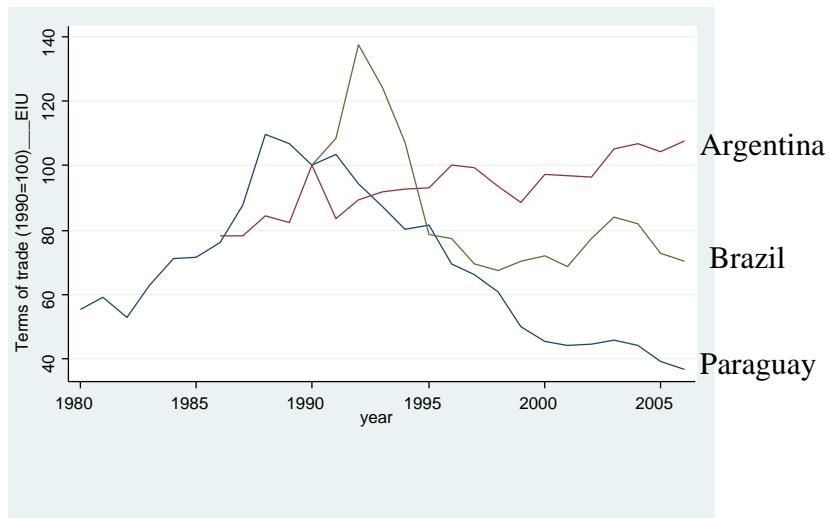
Figure 6
Paraguay's Terms of Trade



Source: EIU

Given many of Paraguay's principal exports are also exported by its neighbors (discussed in greater detail below), a terms-of-trade story might not be convincing given that the recession in Paraguay was unique. However, Paraguay's terms of trade shock was actually unique as well. The following figure shows that since 1990, Paraguay's terms of trade have been collapsing relative to Brazil and Argentina.

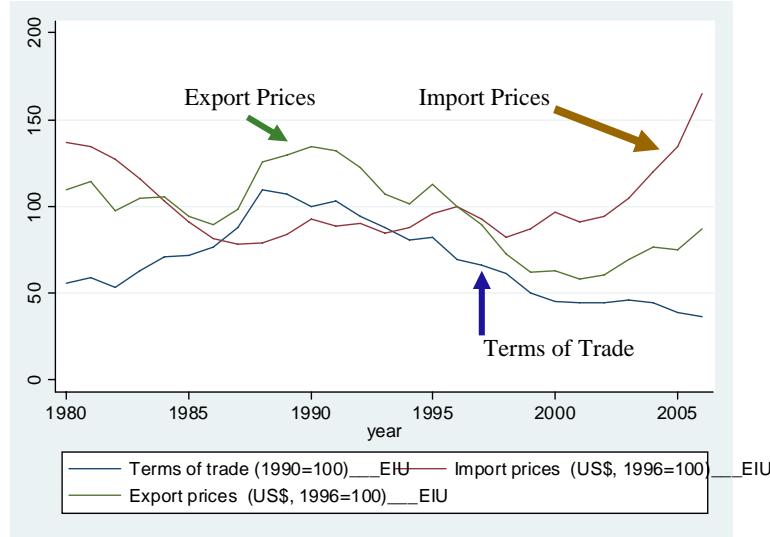
Figure 7
Terms of Trade in Mercosur



Source: EIU.

What is behind this terms-of-trade collapse? From 1990 until 2000, international prices for Paraguay's exports declined steadily. This trend reversed in 2000, but by that time the prices of Paraguay's imports began to climb as well, and much more strongly than the prices of its exports. The increase in the price of imports was associated not only to the rise in international energy prices, of which Paraguay is a net importer, but also because of the appreciation of the Brazilian Real that affects many of Paraguay's imports. However, since Paraguay does not really export much in net terms to Brazil, it did not benefit from the rising domestic prices there. Consequently, the terms of trade decline has continued after 2000 even in the context of rising export prices. The following figure shows these dynamics in detail.

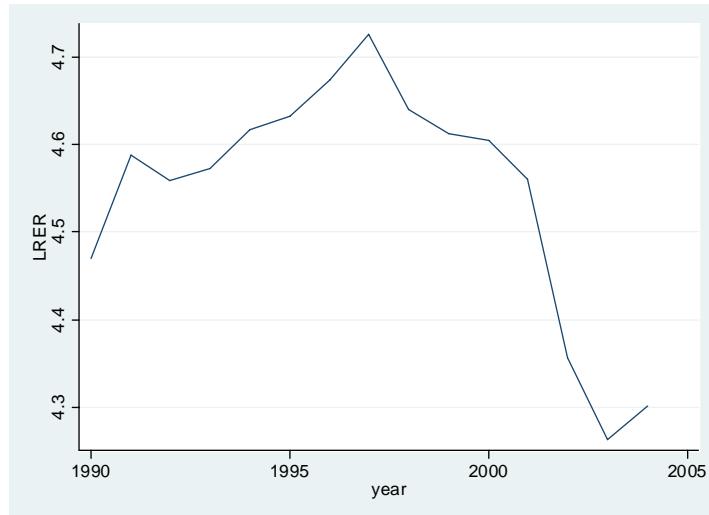
Figure 8
Behind Paraguay's Terms of Trade



Source: EIU

The decline in the terms of trade implied a fall in national income. The country could have either adjusted or financed the missing external revenue. Adjustment requires some combination of a cut in domestic spending and a change in relative prices to stimulate the production of tradables and discourage its domestic consumption. Until 1997 the economy did not adjust, but instead maintained domestic spending and borrowed externally to finance the widening current account deficit. But by 1997 the country faced an end to its ability to borrow abroad and was forced to adjust. The real exchange rate underwent a rather severe realignment, with the real exchange declining over 40% between 1998 and 2004 and domestic spending declined by over 25 percent between 1997 and 2002.

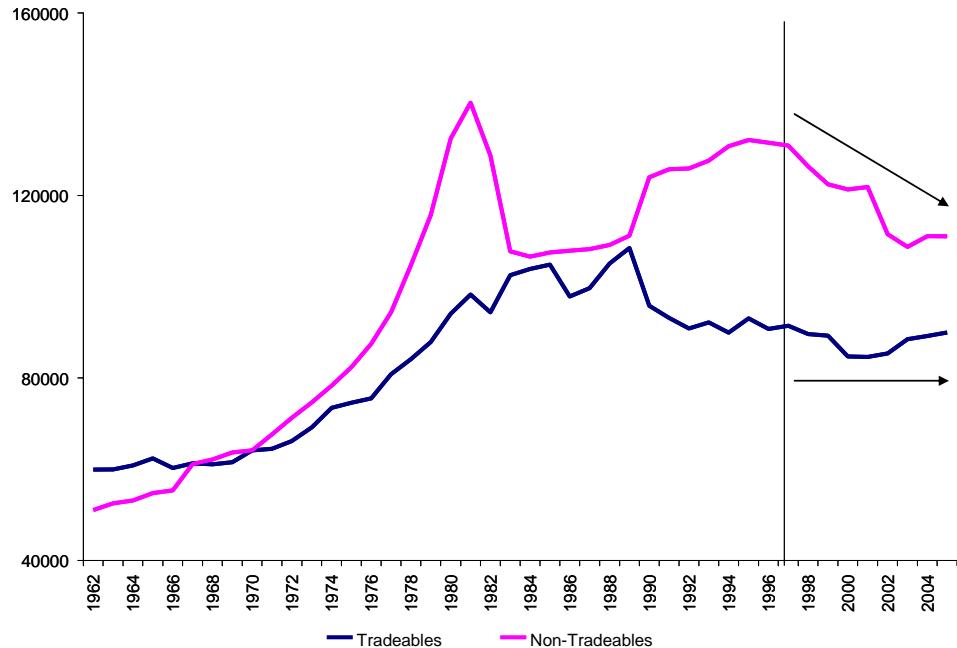
Figure 9
Paraguay's Real Exchange Rate



Source: WDI

In response to these changes, the production of non-tradables fell, while the output of tradables remained fairly stable, indicating a shift in the relative composition of output in favor of tradables (see Figure 10). This can be observed in the sectoral composition of employment: from 1998 to 2002 employment (as a percentage of the working age population) in non-tradables fell by 3.5% while employment in tradables rose by 1.1%.

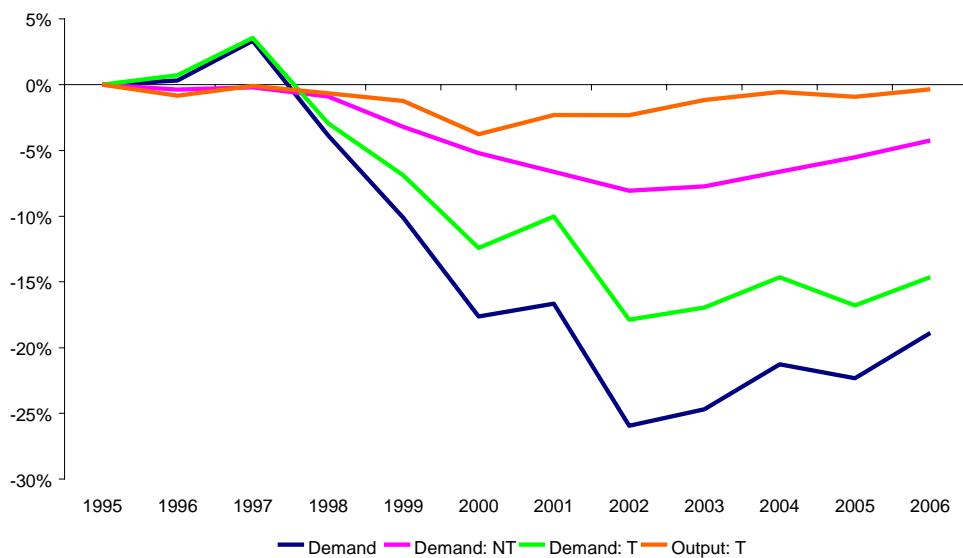
Figure 10
Production of Tradables and Non-Tradables in Paraguay



Source: Banco Central de Paraguay

The terms of trade decline and depreciation of the real exchange rate caused adjustments in spending as well. The demand for tradable goods fell significantly due to the cut in overall spending and the expenditure switching effect caused by the real exchange rate depreciation. Output of tradables remained fairly steady and the gap between expenditure and output of tradables narrowed significantly, thus allowing a reduction in the current account deficit. The demand for non-tradables, which is necessarily equal to the output of the sector declined much less than the demand for tradables and thus prevented the recession from being deeper.

Figure 11
Adjustment to the TOT Shock
(% 1995 GDP)



Note: T = tradables, NT = non-tradables.

Source: Calculations based on data from Banco Central del Paraguay.

Overall, this was a relatively efficient adjustment because the required decline in spending took place mostly in tradables and this sector also was able to partially compensate for the inevitable relative decline in non-tradables. If exports had risen by even more, or the relative demand for tradables fallen by more, the recession could have been avoided entirely. Regardless, the recession was much less painful than it could have been because of increases in the export of agricultural products and agro-based manufactures.

Since 2003 exports have continued their upward trend, in large part thanks to the rapid spread of soybean production based on genetically modified seeds, which have fueled a boom in investment and exports in this crop. Cultivation of soybeans has risen from 558 thousand hectares in 1990 to over 2.2 million hectares in 2006. While the terms of trade have continued to decline because of rising import prices, the price of exports relative to the GDP deflator increased significantly, sustaining this export boom and a renewed GDP growth acceleration.

It is important to point out, and we will expand on this below, that the production of soybeans is very un-intensive in labor. In the US, a hectare of soybeans requires barely 6 hours of work per year while the equivalent number for Brazil is about 15 hours per year. This is at least less than 1/15th of the equivalent labor input for a crop such as sugar, assuming mechanized harvesting (Wander 2006). This means that soybeans are intensive in land and capital but not labor. Therefore, the income generated by this activity flows to the owners of these factors of production and do not generate broad-based participation in the growth process.

More recently, the control of foot and mouth disease, the opening up of some meat export markets and the increase in the relative price of sugar has expanded the areas of agricultural growth in products that could generate significant more demand for labor. We shall return to these issues below.

In summary, Paraguay has exhibited low long-run growth. In the few instances when growth has been high it has been because the country was able to latch on to some dynamic export products. Growth between 1965 and 1981 was driven by strong dynamism in agricultural exports in the context of strengthening commodity prices and in the “export” of construction services for the Itaipú dam. Between 1986 and 1989 cotton and soybeans lead the way. Since 2003 it has been soybeans and more recently meat leading the way. Periods of growth have been periods of export growth that have only occurred when international prices are attractive or when there is some type of productive innovation (as with the no-till production of GMO soybeans. But we have not observed any sustained process of growth unless one of these two things occurs.

THE CHALLENGE OF EXPORT GROWTH

Paraguay’s growth diagnostic is therefore framed around the following question: what is preventing more sustained export growth? To increase its exports Paraguay could produce either more of the same, better of the same (improved quality) or new and higher productivity goods, i.e. goods that would be internationally competitive even if they had to pay more than the prevailing wage rate.

There does seem to be room for growth through more and better of the same. For example, there is no reason why meat exports can not expand significantly, given that food and mouth disease has been controlled and global markets for beef are expanding quickly. The agricultural frontier in terms of suitable uncultivated land for soybeans and sugar is also significant. For example, 2.2 million hectares of soybeans were harvested in 2005. However, the FAO estimates that even using low-input production methods, there are 4.5 million hectares of moderately suitable or better land for soybean production in Paraguay, meaning only half has been exploited.

Interestingly, according to the Geographic Information System (GIS) Paraguay is even better endowed for sugarcane than it is for soybeans, as shown in the table below. The country only has 542000 hectares of land which is classified either as suitable or very suitable for soybeans, but it has already planted 2.2 million hectares, 4 times more than

this amount. To do so, it has had to go to lands which are deemed only moderately suitable. In total, the country has planted about half of all lands deemed moderately suitable or better for soybeans. By contrast, the country has over 4.6 million hectares that are deemed either very suitable or suitable for sugar but has planted barely 75,000 or 1.6 percent of the total.

Table 2
Arable lands by crop: current and potential use

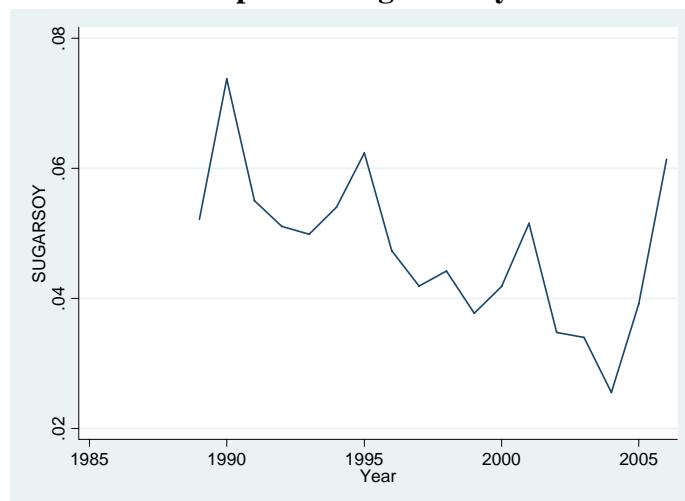
Commodity	Harvest (H)	Very Suitable (VS)	Suitable (S)	Moderately Suitable (MS)	VS+S	VS+S+MS	H/ (VS+S)	H/ (VS+S+MS)
Sugar								
cane	75	610	3994	4870	4604	9474	1.6%	0.8%
Soybeans	2200	6	536	3915	542	4457	405.9%	49.4%
Maize	410	178	3243	2952	3421	6373	12.0%	6.4%
Wheat	300	0	912	5311	912	6223	32.9%	4.8%

Source: GIS and FAO

Surely, part of the explanation has to do with the fact that prices for soybeans have been improving relative to those of sugar over the last 15 years. But this situation has now reversed with the relative price of sugar doubling between 2004 and 2006 in part due to the use of sugar in bio-ethanol. This can be readily observed in the following figure, which shows the price of sugar relative to that of soybeans (with increases indicating a greater price of sugar with respect to soybeans).

In Brazil this has implied that sugarcane has started to displace soybeans in the areas that are both appropriate and close to the relevant infrastructure. Provided that the environment is adequate, this trend should also be observable in Paraguay.

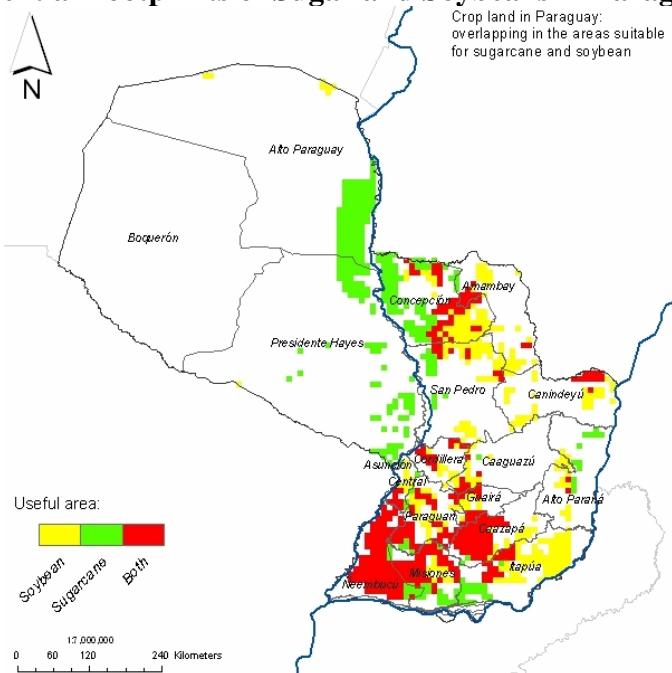
Figure 12
Relative price of sugar to soybeans



Caribbean sugar, US cents per pound; Brazilian soybeans, US\$ per ton. Source: IFS.

Fortunately, much of the potential footprint of sugar does not coincide geographically with that of soybeans (see map below). The Alto Paraguay region appears with a great sugar potential while the Paraná riverside tends to have a greater affinity to soybeans. This calls for a rather different set of territorial priorities in terms of regional development and infrastructure needs. This map is based on calculations using the GIS data but with a different cut-off of suitability of land. It suggests that Paraguay has 2.04 million hectares suitable for sugar and not soybeans, 2.1 million hectares suitable for soybeans and not sugar and 2.3 million hectares suitable for both, for a total of some 6.4 million hectares. This constitutes a huge agricultural frontier relative to current uses.

Figure 13
Potential Footprints of Sugar and Soybeans in Paraguay



Source: Author's calculations using Global AEZ

Moreover, sugarcane is much more labor intensive and would require processing relatively near the areas of production, whether for sugar or for bio-fuels. In addition, since workers need to live near the areas of production, infrastructure is more important. By the same token, the logistic system for sugar refining and bio-ethanol is much more demanding than for soybeans.

There is obviously an unexploited agricultural frontier that could have fueled export and output growth in existing products. Determining what has prevented such an expansion is an important question for a growth diagnostic to answer. But would such an expansion in the existing export products sufficient to accelerate future growth? Moreover, are there opportunities in new sectors, particularly new agricultural products, which have also gone unexploited? This is the focus of the following section.

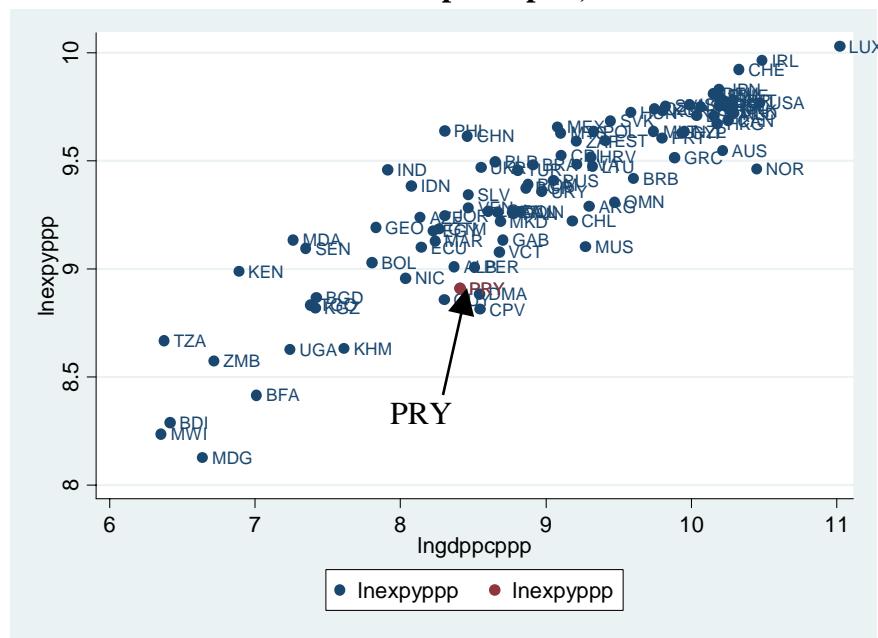
THE COMPOSITION AND TRANSFORMATION OF THE EXPORT BASKET

Paraguay's export basket is concentrated in a narrow set of traditional goods. Cotton, meat, and soybeans represent over 70% of the export basket, with the only other consequential exports being wheat, corn, wood, sugar, and tobacco. Not surprisingly, the dynamics discussed above reveal that international prices of these crops are a significant determinant of export and output growth.

The countries that export Paraguay's basket of goods tend to be poor. It has been shown that low income countries grow faster when they export goods typically exported by countries substantially richer than themselves (Hausmann Hwang and Rodrik, 2006, or HHR). These are goods that are competing with countries paying much higher salaries and this gap provides a cushion to pay for differences in productivity and the time to overcome them through learning. HHR call the level of sophistication of a *product* (PRODY) the weighted average of the income per capita of countries with comparative advantage in that product. They call the level of sophistication of a *country's* exports EXPY and measure it as the weighted average of the PRODYS of the basket of goods the country exports. As the following figure shows, poor (rich) countries tend to have low (high) EXPY. However, the relationship is not very tight. For countries at the same level of GDP per capita (i.e. on the same vertical line) the differences in EXPY can be substantial.

In particular, Paraguay has one of the lowest levels of export sophistication (EXPY) of a country at its income level. It is about 70 percent below the income per capita of the countries that compete with China or the Philippines.

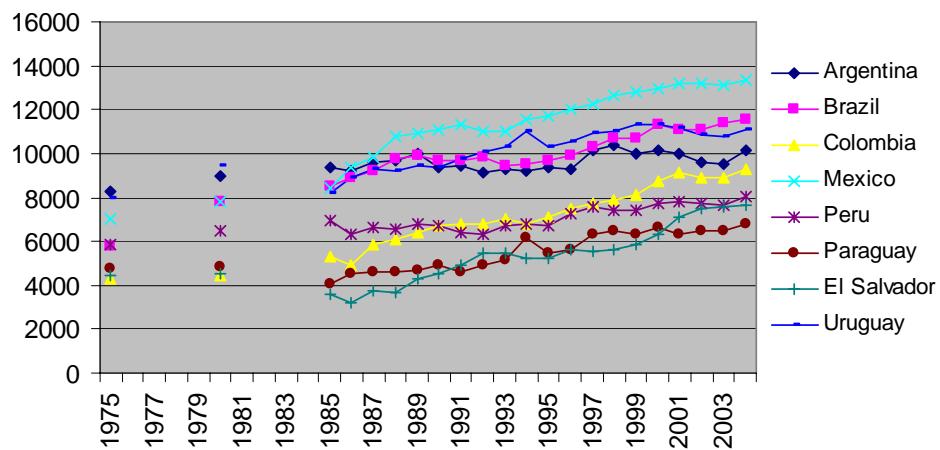
Figure 14
EXPY vs. GDP per capita, 2004



Source: Authors's calculations based on WDI and UN-COMTRADE

Given its level of income, Paraguay is specialized in an unsophisticated export basket, and has been for some time. The following figure shows the evolution of EXPY over time. Paraguay began in 1975 at the same level as Colombia and El Salvador, but has since been surpassed by both. Currently, Paraguay has one of the least sophisticated export baskets in Latin America.

Figure 15
EXPY, Comparative

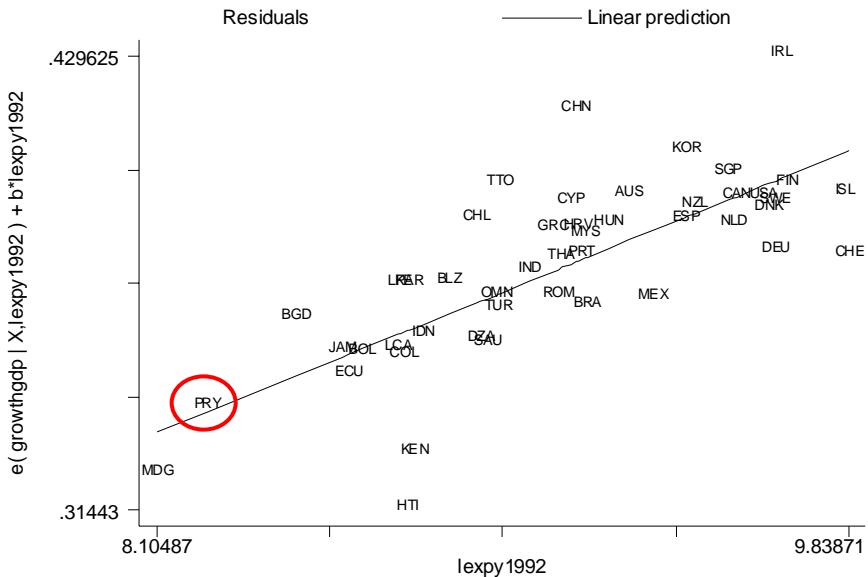


Source: Author's calculations using UN COMTRADE

This is a troubling finding, because controlling for initial GDP per capita, countries with lower EXPY tend to grow more slowly in the future. In other words, countries tend to converge to the level of income of their competitors in the products they are in. Or yet again, countries become what they export. This is shown in the graph below that charts the initial income per capita of a country in 1992 against the subsequent growth in the 1992-2003 period, controlling for other determinants of growth. The graph shows the strong relationship between initial export sophistication and subsequent growth.

Given the finding that countries with less-sophisticated export baskets grow slower, Paraguay's low long-term export growth should not be very surprising. As the following figure shows, Paraguay's low output growth has been commensurate with the composition of its export basket.

Figure 16
Initial EXPY and Subsequent Output Growth



Source: Hausmann Hwang & Rodrik 2006

To understand the binding constraints to growth in Paraguay, it seems important to determine what has prevented the country from discovering a more sophisticated export basket that could fuel future growth. Hausmann & Klinger (2006) investigate the determinants of the evolution of the level of sophistication of a country's exports, and find that this process is easier when moving to 'nearby' products. This is based on the idea that every product involves highly specific inputs such as knowledge, physical assets, intermediate inputs, labor training requirements, infrastructure needs, property rights, regulatory requirements or other public goods. Established industries somehow have sorted out the many potential failures involved in assuring the presence of all of these inputs, which are then available to subsequent entrants in the industry. But firms that venture into new products will find it much harder to secure the requisite inputs. For example, they will not find workers with experience in the product in question or suppliers who regularly furnish that industry. Specific infrastructure needs such as cold storage transportation systems may be non-existent, regulatory services such as product approval and phyto-sanitary permits may be underprovided, research and development capabilities related to that industry may not be there, and so on.

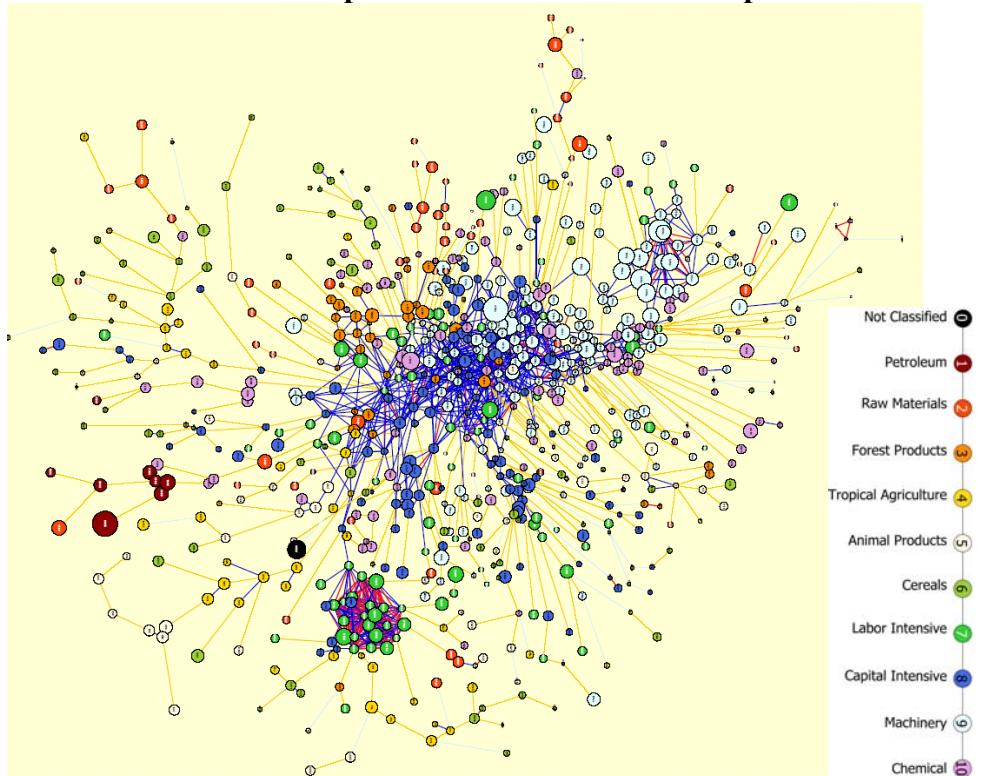
These firms moving to new activities will therefore have to adapt whatever capabilities exist. We find evidence supporting the view that the assets and capabilities needed to produce one good are imperfect substitutes for those needed to produce another good, but this degree of asset specificity will vary. The probability that a country will develop the capability to be good at producing a particular new good is therefore related to its installed capability in the production of other similar, or nearby goods for which the currently existing productive capabilities can be easily adapted. The barriers preventing

the emergence of new export activities are less binding for nearby products which only require slight adaptations of existing capacity.

This is found by developing a measure of ‘near’ using the probability of exporting both goods with comparative products, calculated using international data. The authors show that these distances condition the process of discovery. The appendix and source papers can be consulted for greater technical detail, but the important idea is that Paraguay may not be able to increase the sophistication of its export basket and move to nearby products simply because there is nothing nearby.

We consider this possibility by visualizing the product space and Paraguay’s orientation within it. The pairwise distances between products are converted to a graphical map of the international product space, which is shown in the figure below. Each node is a product, its size determined by its share of world trade. In these graphs, ‘nearness’ is shown by color-coding the linkages between pairs of products. A light-blue link indicates a proximity of under .4, a beige link a proximity between .4 and .55, a dark-blue link a proximity between .55 and .65, and a red link a proximity greater than .65. Links below 0.55 are only shown if they make up the maximum spanning tree, and the products are color-coded based on their Leamer (1984) commodity group.

Figure 17
A Visual Representation of the Product Space



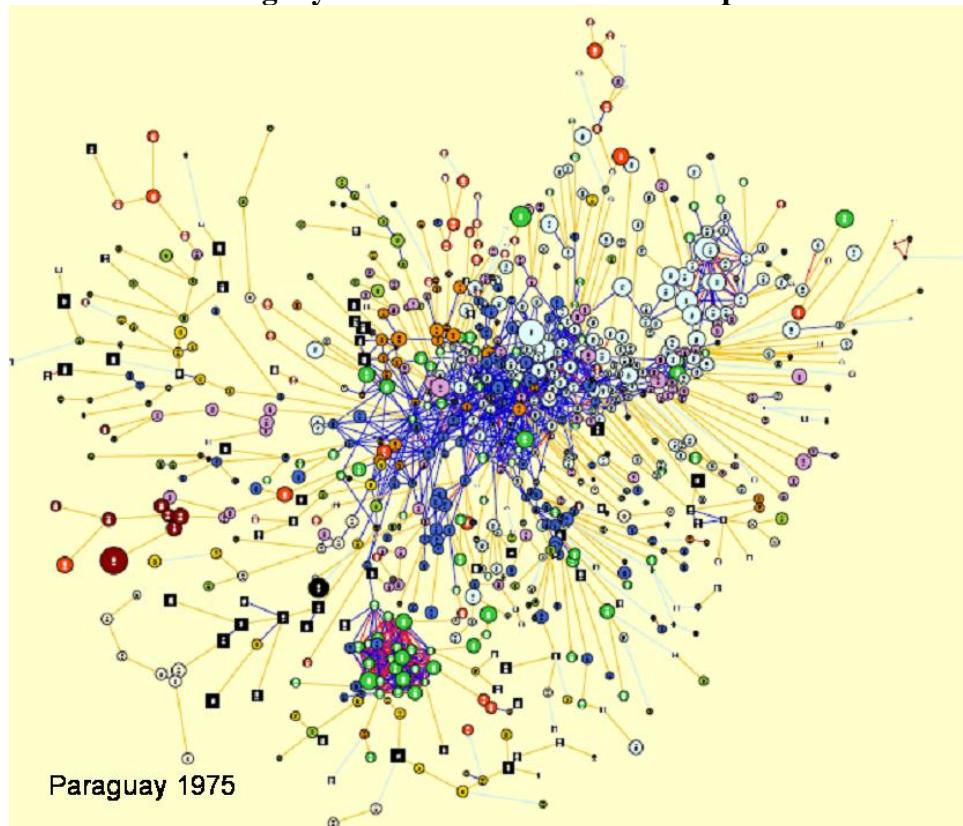
Source: Hidalgo et. al. 2007

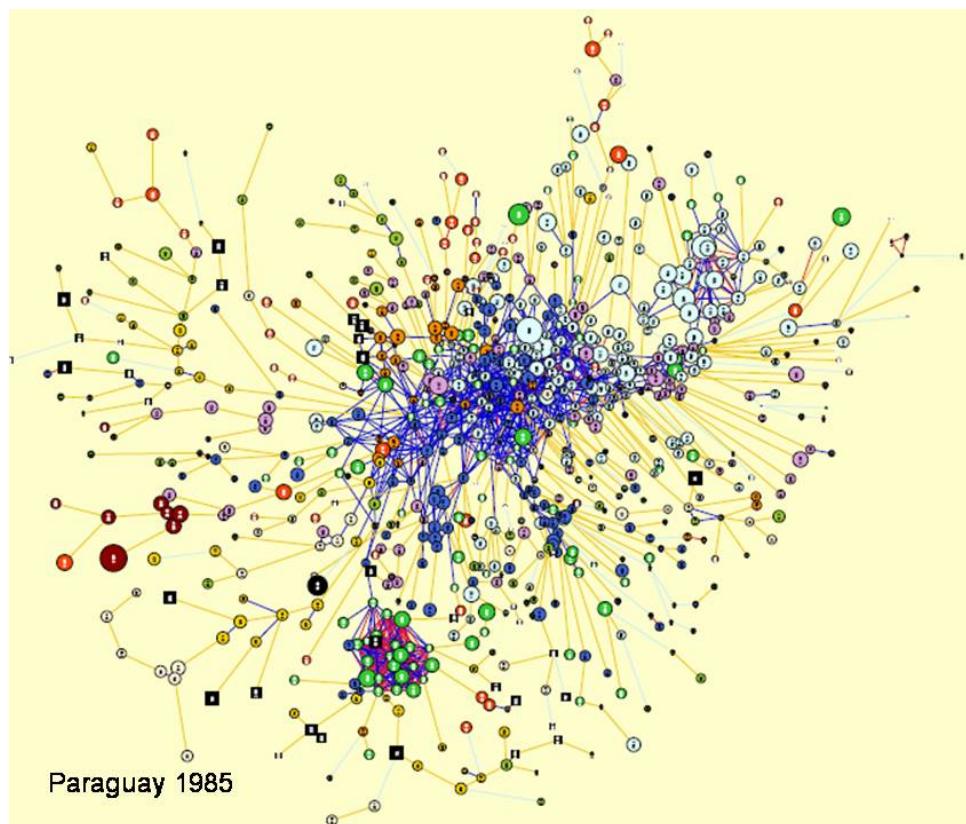
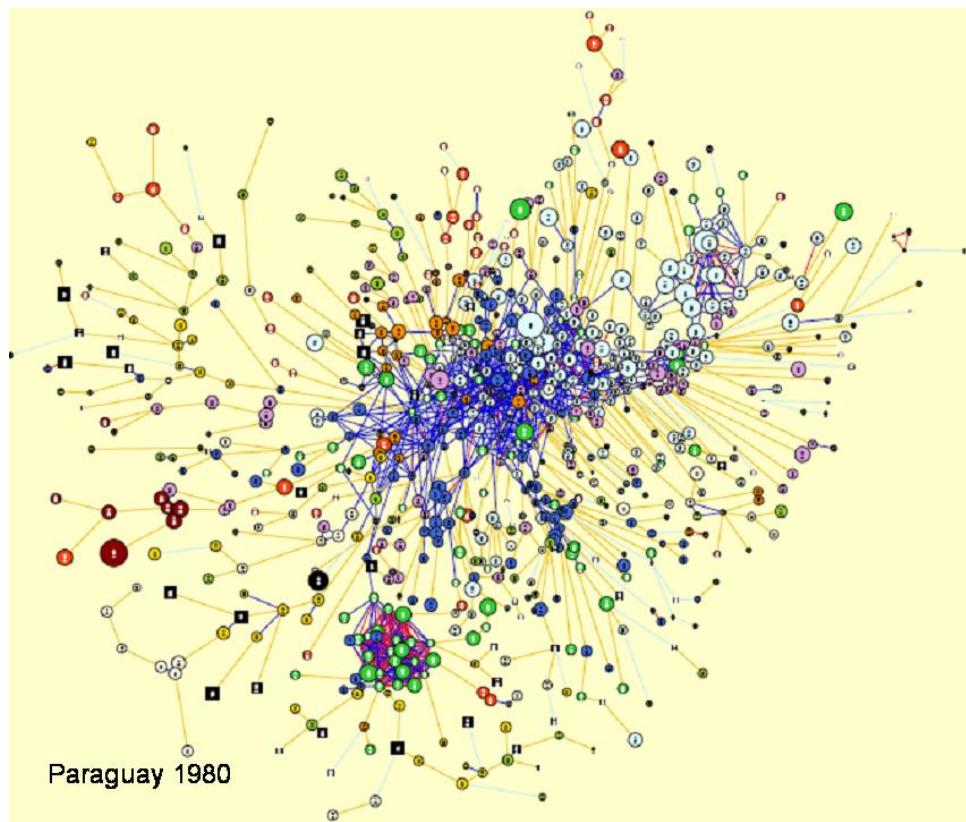
We can immediately see from this figure that the product space is highly heterogeneous. There are peripheral products that are only weakly connected to other products. There are some groupings among these peripheral goods, such as hydrocarbons products (the large red nodes on the left side of the network), seafood products (below hydrocarbons products), garments (the very dense cluster at the bottom of the network), and raw materials (the upper left to upper periphery). Furthermore, there is a core of closely connected products in the center of the network, mainly of machinery and other capital intensive goods.

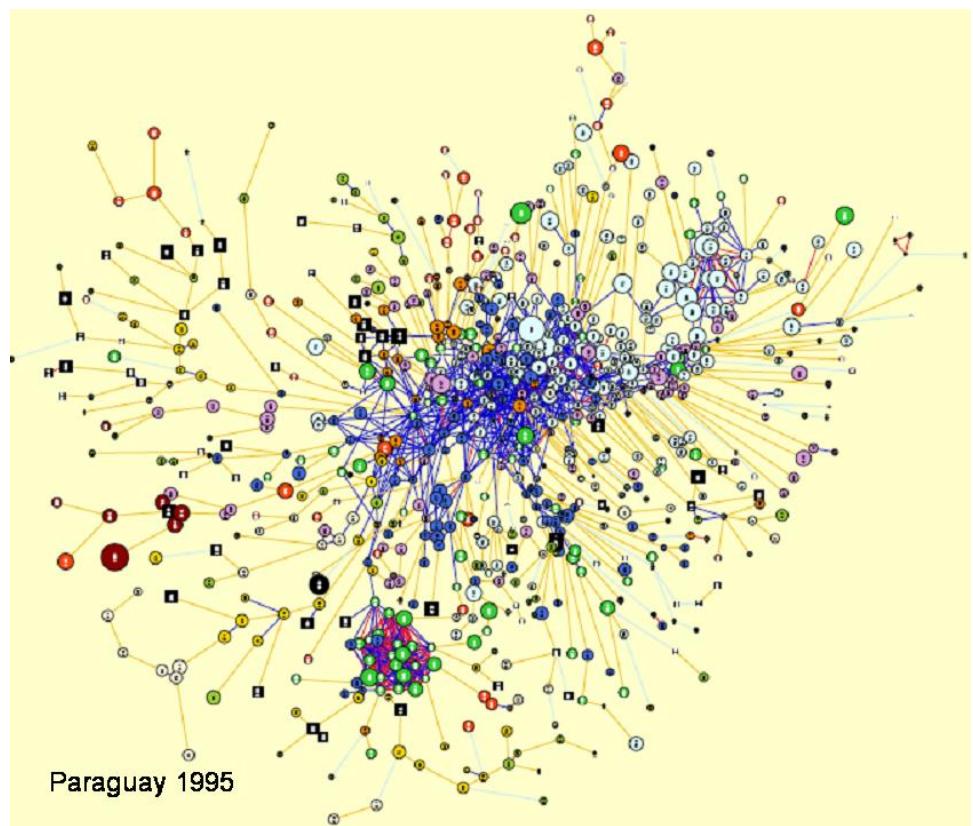
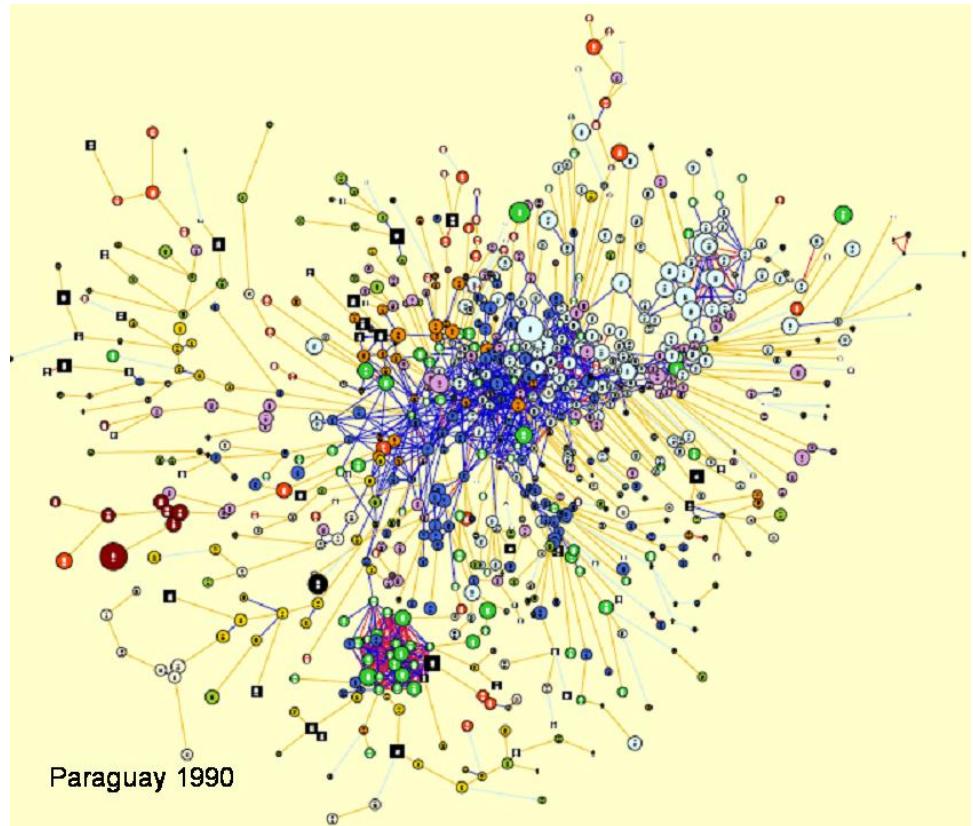
This heterogeneous structure of the product space has important implications for structural transformation. If a country is producing goods in a dense part of the product space, then the process of structural transformation is much easier because the set of acquired capabilities can be easily re-deployed to other nearby products. However, if a country is specialized in peripheral products, then this redeployment is more challenging as there is not a set of products requiring similar capabilities. The process of structural transformation can be impeded due to a country's orientation in this space.

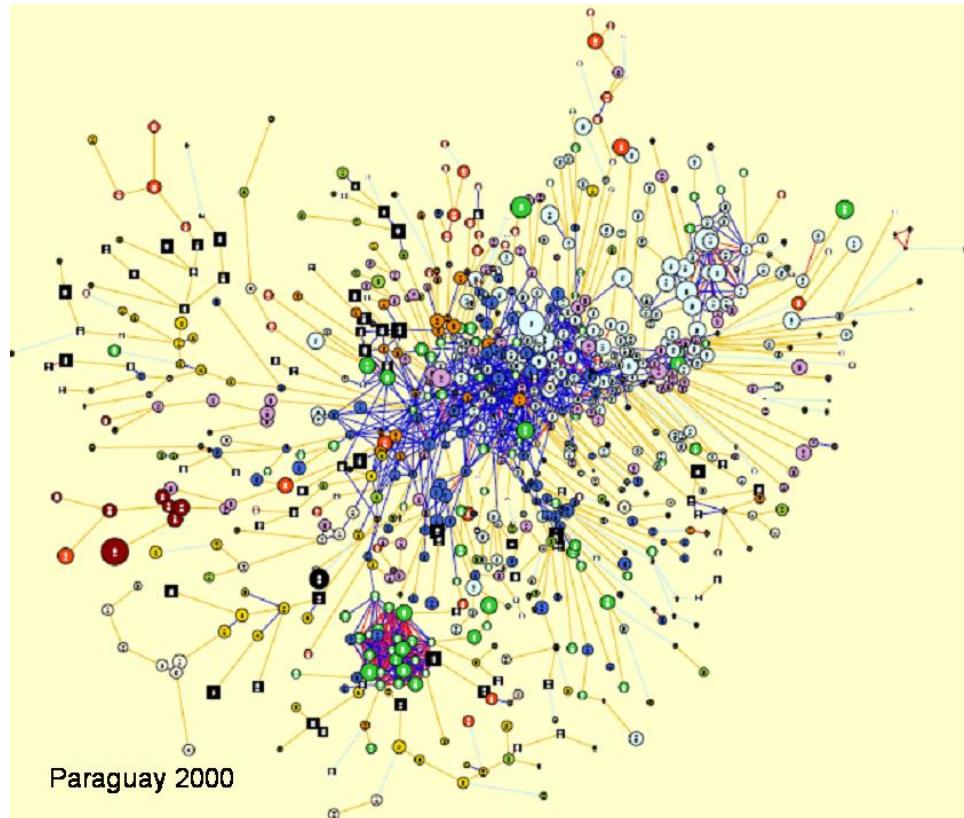
The figures below show Paraguay's evolution in this product space, where a black square on top of a product indicates that it is exported with comparative advantage.

Figure 18
Paraguay's Evolution in the Product Space







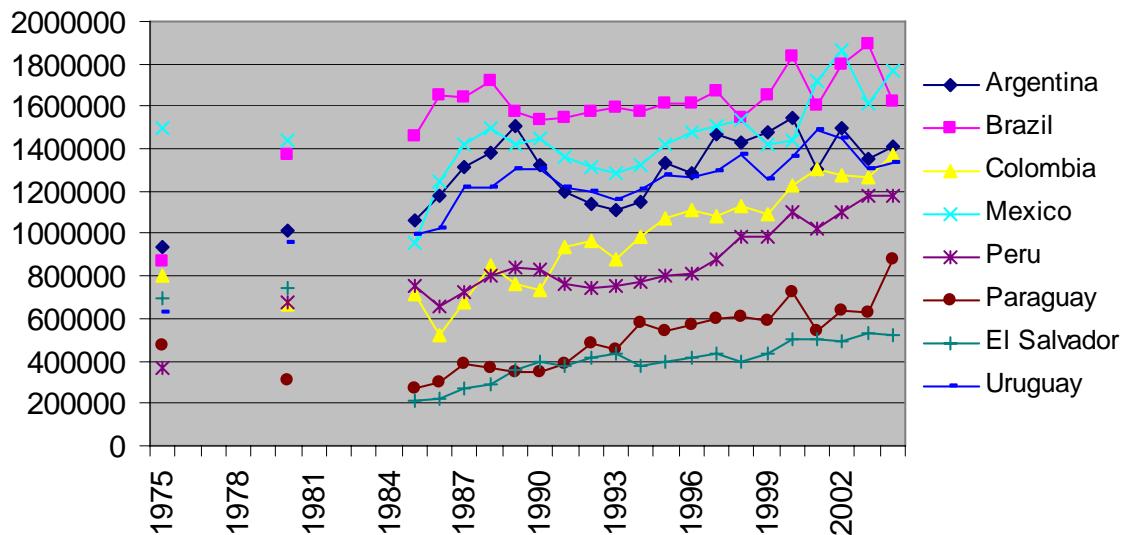


Source: Author's Calculations

These figures show that Paraguay's productive capabilities are concentrated in very sparse parts of the product space, and they have undergone very little changes over time. There is some movement in the orange products above and to the left of the central core (forestry products), and production in peripheral agricultural products. Yet there has been no movement to other areas of the space, or penetration of either the garments cluster, electronics cluster, or industrial core.

The 'connectedness' of an export basket can also be represented in a single number, open forest, which represents the option value of the current export package (see appendix for technical details). The open forest for Paraguay and some comparators is shown below.

Figure 19
Open Forest, Comparative



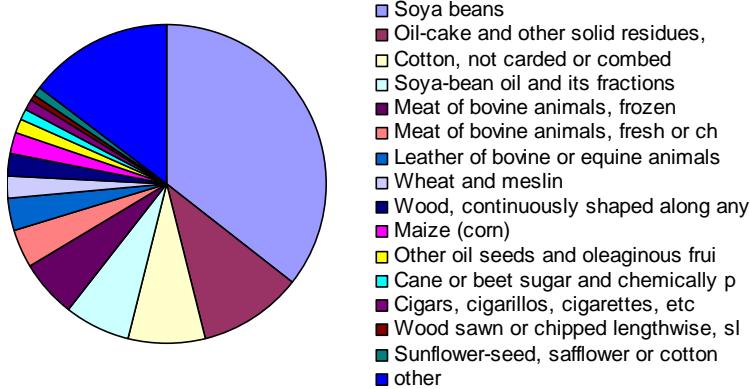
Source: Author's Calculations using Feenstra et. al. (2005) for the 1975-2000 period, and UN COMTRADE for the 2000-2004 period, merged using relative changes from 2000 observation which is common to both series.

Along with the low and stagnant export sophistication shown above, we see that Paraguay is in a sparse part of the product space. Paraguay's options for future structural transformation have improved slightly over the past 15 years, but this increase has been more or less in-line with increases in the series. While Paraguay has more trees that are both nearby and attractive compared to El Salvador, its options are much more limited than Peru or Colombia.

Another piece of evidence that structural transformation is a problem is Paraguay's export performance within Mercosur. Through Mercosur, Paraguay has access to two large, highly protected markets. This allows for import substitution industrialization to happen at a much larger scale and could have triggered new exports directed at this much larger regional market.

Paraguay exports are highly concentrated, with 15 product lines at the HS 4-digit level representing over 85% of exports.

Figure 20
Paraguay's Export Composition, 2004

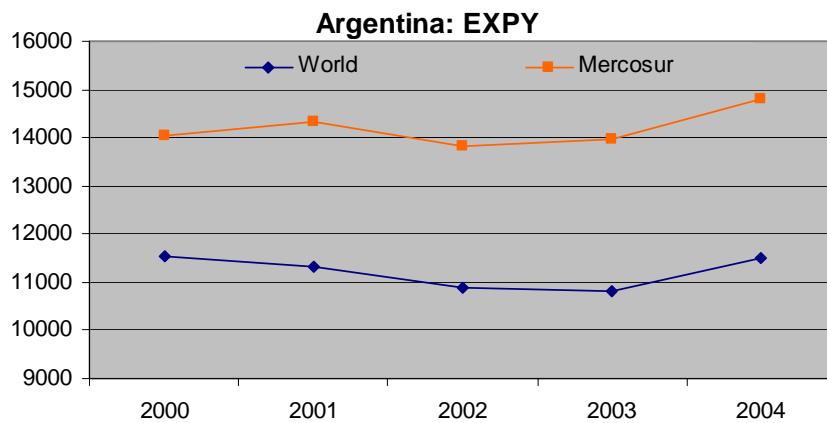


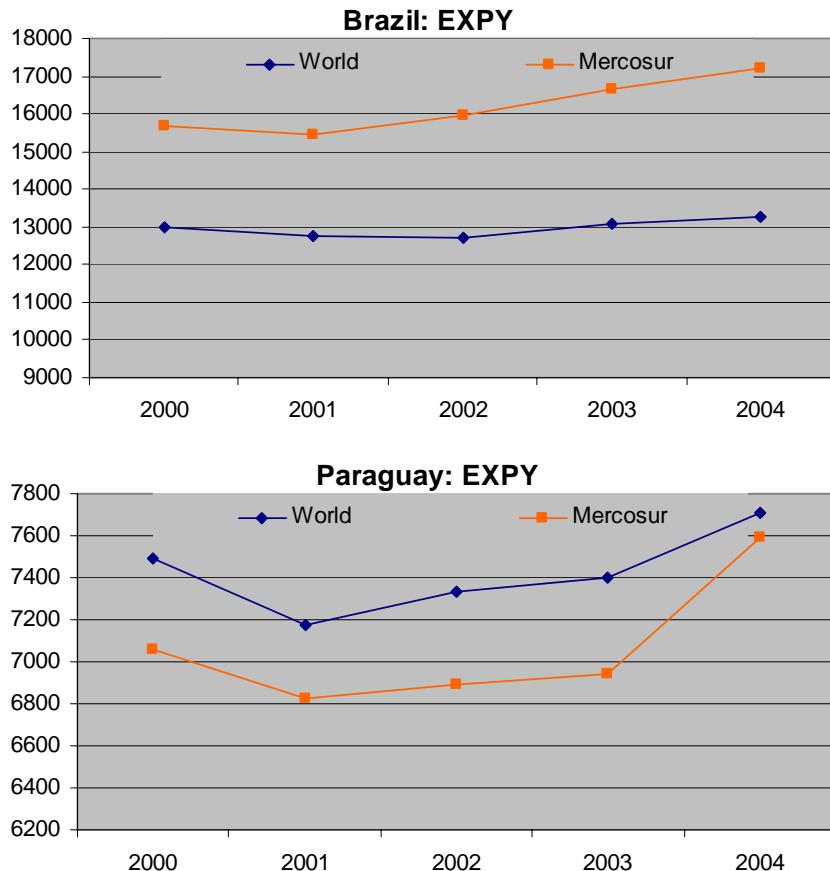
Source: UN COMTRADE

Interestingly, the major Mercosur countries are not net importers of these products. Argentina is a net exporter of all 15 products, and Brazil is a net exporter of 13 of the 15, with Argentina's net exports of those two products larger than Brazil's net imports. This shows that proximity to Argentina and Brazil coupled with the common market rules of MERCOSUR has not encouraged the development of new products destined to exploit the complementarities with the regional market.

This is a quite surprising finding that is unique to Paraguay within Mercosur. Unlike all of the other members of Mercosur, Paraguay's export sophistication within the block is actually *lower* than outside of it, as shown below.

Figure 21
EXPY in Mercosur





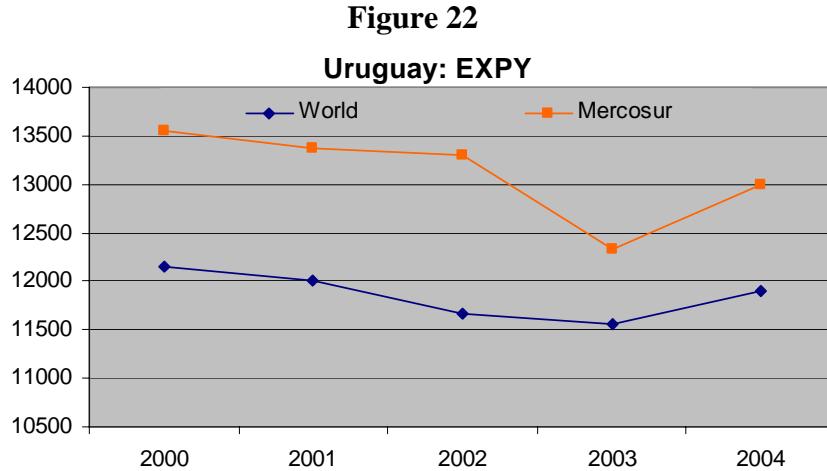
Source: Author's calculations using UN COMTRADE

In other words, the other members of MERCOSUR sell to each other goods that are more sophisticated (e.g. cars, steel products) than the goods they predominantly sell in global markets (commodities). This allows them to use the regional markets as a potential stepping stone into more sophisticated and better connected parts of the product space. This, however, has not happened in Paraguay.

Why is this? It is common to blame this outcome on the difficulties faced by the smaller members of MERCOSUR when exporting to Argentina and Brazil, particularly barriers against the export of processed or more sophisticated goods that can compete with local production in those markets. For example, Argentina allows the import of raw soybeans from Paraguay, but has erected barriers to the import of processed soy. Argentina has also restricted the export of meat products to Chile through its territory. These internal rules may be holding back the discovery of sectors by Paraguay for export within Mercosur.

While it is true that many problematic barriers to intra-Mercosur trade remain, we can control for this restrictiveness by comparing Paraguay to Uruguay. After all, Uruguay has also suffered significantly from restrictions to its trade and investment imposed by its larger neighbors. As the figure below shows, the pattern we observe in Paraguay is not present in Uruguay. Uruguay has successfully exploited opportunities within Mercosur to

upgrade its export package, with goods sold within the block being more sophisticated than those sold outside of it.



Source: Author's calculations using UN COMTRADE

This record within Mercosur is another indication that the discovery of new export activities in Paraguay is a problem. In spite of proximity and relatively free access to a large regional market not much has appeared to exploit new opportunities there. One exception is the re-export of information technology (IT) products out of Ciudad del Este. The market stimuli in terms of a highly protected regional market provide the incentive to supply, but little manufacturing activity takes place within Paraguay for that market.

But, is the country's location in the product space to blame for this record? Does low open forest explain little structural transformation, improvements in export sophistication, and growth? Or is there some other explanation unique to Paraguay? One way to evaluate this is to ask whether the frequency of transitions to new products is unusually low in Paraguay, after controlling for its position in the product space. To gauge this question we use the framework in Hausmann & Klinger (2006) where they estimate probit regressions on the probability of transitioning to a product not initially exported in a 5-year panel from 1985 to 2000 and controlling for the country's fact endowments, technological sophistication and position in the product space. We include country dummies to capture whether the probability of transition is higher or lower than expected given these other controls.

As the table below shows, this estimated coefficient is statistically significant in some cases, suggesting either unexpectedly rapid structural transformation if positive, and unexpectedly slow structural transformation if negative. Therefore factors other than location in the product space are particularly important in the cases of Romania, and El Salvador, but not in the case of Venezuela or Mexico.

Interestingly, in the case of Paraguay we see a statistically significant and negative dummy. That is, between 1975 and 2000 there was *a statistically significant pattern of slow structural transformation, controlling for open forest*. The unconditional probability

of transitioning to an un-exported product in this period is only 1.3%, so this means that country-specific factors in Paraguay other than their orientation in the product space are reducing the probability of moving to new products by over half!

Table 3
Estimated Coefficients on Country Dummies

El Salvador	-0.010 (3.91)**
Romania	0.016 (3.08)**
Venezuela	-0.001 (0.33)
Mexico	-0.001 (0.17)
Paraguay	-0.007 (2.52)**

A positive value indicates movements to new products occurred with greater frequency than predicted by the Hausmann & Klinger (2006) model. t-statistics in parenthesis.

*: significant at 5% level, ** significant at 1% level. Source: Author's calculations.

This suggests that even though its current location in the product space is poor, there are other constraints holding back the discovery of new export sectors, which we saw above is critical for generating output growth in Paraguay. Given that Paraguay is a land-locked country, relatively far from a major port, it is unlikely to become a hub for assembly manufacturing with a great deal of imported inputs, at least those shipped by sea. But the data does signal that there are nearby opportunities for structural transformation in Paraguay which the country has so far failed to take advantage of. A detailed analysis of this data can be found in the paper "Is a lack of self-discovery a constraint to growth in Paraguay" (Hausmann & Klinger 2007). The data reveals that these nearby opportunities are largely agricultural products, such as meat and dairy products, fruits, vegetables, and also some crops. Many products in these industries are currently not exported to a significant degree, yet hold great promise for Paraguay and should be relatively easy to exploit. So it is not only the case that the agricultural products that currently dominate the export basket have room to grow, as discussed above, but also that there are other new opportunities in these sectors.

This clarifies the challenge for the present diagnostic: what is holding back the process of sustained export growth through the expansion of existing, mainly agricultural, products, and also what is hindering the exploitation of new products, which are also mainly in the agricultural and agro-processing sector? Our analysis signals that institutional weaknesses, particularly in the interaction between the business environment and corruption, as well as infrastructure, are the binding constraints to this process. We will examine these binding constraints first, followed by a discussion of the evidence for rejecting other constraints. We then conclude with the policy implications of this analysis.

THE BINDING CONSTRAINTS TO GROWTH IN PARAGUAY

Suppose one is trying to identify the binding constraint to there being so few animals in the Sahara desert. It is helpful to notice that among the few animals that one does find, there are more camels than hippopotami. The fact that camels are un-intensive in water whereas hippos are very intensive in water signals that the binding constraint that limits the animal population in the Sahara desert may have something to do with lack of water.

Similarly, in Paraguay we can identify some high-profile camels. First is soybeans. Why have soybeans boomed so significantly in the recent past? What in the context makes them camel-like? The production and export of soybeans is un-intensive in infrastructure. The no-till GMO technology requires minimal labor inputs. The logistics requirements are low as output only has to be shipped out once a year rather than every day, and is more robust to delays, poor storage, and rough handling than an agricultural product like fresh fruit. Processing can be carried out relatively far from the farm (as opposed say to sugar) and is done mainly in Argentina. Moreover, the product is shipped from over 20 private ports built their own ports on Paraguay's rivers, thereby by-passing the need for publicly-provided port services.

In fact, much of the boom in soybeans can be explained by the extension of the Hidrovía, which implied a large reduction in transportation costs along the Paraná River. This can be seen as a somewhat exogenous shock to the infrastructure endowment of the country (as much of the requisite investments in dredging and equipment were done by Argentina and Brazil), suggesting that infrastructure and transportation costs may be a binding constraint that prevents a more intensive use of the country's ample agricultural frontier. A cursory analysis of the GIS-based map presented above shows ample regions that are promising for either sugar or soybeans that are yet unexploited, probably because they are far from the Hidrovía. In other words, soybeans grow where there was an exogenous infrastructure shock. Sectors and regions that did not undergo such a shock are constrained.

In addition to being un-intensive in infrastructure, soybeans are not intensive in the type of transactions and contract enforcement that may hamper other activities. So it can thrive in a weak business environment. Moreover, their production is at a large enough scale that it can pay for protection from formal or informal expropriation, if this becomes an issue.

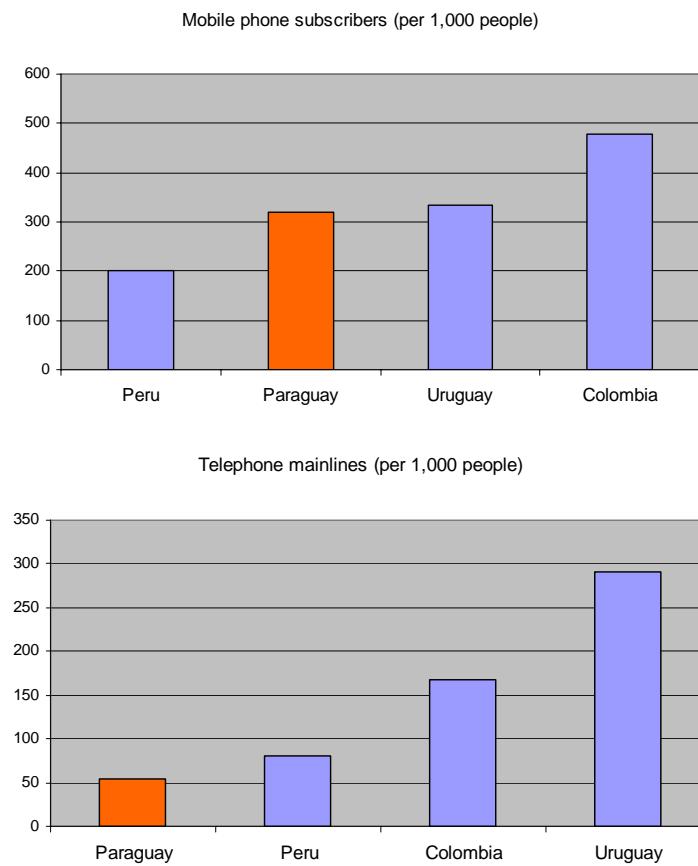
The institutional requirement of the biofuels industry is also very different. It would involve the creation of a domestic market with its rules on gasoline standards for automobiles and international negotiations for the participation in an emerging global market. Hence, whether the country is able to penetrate the higher value-added field of sugar-based bio-ethanol or stay in soybeans will depend on infrastructure and institutions to a large extent.

Another camel seems to be the high levels of productivity and the successful export of a large variety of agricultural goods from the Mennonite communities in Paraguay. Many

of the products exported by these communities are precisely those that the analysis of the product space reveals to be nearby but relatively unexploited. Anecdotal evidence reveals that these communities provide much of their own infrastructure and micro-level institutions to regulate business transactions and enforce contracts within the community. Even though they are subject to the same macroeconomic policies, political instability, labor code, and tax system as the rest of Paraguay, they have been able to successfully exploit opportunities that the rest of the country has not.

This analysis points to infrastructure and institutional constraints as being behind the inability of the country to break into higher productivity activities. It is useful in this context to look at the available internationally comparative measures that exist. For example, while mobile coverage is greater than Peru and on par with Uruguay, fixed line coverage is extremely poor (possibly itself a cause of higher mobile coverage).

Figure 23

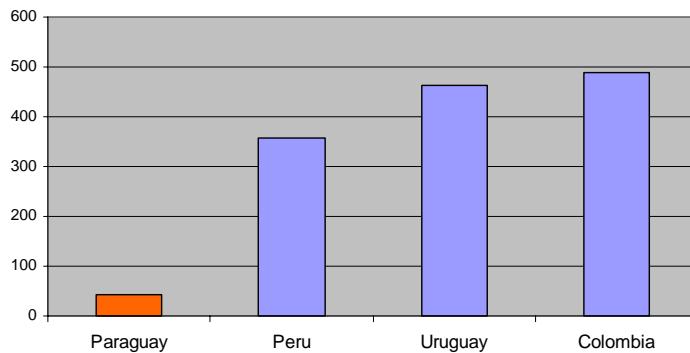


All figures are for 2005. Source: WDI

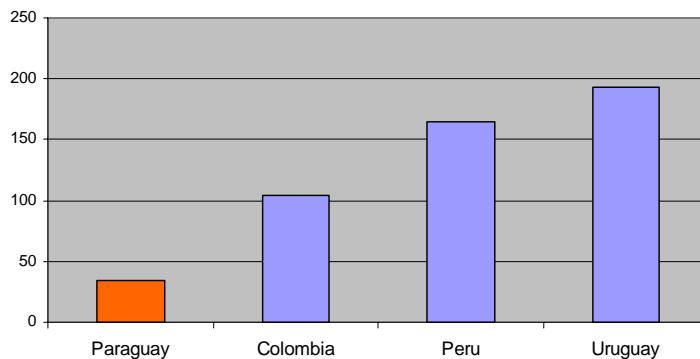
In terms of the internet, Paraguay ranks extremely low, with very small bandwidth and few users.

Figure 24

International Internet bandwidth (bits per person)



Internet users (per 1,000 people)



All figures are for 2005. Source: WDI

Paraguay also rates extremely low in the global competitiveness report infrastructure rankings. Most worrying is the country's extraordinarily low ranking in air transport. Unlike most of the comparator countries in Latin America, Paraguay is landlocked, and therefore assembly-based manufacturing using imported inputs from sea shipping is unlikely to be competitive. But one alternative not closed off by Paraguay's geography is high value-per-weight time sensitive sectors using air shipping, such as cut flowers or certain aquaculture. The emergence of such industries would be prevented by the poor quality of the air transport infrastructure. This is an important comment as there is evidence that the cut-flower sector in Ecuador failed in the 1970s and was only successful in the 1990s because of the state of the air transportation system. Now, problems in air transportation usually reflect institutional problems more than lack of financial resources. In this respect it is interesting to note that Paraguay has recently approved legislation to protect the margins of its travel agent industry that has caused the departure of at least one major airline and may be preventing the entry of others.

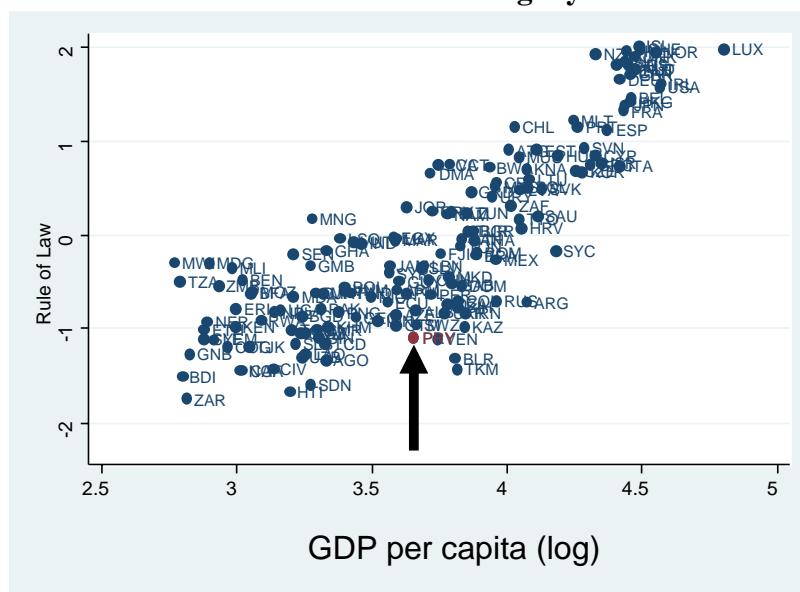
Table 4
Global Competitiveness Report, Infrastructure Ratings

	Rail	Ports	Air Transport
Argentina	2.7	3.6	4.3
Bolivia	1.8	1.	3.7
Brazil	1.8	2.7	4.5
Colombia	1.4	2.8	4.7
Costa Rica	1.2	2.3	4.5
Chile	2.7	4.9	5.7
Dominican Republic	1.1	3.4	4.8
Ecuador	1.2	2.9	4.4
El Salvador	1.5	3.9	5.6
Mexico	2.2	3.3	4.9
Paraguay	1.0	2.3	2.9
Peru	1.6	2.1	3.2
Uruguay	1.5	4.4	3.5
Venezuela	1.3	2.8	4.0
LAC	1.64	3.06	4.34

Note: 1 = Underdeveloped, 7 = Efficient. Source: Global Competitiveness Report 2005/6

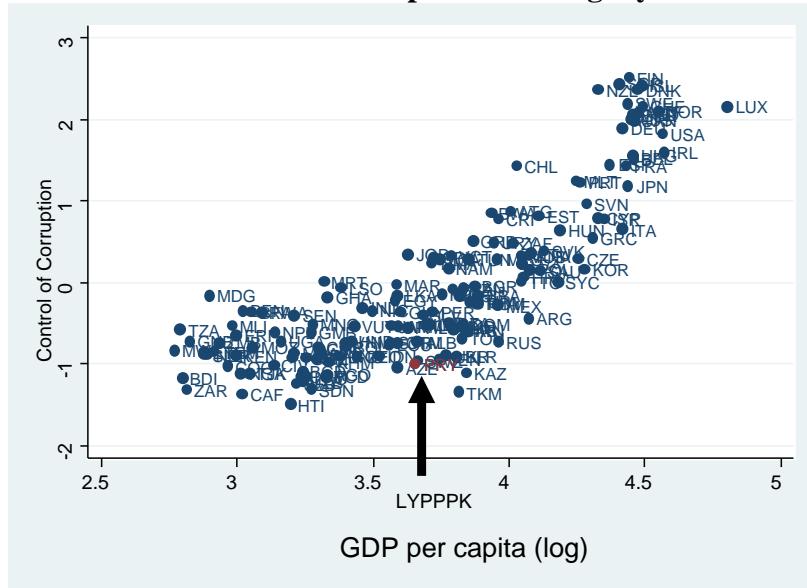
In terms of corruption indicators, Paraguay also ranks very low. Controlling for its level of income, Paraguay has one of the lowest rule of law ratings and control of corruption ratings in the world.

Figure 25
Rule of Law in Paraguay



Source: World Bank

Figure 26
Control of Corruption in Paraguay



Source: World Bank

The Kaufman indicators are good for signaling an area of concern, but they are overly general for a more detailed diagnostic and suitable policy response. One way to drill deeper into this constraint is using the Doing Business indicators collected by the World Bank. Paraguay's summary rankings are shown below. In these comparative rankings, we see a very variable picture, with some aspects of the business climate ranking extremely well (notably in the area of financial services, confirming the rejection of this constraint in the following section), and others such as regulations to formally employ workers, to open and close a business and enforce contracts, ranking very poorly.

Figure 27
Paraguay's Business Climate

The Good,

Country	Registering Property	Getting Credit	Protecting Investors
Argentina	74	48	99
Bolivia	115	65	118
Brazil	124	83	60
Chile	30	33	19
Colombia	56	83	33
Ecuador	84	65	135
Mexico	79	65	33
Paraguay	48	48	46
Peru	32	33	15
Uruguay	138	33	83
Venezuela	75	143	162

the Bad,

Country	Paying Taxes	Trading Across Borders
Argentina	161	71
Bolivia	166	135
Brazil	151	53
Chile	37	44
Colombia	172	128
Ecuador	53	126
Mexico	126	86
Paraguay	103	117
Peru	135	93
Uruguay	76	59
Venezuela	167	116

... and the Ugly

Country	Starting a Business	Dealing with Licenses	Employing Workers	Enforcing Contracts	Closing a Business
Argentina	106	125	138	68	58
Bolivia	149	57	174	98	53
Brazil	115	139	99	120	135
Chile	32	40	58	73	107
Colombia	90	60	77	141	26
Ecuador	139	60	161	96	134
Mexico	61	30	108	87	25
Paraguay	135	124	169	147	124
Peru	92	121	158	95	73
Uruguay	134	56	58	119	37
Venezuela	129	98	165	129	144

Source: World Bank

The broad institutions in Paraguay, such as political instability and the risk of large-scale expropriation by the state, are not found to be binding constraints (see the following section). However, there do seem to be significant problems with the more micro institutions that regulate property rights. Paraguay is the most difficult country in Latin America to enforce contracts in, requiring 46 procedures, well over a year, and 40% the cost of a debt to solve a sale of goods in dispute.

In addition to giving the Kaufman indices more clarity, these indicators about the business environment also put the corruption rankings in a new light. With a regulatory environment as burdensome as that in Paraguay, it may well be that the only way to conduct many business activities is extra-legally. Efforts to reduce the supply of corruption without addressing the sources of demand may be unproductive. If the only way to profitably operate a business is extra-legally, then eliminating corruption without improving the regulatory environment might actually hurt the economy.

Hence, the analysis suggests that while Paraguay is a landlocked country specialized in a very sparse part of the product space, it still has many opportunities that it has been able to exploit. Structural transformation has proceeded more slowly than would be expected

from its poor location in the product space. It has a very large and very fertile agricultural frontier that it has yet to develop. It has preferential access to a very large regional market but it has failed to develop products to exploit this opportunity. It could enter into industries that exploit air cargo, but it has failed to create the conditions for competitive air service. It is well poised to exploit some of the coming opportunities in the area of bioenergy. At the core of these missed opportunities are institutional limitations that prevent the development of infrastructure and the business environment.

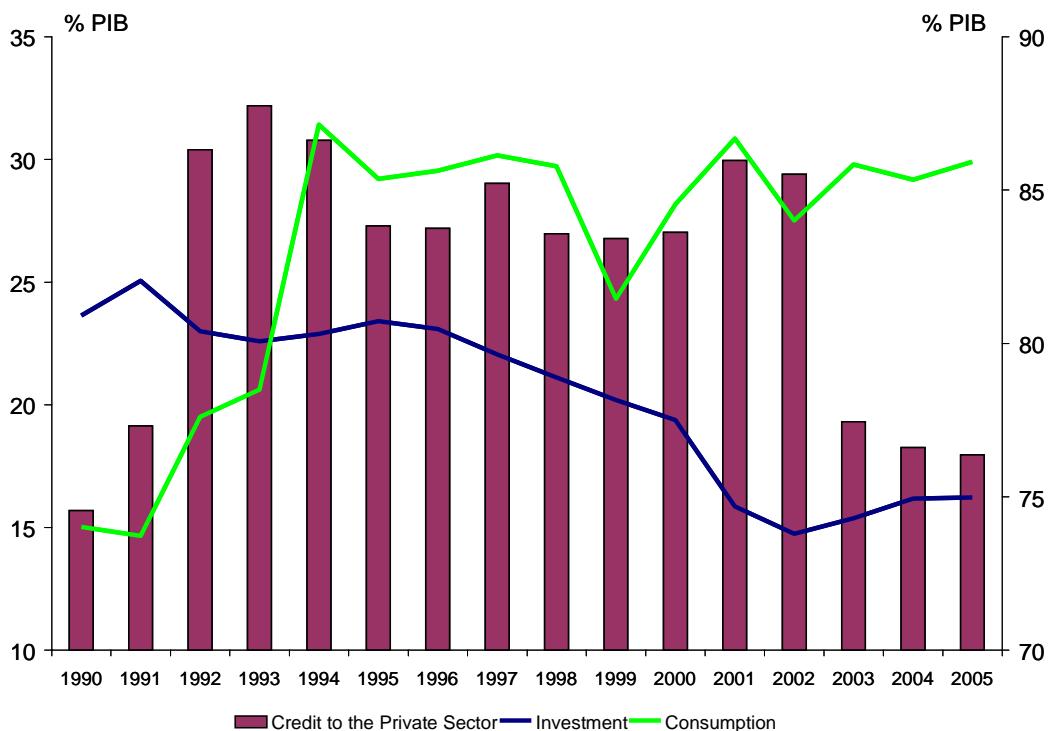
The final section provides policy recommendations based on the identification of these constraints. But first we will review the evidence for rejecting other potential constraints as binding.

DISCARDED CONSTRAINTS

Access to finance

There was a significant decline in private investment during the 1990s, at the same time that a credit boom was taking place. The increase in credit went towards consumption rather than investment, suggesting that investment was more limited by the lack of privately profitable opportunities than due to low availability of credit.

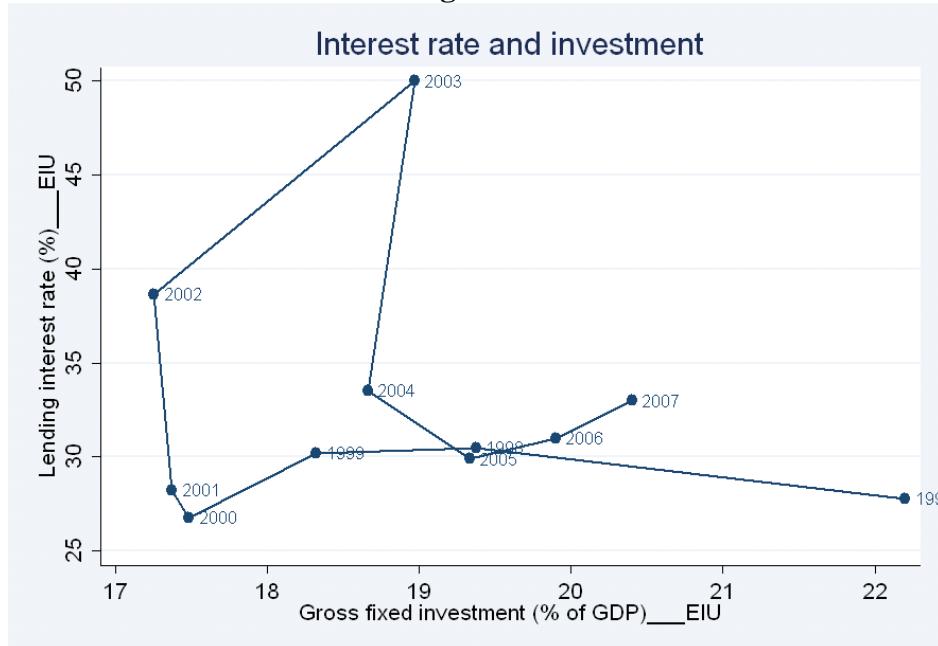
Figure 28
Credit, Consumption, and Investment in Paraguay



Source: International Financial Statistics, IMF.

Moreover, in Paraguay, investment levels do not co-move with interest rates in a manner that is suggestive of the constraint being on the supply of credit. In other words, if credit was the binding constraint we would expect investment to be very sensitive to movements in the interest rate, going up (down) as interest rates fall (increase). Instead we find that investment fell very significantly between 1997 and 2001 with relatively flat interest rates, and rose between 2001 and 2003 in spite of higher interest rates. This suggests that changes in investment are dominated by changes in expected returns, not by insufficient access to finance.

Figure 29

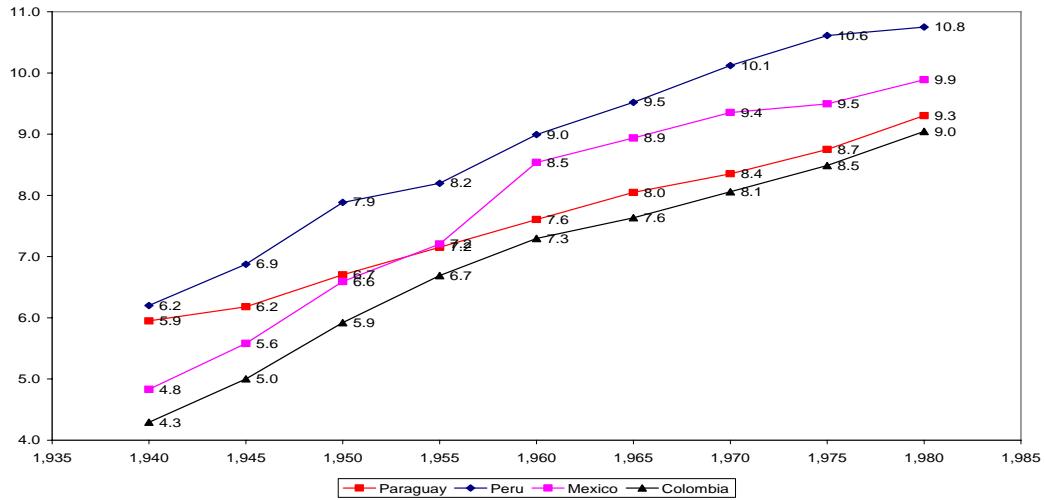


Source: EIU

Education

As evidenced by the years of education among Paraguayans of different ages, the supply of education among those entering the workforce increased steadily while at the same time output per capita is still at the levels of the 1970s when education was much lower.

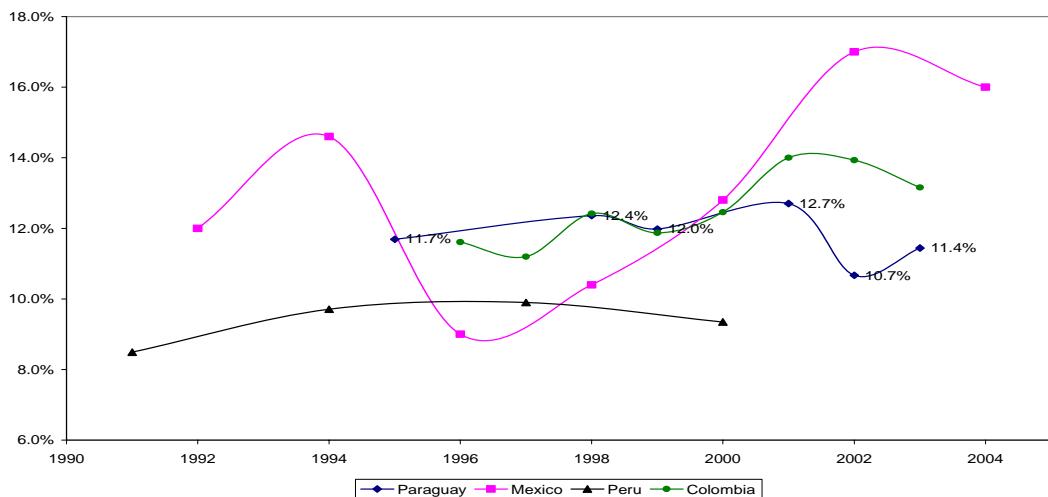
Figure 30
Average schooling of cohort by year of birth



Source: Encuestas Nacionales de Niveles de Vida

Moreover, if education was the binding constraint we should observe a high or rising market price for human capital. But the returns to education are neither high nor rising. In fact, returns to education for urban males in Paraguay have fallen since 2001, in the context of a growth acceleration. If the supply of skilled workers was binding, firms would be offering them increasingly higher wages. This is not the case in Paraguay, leading us to reject the supply of education as a binding constraint to growth.

Figure 31
Mincerian returns to Education, Urban Males

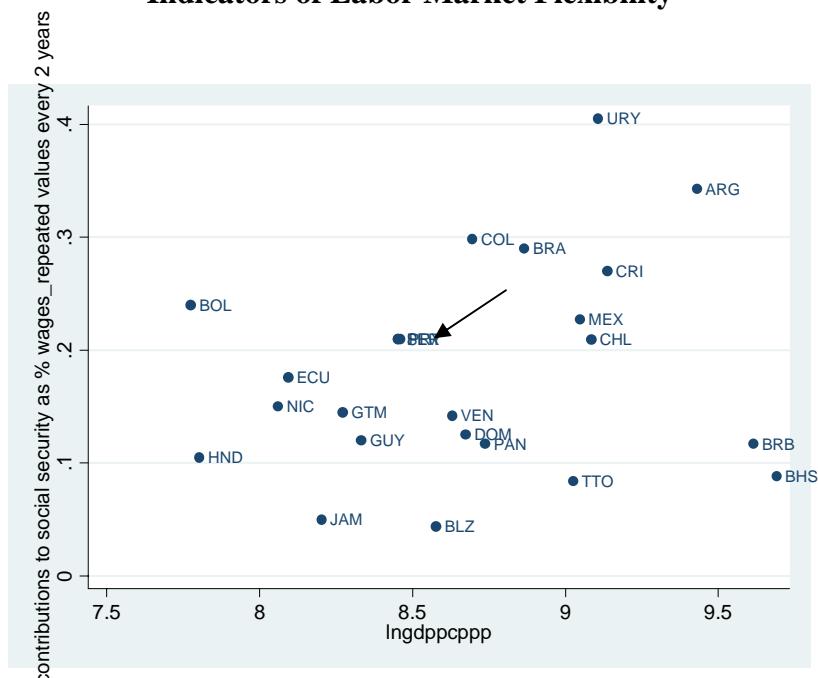


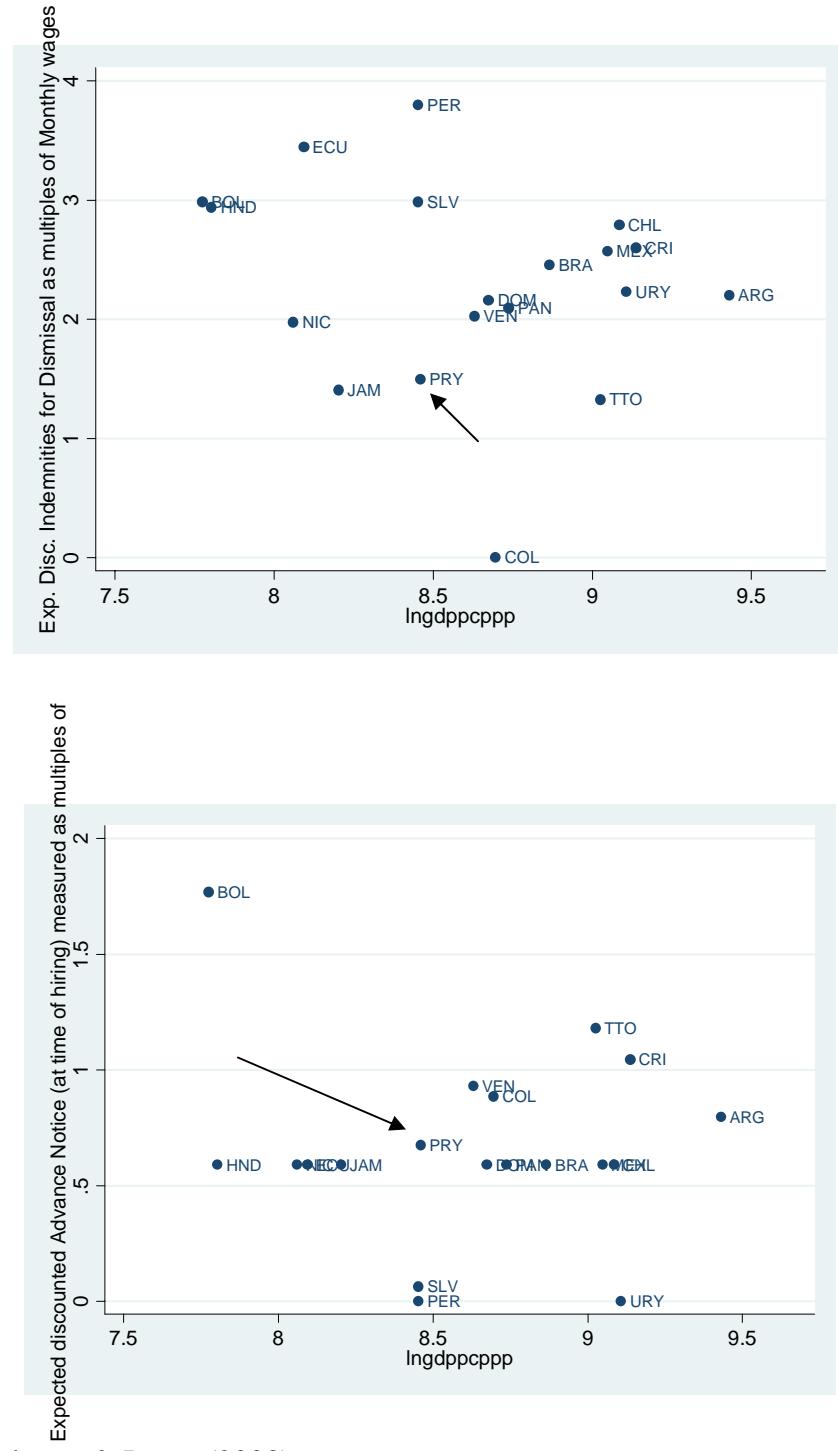
Source: Encuestas Nacionales de Niveles de Vida

Low returns due to labor market rigidities

Paraguay ranks comparatively well on the Heckman & Pages indicators of labor market costs & flexibility. The contributions to social security, the indemnities and the cost of advanced notice for dismissal are below the Latin American average. Nevertheless, one troubling piece of evidence is the poor rating of the country in the labor aspects of the World Bank's Doing Business indicators discussed above, which in some dimensions directly contradict the Heckman and Pages indicators regarding the cost of dismissal. The country also has a fairly high minimum wage as a share of the average wage and very significant indicators of informality. Poor law enforcement and informal contractual arrangements suggest that many sectors of the economy are able to circumvent the problems caused by labor rigidities. The fact that the Mennonite communities are able to flourish in the export of agricultural and animal products while facing the same labor code suggests that this is not a binding constraint.

Figure 32
Indicators of Labor Market Flexibility





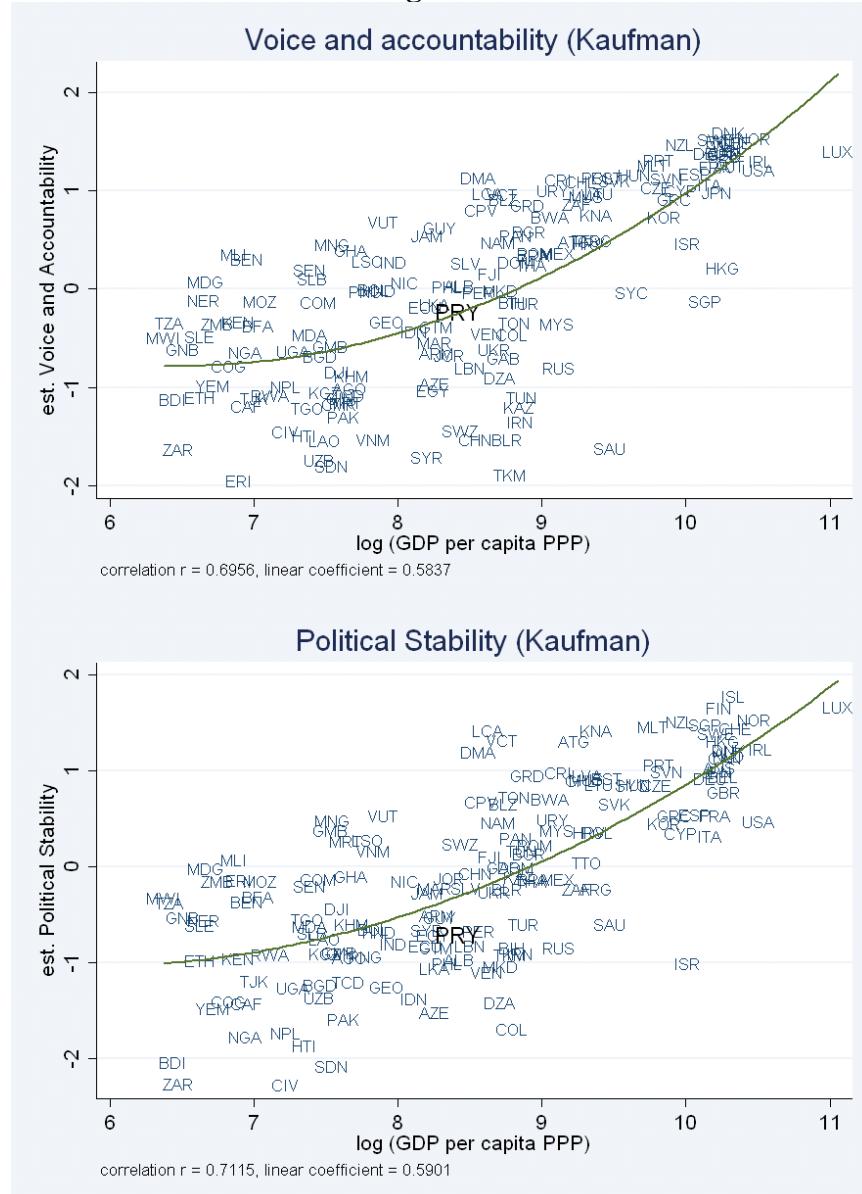
Source: Heckman & Pages (2003)

Appropriability due to Political instability

The growth history of Paraguay is difficult to square with a story of concerns of appropriability due to political instability and large-scale expropriation (as opposed to

expropriation at a smaller-scale due to corruption) as the binding constraint to growth. As opposed to the corruption and rule of law variables, Paraguay rates quite well in terms of voice and accountability and political stability.

Figure 33

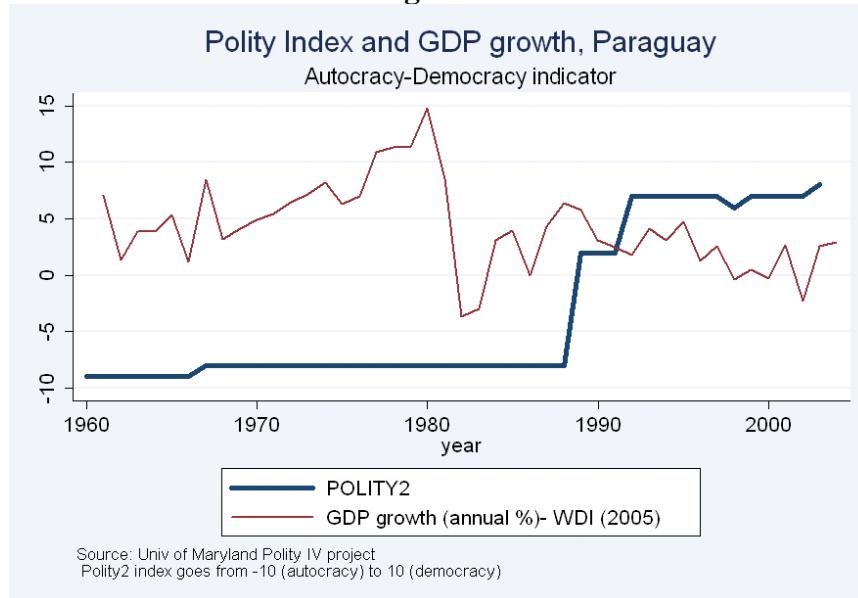


Source: Kaufmann

Moreover, the political dynamics in Paraguay do not match up well with the growth dynamics. Paraguay enjoyed a growth acceleration under Stroessner, but also long periods of stagnation. So the presence of a strongman to steer the economy only exceptionally lead to growth. The presence of democracy has been neither a guarantee nor a hindrance to growth, given that both decline and the recent growth acceleration has taken place under that political system. More importantly, the issue of political instability per se has not been accompanied by dispossession or expropriation of relevant activities.

Unlike movements in the terms of trade, the political system does not match up with the growth experience, and is therefore not convincing as a binding constraint to growth. This does not mean that the workings of the political system are not behind the weak institutional performance we document. But it affects growth through this institutional channel, not through a perceived high political risk per se.

Figure 34



Source: Polity & WDI

Appropriability due to macroeconomic risks

The macroeconomic situation of the country deteriorated in several circumstances including the difficult period between 1997 and 2002. However, the recent turnaround has put macroeconomic fears behind. And yet, with an encouraging international environment, an improved macro situation and ample productive resources left underutilized by the previous recession, the country is only able to sustain rather moderate rates of per capita income growth, a fraction of the recovery that took place in Argentina or Uruguay. If the binding constraint was macroeconomic in nature, we should have seen much more growth than we have.

POLICY IMPLICATIONS

Our analysis indicates that Paraguay's growth rate is tied to export performance. Yet, the country has a poor record of structural transformation, and has only managed to grow in the face of favorable international prices and technological advances that are largely external. Although structural transformation is constrained by the country's specialization in a narrow set of relatively unconnected products, even after controlling for this peripheral productive structure we find that Paraguay has done poorly in terms of discovering new export activities. There are new nearby export activities in the animal

and agriculture sector that remain unexploited, as well as room to grow in the current export basket. Paraguay's failure to capitalize on Mercosur's opportunities provides even more evidence that something is holding back movements to new export activities. At present, the country seems to have hit on very large growth opportunities in the agricultural sector. Soybeans still have ample room to grow. Sugarcane is barely using a marginal percentage of the lands that are suitable for it. Sugarcane requires processing which creates related manufacturing activities, whether for sugar, ethanol, animal feed and energy. The possibilities in meat are equally impressive. And the list could go on. The new products seem to be more labor intensive than soybeans and thus should lead to more social inclusion in the growth process.

Some of these possibilities are new, but many are old. The country's vast fertile land resources have been there since the beginning. Why have they remained undeveloped? Why would they be developed now?

To secure these possibilities, the requisite infrastructure, logistic system, business environment and property rights would have to be secured. In our broader analysis of Paraguay we find evidence supporting the idea that the underlying obstacles that have prevented the country from developing many of the opportunities that appeared plausible are related to two constraints: the provision of infrastructure and a lack of appropriability due to corruption and a poor regulatory environment. The current environment is one where the only activities that can survive have to be un-intensive in infrastructure, or at least it has to be possible for the market to provide what the public sector is failing to deliver. Investments in infrastructure, including air traffic infrastructure, are critical to many of the new opportunities that could accelerate growth.

Moreover, the only way to operate in the current regulatory environment is to bypass it, fueling corruption. This situation prevents sectors from emerging that don't have sufficient scale and transaction intensity to make such corruption an acceptable business expense. To exit this equilibrium, it is not enough to engage in broad programs to fight corruption. Rather, the regulatory environment has to be reformed in order to increase its efficiency and reduce the demand for extralegal solutions to regulatory barriers. This regulatory environment is preventing the exploitation of nearby agricultural products, which is key to generating sustained growth.

But countries do not develop institutions in the abstract. They do so in order to address the real problems faced by real activities. What needs fixing and how best to do it, given the institutional, economic, social and political context of the country is a question that cannot be the outcome of a single study but must involve a social process where society at large is able to identify obstacles and opportunities and action can be brought to the issues raised. Here the quality of the social debate and the nature of the political process become crucial.

The government will not know what needs fixing unless it engages deeply with the private sector. But this engagement has to be understood by the rest of society, not as a conspiracy to appropriate public funds but a cooperative engagement to enhance

productivity and social welfare. The legitimacy of this process vis a vis society at large is key. To assure it, participation and openness to different stakeholders, transparency of the requests and the decisions adopted,

For example, the opportunities for export growth through both more of the same and through moving to new export goods are concentrated in the agricultural sector. This suggests that the government focus on providing the necessary public inputs that these activities require. Such inputs are highly specific: the public goods needed by the dairy sector, for example, are likely to differ greatly from those required by the biofuels industry. It is therefore important that cues to the nature of the required public goods and the quality of the current provision come from private sector actors themselves, who are most aware of their particular requirements. But given the country's opportunity set, some likely inputs are the logistics system, rural infrastructure, agricultural research and extension services, food safety certification and sanitary and phytosanitary standards. To provide these inputs, it is necessary that the needs be identified and prioritized. Institutions that deliver these public inputs should be reformed (if they exist) or set up. Funding should be adequate, but given that these are inputs to productive activity in a relatively low income country, they should be ideally financed through service charges and through levies on the sectors themselves: willingness to pay is a good indication of the need sector-specific public input. Subsidies should be avoided as they may trigger the wrong kind of incentives in the motivations for private sector participation in the process.

The effectiveness of the requisite institutions will depend on their governance structure, their transparency and accountability and on the existing of monitoring bodies with a vested interest in seeing them succeed.

Growth also needs to be shared. The principal form of social participation in the growth process is through higher productivity jobs. But taxation should be adequate and enforced effectively so that the benefits of growth can be better distributed throughout society. If this is not done, property rights will always be perceived as weak as they would not garner significant social support.

At present, the change in international agriculture prices and the prospects of a bio-energy industry are creating enormous new opportunities for Paraguay. Other opportunities that can exploit Paraguay's land and use air transport could probably arise if the right ideas, technologies and institutional arrangements (including the air cargo sector) could be forthcoming. This can lead to a new sustained period of growth as that experienced in the 1960s and 1970s. Making the most out of this opportunity is key. In this respect, there is an ample agricultural frontier to expand and products such as meat, dairy and the sugar complex whose labor inputs are much more significant than those of soybean production. Capturing these opportunities and allowing them to flourish seems key to a future of faster progress in Paraguay.

APPENDIX

Source Acronyms:

EIU: Economist Intelligence Unit

IFS: International Monetary Fund International Financial Statistics

Kaufman: World Bank Governance Indicators

WDI: World Bank World Development Indicators

Technical Details

EXPY

Hausmann Hwang and Rodrik (2006) develop a measure of the revealed sophistication for each product, which they call PRODY, as the revealed comparative advantage (RCA)-weighted GDP per capita of each country that exports the good:

$$PRODY_k = \sum_j \frac{(x_{jk}/X_j)}{\sum_j (x_{jk}/X_j)} Y_j$$

where x_{jk} equals exports of good k by country j , X_j equals total exports by country j , and Y_j equals GDP per capita of country j . This is the GDP of the ‘typical’ country specialized in that product, and can be used to measure the sophistication of a country’s entire export basket, which the authors call EXPY. EXPY is simply the PRODY of each good (l) that the country (i) exports, weighted by that good’s share in the country’s export basket (X_i). It represents the income level associated with a country’s export package.

$$EXPY_i = \sum_l \left(\frac{x_{il}}{X_i} \right) PRODY_l$$

Proximity

This is found by first developing a measure of distance between products. We measure the distance between each pair of products based on the probability that countries in the world export both. If two goods need the same capabilities, this should show up in a higher probability of a country having comparative advantage in both. Formally, the inverse measure of distance between goods i and j in year t , which we will call proximity, equals

$$\varphi_{i,j,t} = \min \{ P(x_{i,t} | x_{j,t}), P(x_{j,t} | x_{i,t}) \}$$

where for any country c

$$x_{i,c,t} = \begin{cases} 1 & \text{if } RCA_{i,c,t} > 1 \\ 0 & \text{otherwise} \end{cases}$$

and where the conditional probability is calculated using all countries in year t . This is calculated using disaggregated export data across a large sample of countries from the World Trade Flows data from Feenstra et. al. (2005) and UN COMTRADE.

Density and Open Forest

To measure what was nearby, we must use the pairwise measures of distance defined above to calculate the distance of every product from a country's export basket as a whole. We call this measure density. It is the distance of good i from country c 's export basket at time t . It is the sum of all paths leading to the product in which the country is present, scaled by the total number of paths leading to that product. As with proximity, we define x based on whether or not the country has revealed comparative advantage in the product (if $RCA >= 1$). Density varies from 0 to 1, with higher values indicating that the country has achieved comparative advantage in many nearby products, and therefore should be more likely to export that good in the future.

$$density_{i,c,t} = \left(\frac{\sum_k \varphi_{i,k,t} x_{c,k,t}}{\sum_k \varphi_{i,k,t}} \right)$$

Density is a key variable in the process of growth diagnostics: it can be taken as an indicator of the degree of coordination needed to produce any given product. If the product is very near to the current export basket, density will be high, meaning that most of the capabilities needed in the new sector will already exist in other sectors. On the other hand, if density is low, then the human capital, physical capital, property rights, infrastructure, and every other sector-specific factor of production that the sector needs will not exist, and can not be easily adapted from what does exist.

To measure whether a lack of coordination was holding back structural transformation, we can use density to determine if there are nearby opportunities for structural transformation available that were not capitalized on because of some other constraint, or if there were simply no nearby products that could fuel structural transformation in the absence of coordination.

To do this, we need to use density, which is at the country/product level, to measure the opportunity set for the country as a whole. This measure, called 'open forest', answers the question "how green is your valley"—is the current export basket in a part of the product well-connected to other new and valuable opportunities for structural transformation, or is it in a sparse, unconnected part of the product space. It is calculated as follows:

$$open_forest_{c,t} = \sum_i \sum_j \left[\frac{\varphi_{i,j,t}}{\sum_i \varphi_{i,j,t}} (1 - x_{c,j,t}) x_{c,i,t} PRODY_{j,t} \right]$$

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