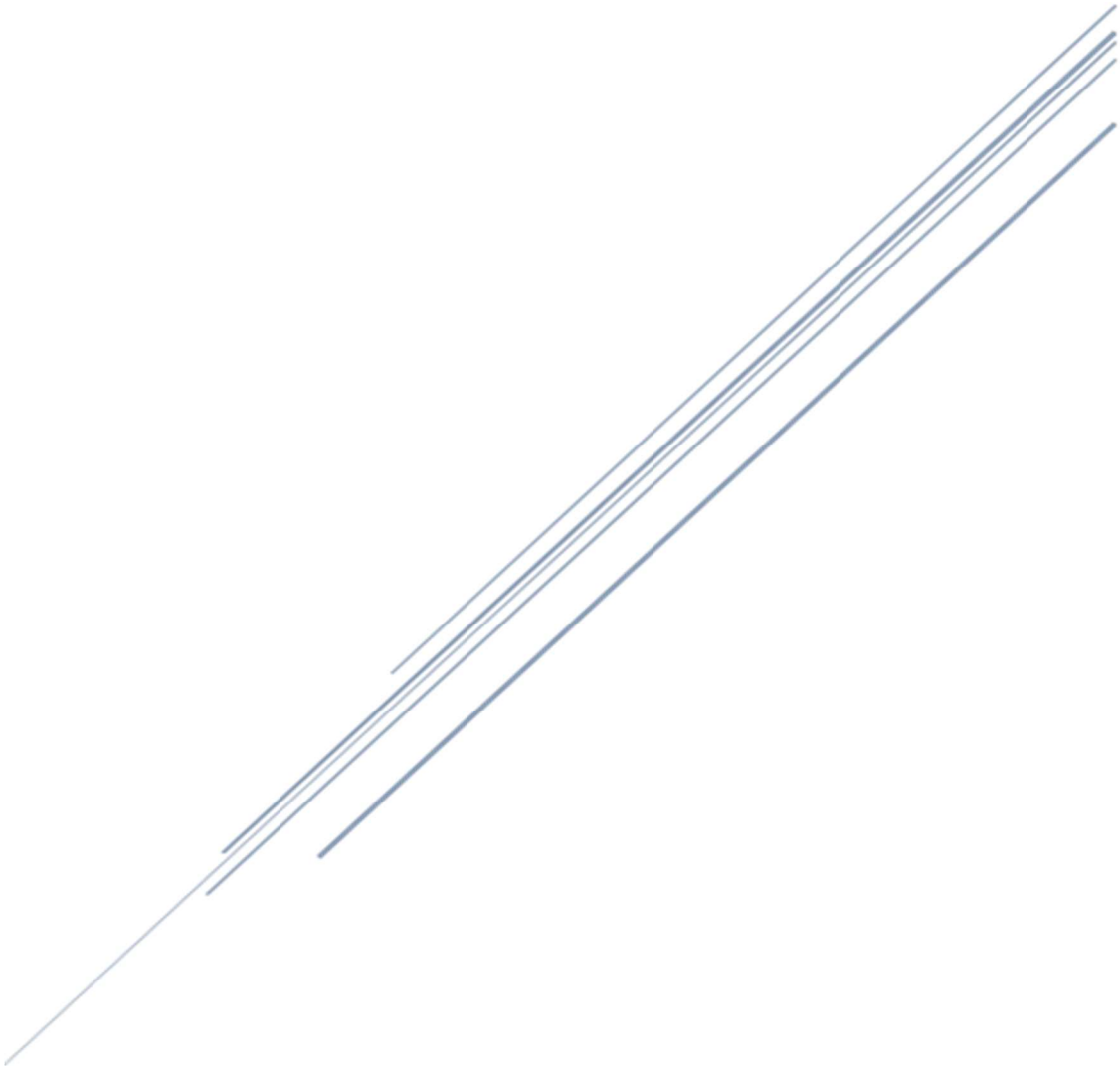
FGV | INTERNATIONAL INTELLIGENCE UNIT

AN APPROACH TO THE BRAZILIAN COMPETITIVENESS



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AN APPROACH TO THE BRAZILIAN COMPETITIVENESS[1]

1. Introduction.

This Trade Brief presents a first evaluation of Brazilian international competitiveness as reflected by its foreign trade portfolio. It employs adaptations to the known "Hausmann & Hidalgo (HH) methodology", which allows to infer countries' technological competitiveness, highlighting its most and least complex products. It examines the ubiquity and diversification of exported products and provides insights into the technological capabilities of different countries. There is an extensive literature on the HH methodology and it is not the purpose of this Brief either to discuss it or post a significant list of the theoretical and empirical developments pursued so far.

Work is in progress at FGV IIU on both classical and newer uses and adaptations of the methodology, in order to produce a modern toolkit for several applications within the scope of the Unit's attributions.

In the present exercise, 40 countries are used, with exports at the 6-digits HS 2017 classification. Data refer to 2022 and come from UN COMTRADE.

Section 2 describes the basic setting and explanations, while sections 3 and 4 deal with countries and products analyses, respectively. Section 5 dwells a little on China and US technological competition and also positions Brazil with respect to China. The last section concludes.

[1] Contributions by Lucca Pereira Horta, including comments and analyses, were invaluable.

2. Basic setting.

The method will be applied to 40 countries, covering different regions of the world:

Africa: Egypt (EGY), Mozambique (MOZ), Nigeria (NGA), Senegal (SEN), South Africa (ZAF);

Americas:

North - Canada (CAN), Mexico (MEX), United States (USA);

Central - Costa Rica (CRI), Guatemala (GTM);

South - Argentina (ARG), Bolivia (BOL), Brazil (BRA), Chile (CHL), Colombia (COL), Paraguay (PRY), Peru (PER), Uruguay (URY);

Asia: China (CHN), India (IND), Japan (JPN), South Korea (KOR), and all ASEAN members except Brunei and Laos (Cambodia (KHM), Indonesia (IDN), Malaysia (MYS), Myanmar (MMR), Philippines (PHL), Singapore (SGP), Thailand (THA) and Vietnam (VNM));

Central Asia: Kazakhstan (KAZ);

Europe: France (FRA), Germany (DEU), Ireland (IRL), Italy (ITA), Spain (ESP), United Kingdom (GBR);

Middle East: Jordan (JOR), Turkey (TUR), United Arab Emirates (ARE).

At the heart of computations lies matrix M_{cp}, *countries x products*, composed only of 0-1s, where for each of the 40 countries *c,* a row of 1 and 0 is constructed, with 1 used for every product *p* country *c* has a (Balassa's) revealed comparative advantage greater than one, i.e., $RCA_{c,p}$>1. The final dimension of the matrix is 40 x 2 622[2].

[2] Products not effectively exported (*i.e.*, with revealed comparative advantage greater than 1) by at least one of the 40 countries considered are discarded.

The RCA index when a sample of countries – instead of the whole world – is considered takes into account only exports to the other countries in the sample, both in the numerator and denominator, as exemplified in previous Trade Briefs[3].

Following Hausmann and Hidalgo (2009)[4], the analyses begin by computing two numbers: $k_{c,0}$, the quantity of products for which country *c* has a revealed comparative advantage, i.e., its *diversity*, and $k_{p,0}$, the number of countries for which product *p* has a comparative advantage, i.e., its *ubiquity*.

A sequence of several numbers may be derived from the two above, by repeated use of the *method of reflections*. The method combines the previous value of a product indicator to produce a next value of a country indicator, and vice versa. In this way, taking the sequence of countries numbers, for instance, all those related to an even iteration will convey information on (average) diversity, and all those to an odd iteration, on the (average) ubiquity of the products effectively exported by *c*, or, in other words, averages of the number of countries that export *c* products.

More formally, the iterations for the k_c's and k_p's, for *n = 1,2, ...*, are:

$$k_{c,n} = \frac{1}{k_{c,0}} \sum_{p=1}^{N} M_{cp} k_{p,n-1}$$

$$k_{p,n} = \frac{1}{k_{p,0}} \sum_{c=1}^{N_c} M_{cp} k_{c,n-1}$$

where M_{cp}, as previously defined, is 1 if *c* exports *p* with $RCA_{cp} > 1$, and 0 otherwise; *N* is the quantity of products (2 622 in our data); and N_c, of countries (40).

As said, even interactions of k_c (i.e., $k_{c,2n}$) are measures of diversification, while odd ones ($k_{c,2n+1}$) are measures of country sophistication.

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[3] See, in particular, Assessing Brazilian Trade Competitiveness I: Basic Results and the South American Context, **FGV IIU Trade Brief**. (available at www.iiu.fgv.br)

[4] César A. Hidalgo and Ricardo Hausmann (2009), The Building Blocks of Economic Complexity, *Proceedings of the National Academy of Sciences*, 106(26): 10570-5, for further explanations and insights on the material in this and the next sections.

Consider $k_{c,2}$, for instance: it is the average (over products) of the average diversification ($k_{c\prime,0}$) of exporters *c'* of product p_c in P_c, the set of products exported by country c. It is a more refined measure of diversification than $k_{c,0}$, in the sense that it considers not only what country *c* exports, but also *how diversified are the countries that export the same products*. It potentially reveals some information about the production process and is, as expected, strongly correlated with $k_{c,0}$ (the correlation index, in the case of this Brief, is 0.94).

Moving to $k_{c,3}$, defined as average (over products p_c in P_c) of a measure defined for each product as the average ubiquity (say $k_{c\prime,1}$) over exporters of p_c, *c'*. The correlation between $k_{c,1}$ and $k_{c,3}$ in the present data is 0.93, again very strong.

As $k_{c,3}$ is arguably a better measure of complexity than $k_{c,1}$, $k_{c,4}$ – derived indirectly from $k_{c,3}$ instead of $k_{c,1}$ – is preferred to $k_{c,2}$, and so forth.

3. Cross-country analyses

3.1. General analysis.

Exhibit 1 shows a dispersion diagram for countries, using the $(k_{c,0}, k_{c,1})$ pair, the simplest definitions for diversification and complexity. Taking numbers $k_{c,1}$, a lower value can be interpreted as a higher complexity, as it indicates that the capabilities necessary for producing the products exported by that country are rarer and, for this reason, may require more sophisticated technologies.

China is by far both the most complex (lowest $k_{c,1}$) and diversified country (greatest $k_{c,0}$), followed by Japan in complexity and Italy in diversification. Kazakhstan broadly exports, perhaps surprisingly, products that are far less common than average, while presenting very low diversification. There is a clear downward – although far from linear – relationship between average ubiquity and diversification. The $k_{c,0}$ and $k_{c,1}$ averages are indicated by a vertical and a horizontal line, respectively. Average $k_{c,0}$ is 765.6, while average $k_{c,1}$ is 7.4.

Exhibits 2 to 6, present histograms for $k_{p,0}$ (number of countries that export p) for the goods effectively exported by Brazil, China, Germany, Italy and the USA, respectively. In blue, the log-normal approximation is drawn, whose respective mean and standard deviation are also shown. Though there is not much variation in these main parameters, Brazil presents the highest values (both for the mean and standard deviation) while China the lowest ones, giving a synthetic view of the complexity of the two economies[5].

Out of the 155 products that are effectively exported by only one country in our sample, 62 are exported by China. USA is the sole exporter of 18 products; India 14; Canada, 8; Germany and Japan, 7; Philippines, 6; France, 5; Spain, UK and Indonesia, 4; South Africa and Thailand, 3; Chile and Ireland, 2; Italy, South Korea, Mexico, Nigeria, Turkey and Vietnam, only 1.

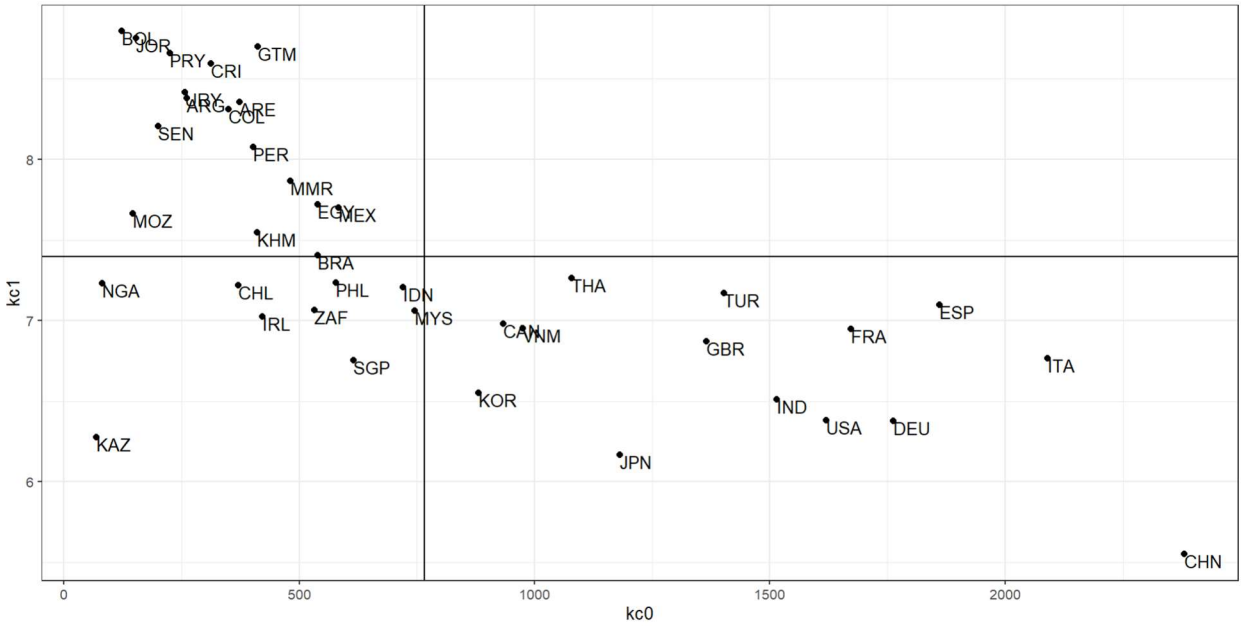

Exhibit 1 – kc0 and kc1 diagram (data source: COMTRADE)

[5] All distributions are skewed to the right, a sign of more complex economies (see J. Felipe, U. Kumar, A. Abdon and M. Bacate (2012), Product complexity and economic development, *Structural Change and Economic Dynamics* 23; 36-68).

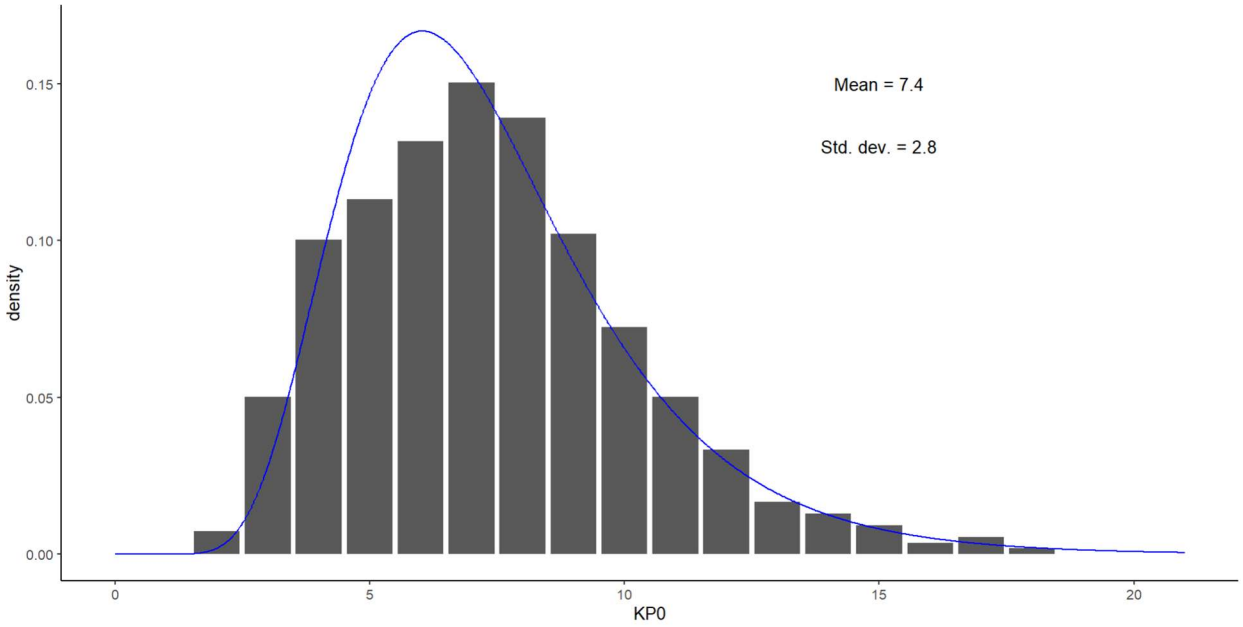

Exhibit 2 - kp0, Brazil (data source: COMTRADE)

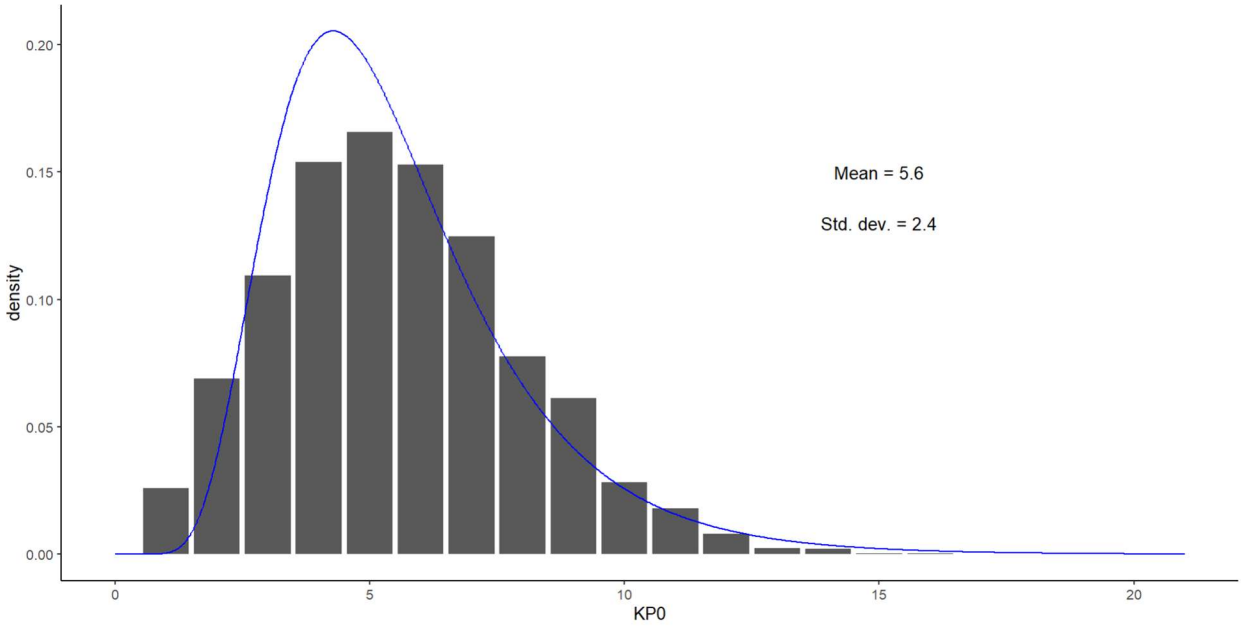

Exhibit 3 - kp0, China (data source: COMTRADE)

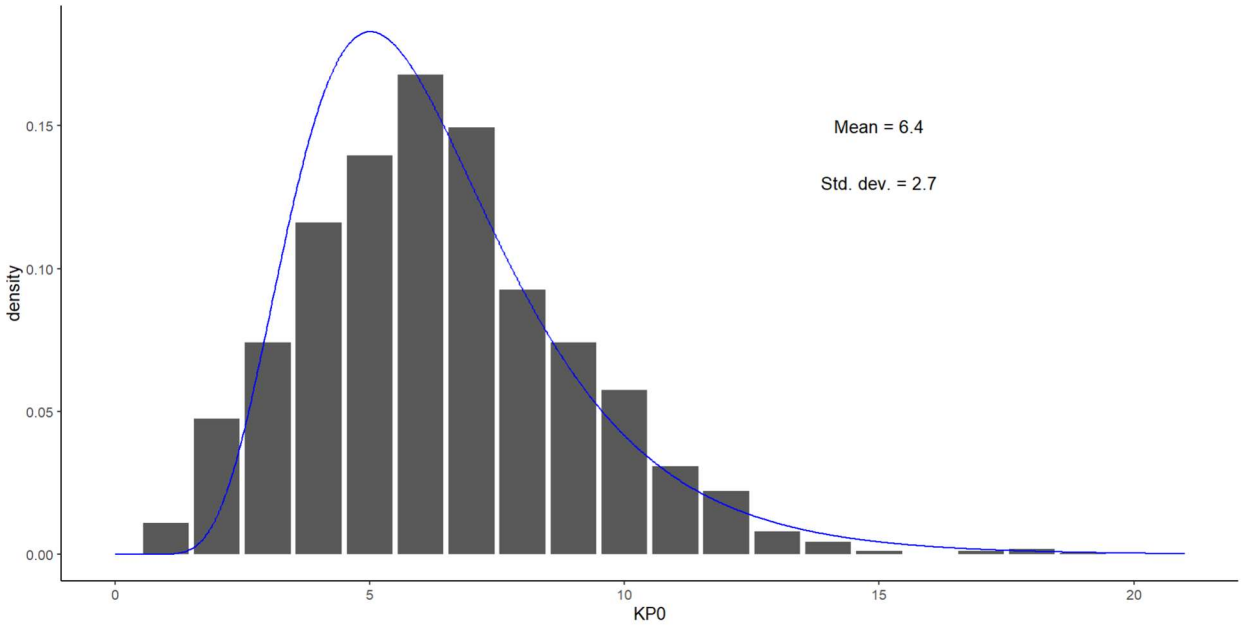

Figure 4 - kp0, US (data source: COMTRADE)

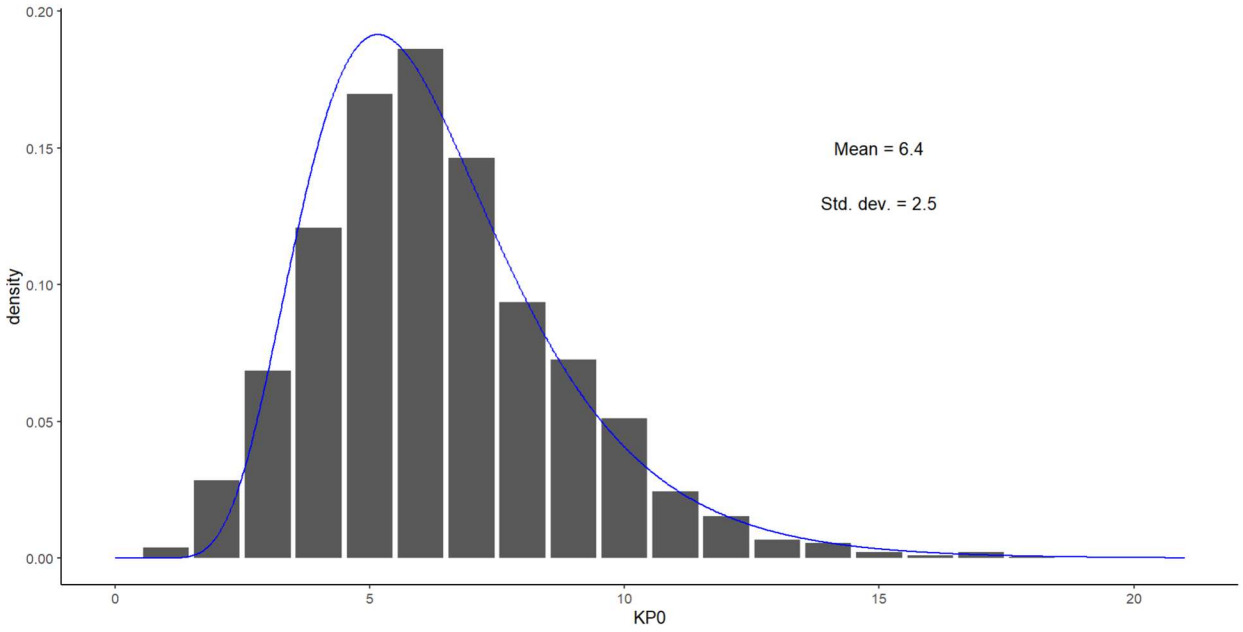

Figure 5 - kp0, Germany (data source: COMTRADE)

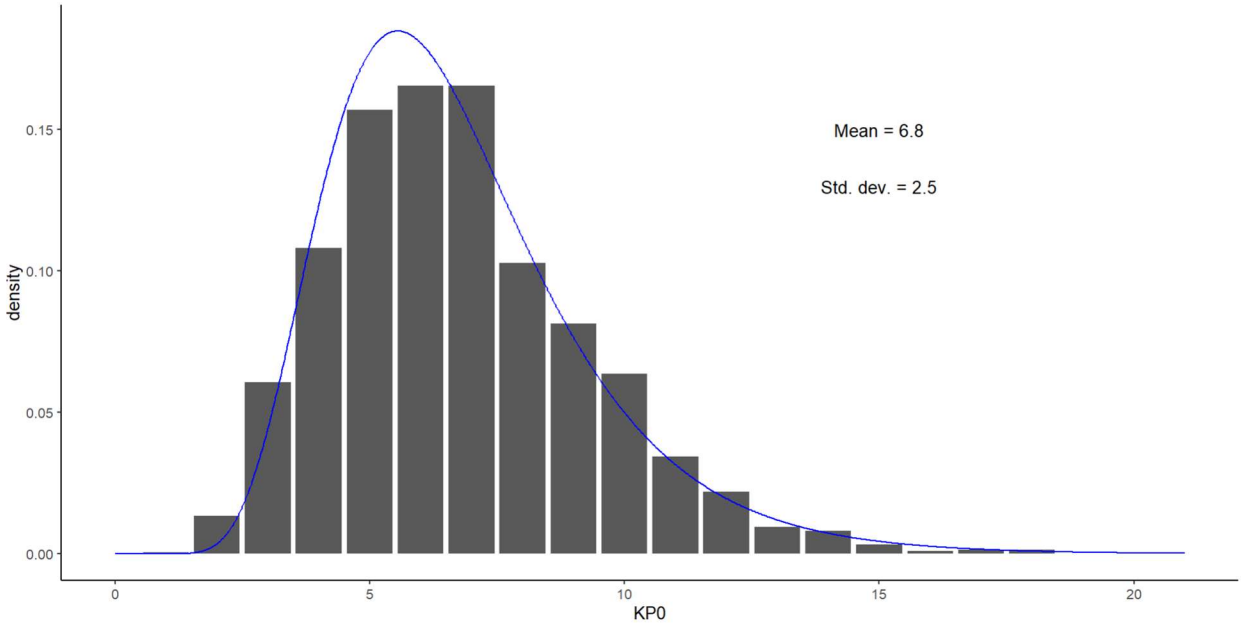

Exhibit 6 – kp0 Italy (data source: COMTRADE).

A recurrent problem with Exhibit 1 is when non-complex goods present relatively low $k_{p,0}$, what would lead to interpret them as technologically advanced. Observing that $k_{c,1}$ is constructed from $k_{p,0}$, an intuitive (and extreme) example for challenging the use of $k_{c,1}$ to measure ubiquity is to think of a backwards country that is the only one capable of growing some specific crop. While this product has a very low ubiquity, it is not necessarily complex. Therefore, $k_{c,1}$ may be a poor measure of a country economic complexity.

A plot using $k_{c,2}$ and $k_{c,3}$ is then presented in Exhibit 7. Even, as showed, the respective measures follow each other closely, Bolivia is the less complex and one of the less diversified countries in the sample. In comparison to Exhibit 1, China is now followed closely by Japan as the most sophisticated country, although it still is the most diversified one. Mexico becomes more diversified than the average, but just as complex as the other average. Singapore[6] is more diversified in comparison to the previous plot. In the two Exhibits, Brazil and Egypt remain close

[6] Results for Singapore should be taken with care as the country re-exports many goods whose origin is (mostly) in other ASEAN members. It also "re-exports" imported goods whose final destination is a third country.

both in terms of average diversification and complexity, though the latter is even closer to the Emirates in Exhibit 7.

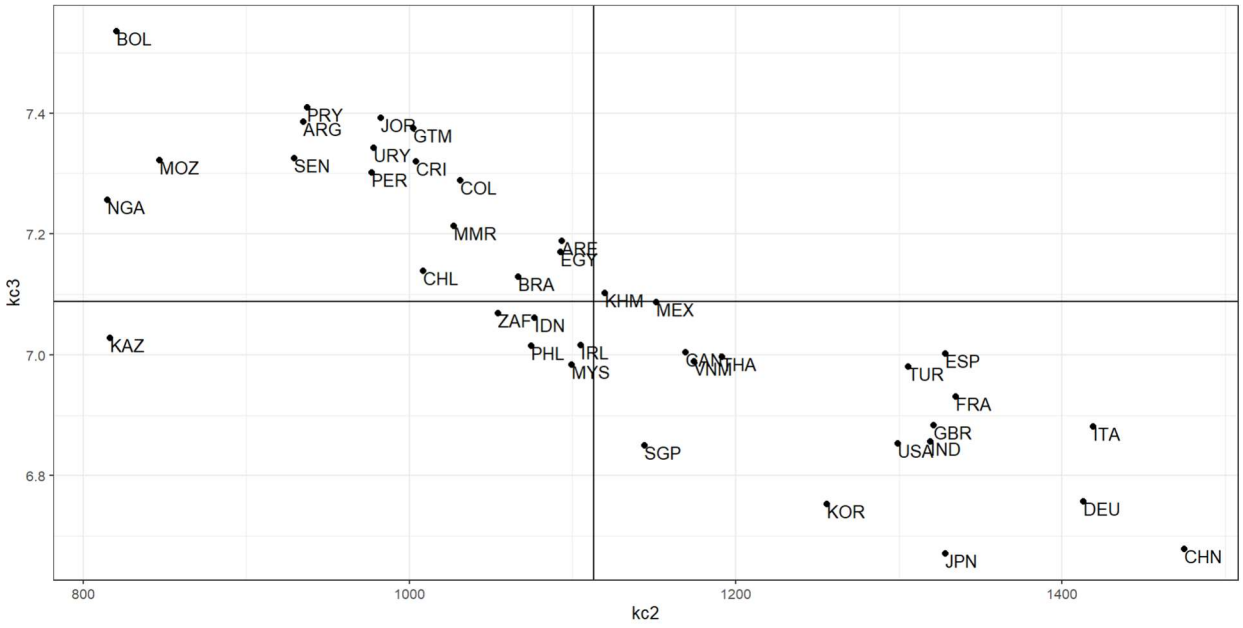

Exhibit 7 - kc2 and kc3 (data source: COMTRADE).

Exhibit 8 repeats the countries plot now for $k_{c,6}$ and $k_{c,7}$. The relationship is roughly linear. China is surpassed in both complexity and diversification by Germany and Japan, and by Singapore and South Korea in complexity. This signals that China is still surrounded (behind in the plot at stake) by a small set of rich and technologically developed countries in the dispute for technological supremacy, although it already presents itself at roughly the same level of the US, given the small difference between $k_{CHN,7}$ and $k_{USA,7}$.

In comparison to Exhibit 1, both Nigeria and Kazakhstan are in more "as-expected positions" (low complexity and low diversification), highlighting again the importance of further iterating the algorithm. Among the ASEAN countries, Philippines and Malaysia are both more complex and diversified than average, while Cambodia is only a little more diversified than average. A group of four countries –Bolivia, Mozambique and the above-mentioned Nigeria and Kazakhstan– is clearly behind in technological development in comparison to the other countries in the sample.

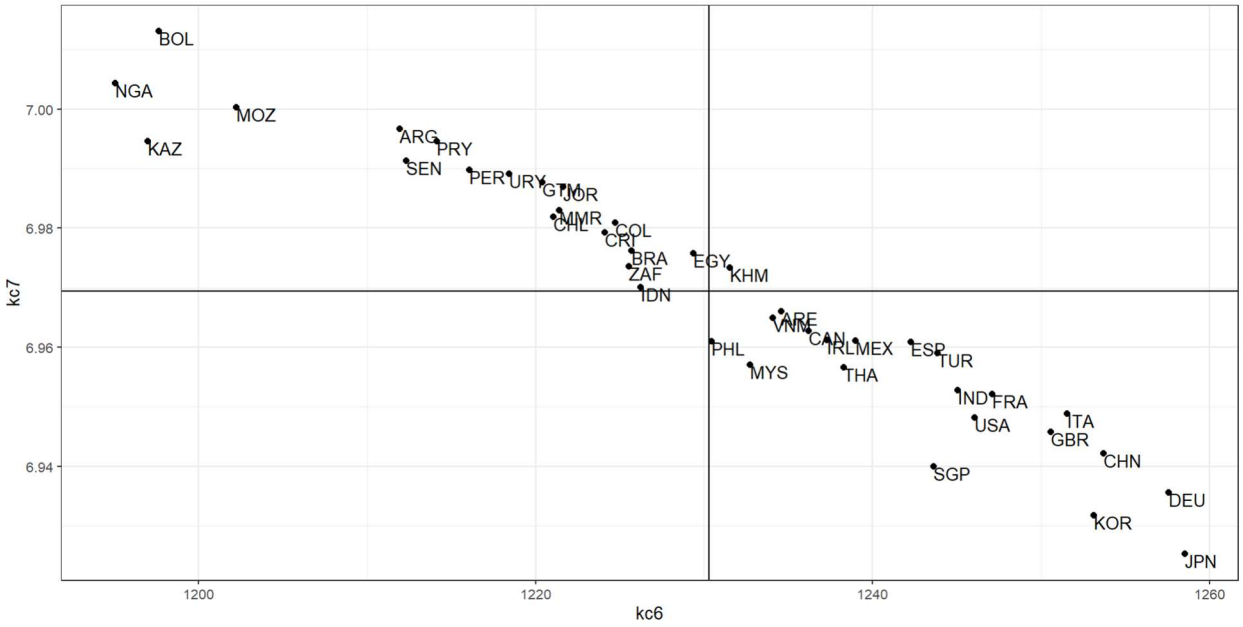

Exhibit 8 - kc6 and kc7.

3.2. Brazil's position.

Brazil begins (Exhibit 1) at the bottom of the first quadrant, surrounded by Cambodia, Egypt, Mexico and the Philippines. It is detached from most South American countries though not very far from Chile, which appears as less diversified but somewhat more complex, though this is likely due to the shortcomings of the $k_{c,1}$. Diversity leaves it far from economies like Thailand and Turkey, supposedly to guard similarities with it, which are roughly at the same complexity level as Chile's.

The first plot gives a crude view of the country's diversification x ubiquity duality.

In Exhibit 7 the relative position with Chile seems more reasonable, while it is now also surrounded by South Africa and India. Thailand and Turkey remain far and more sophisticated; separation from the rest of South America is clear.

Exhibit 8 places Brazil close to South Africa, while Colombia and Costa Rica approach, leaving Chile behind. It is also somewhat close to Egypt, separated by diversification. Philippines, Thailand and Turkey, especially the last two, are now quite far.

Summing up, Brazil, which though borderline always remains in the first quadrant (of less sophisticated economies), is an economy guarding similarities with Egypt, South Africa and India, and -probably due to its significant agricultural exports- further than expected from otherwise close ones like Thailand and Turkey. The country is definitely not in the league of technologically more sophisticated economies. It is also reasonably detached from its South American neighbours.

4. Products analysis

As introduced earlier, $k_{p,0}$ is the quantity of countries that effectively export product p (ubiquity); $k_{p,1}$ – following the equations in the previous chapter – is the average diversification of exporters of product p. A similar argument follows from the previous section, with classes inverted: even k_p's are indirect measures of the technology needed to produce product p (relates to p's ubiquity and the ubiquity of related products), and odd k_p's are measures of diversification related to product p.

Exhibit 9 shows the relationship between $k_{p,0}$ and $k_{p,1}$. A regression line indicates the negative correlation between the two measures, further evidence that complex goods are accompanied by greater exports diversification.

Aluminium; waste and scrap (760200) is the most ubiquitous product, effectively exported by 19 out of 40 countries. *Aluminium* is followed by *Coffee; husks and skins, coffee substitutes containing coffee in any proportion* (090190); *Sugars; sucrose, chemically pure, in solid form, not containing added flavouring or colouring matter* (170199); *Plastics (…); waste, parings and scrap* (391590); and *Copper; waste and scrap* (740400), each exported by 18 countries.

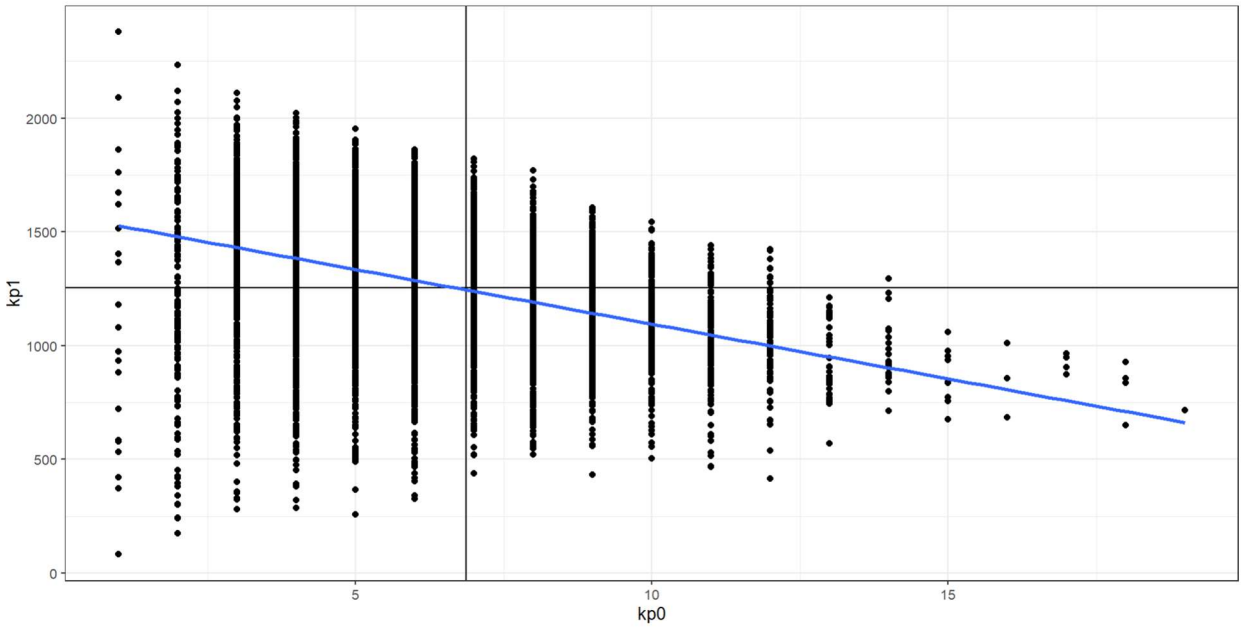

Exhibit 9 - kp0 and kp1 (data source: COMTRADE)

Exhibit 10 presents the relationship between $k_{p,6}$ and $k_{p,7}$, reinforcing the negative correlation previously showed in Figure 9[7].

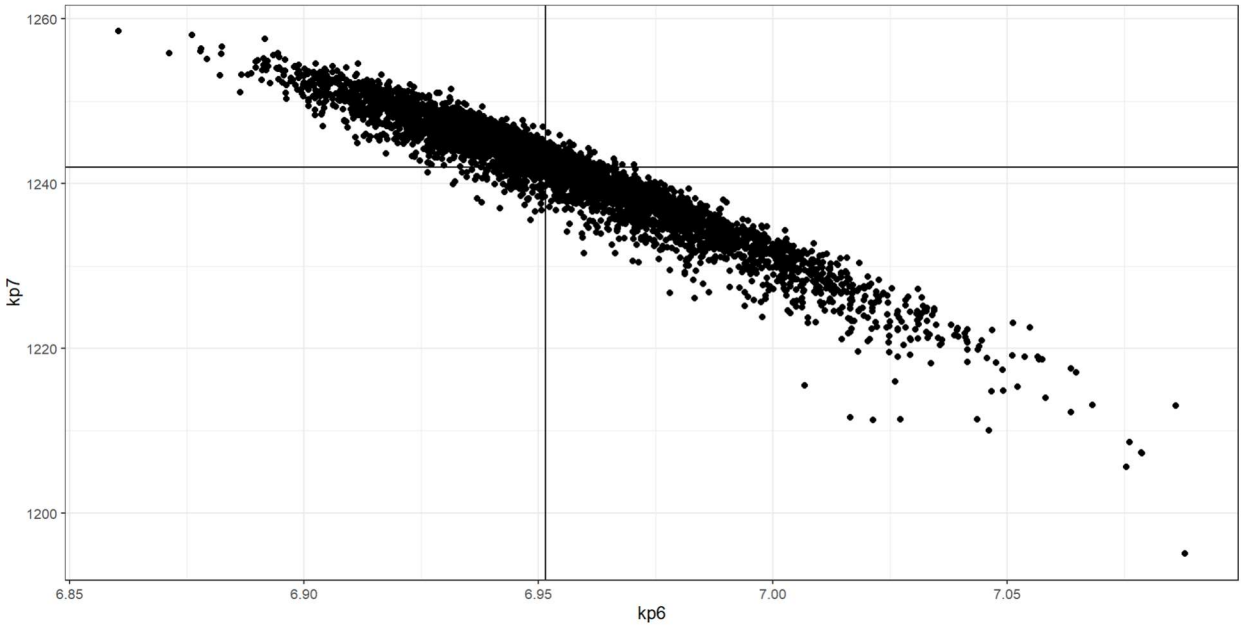

Exhibit 10 - kp6 and kp7 (data source: COMTRADE)

[7] As the negative association is clear and roughly linear, the regression line has not been drawn.

Table 1 presents the bottom and top ten $k_{p,6}$'s values (as standard deviations of the average). The first seven top complex goods are exported solely by Japan, followed by three others, exported only by Japan and South Korea.

Table 1: 10 lowest and highest kp6 (in standard deviations from average)

	Product code	kp6	Product code	kp6
1	270720	-2.9	290433	4.3
2	284310	-2.9	230250	4.3
3	290612	-2.9	030292	4.0
4	370120	-2.9	080122	4.0
5	540339	-2.9	080121	4.0
6	700530	-2.9	121130	3.9
7	890610	-2.9	261610	3.7
8	270820	-2.6	200891	3.6
9	284190	-2.6	071334	3.6
10	370790	-2.6	090300	3.6

See the Appendix for the Codes description.
Data source: COMTRADE

Table 2 highlights products with lowest and highest diversification; as for the latter, most are related solely to Japan, followed by exports from both Japan and Germany.

Table 2: 10 lowest and highest kp7 (as standard deviations from average)

	Product code	kp7	Product code	kp7
1	290433	-6.3	270720	2.2
2	121130	-4.9	284310	2.2
3	030292	-4.7	290612	2.2
4	080122	-4.7	370120	2.2
5	080121	-4.5	540339	2.2
6	271129	-4.3	700530	2.2
7	284130	-4.1	890610	2.2
8	252490	-4.1	400249	2.2
9	261390	-4.1	844313	2.2
10	720250	-4.1	846140	2.2

See the Appendix for the Codes description.
Data source: COMTRADE

5. US and China exports of high-tech products

5.1. The two rivals.

One can specifically place high-tech products in the US and Chinese exports. Exhibit 11 extracts from Exhibit 10 only the products that present a $k_{p,6}$ below 6.9, highlighting those exported by China, US, none or both. Both countries are present: many exports are from China, some from the US, and a few are from both. In the former group, there are 132 products (exported by China) while only 24 are solely exported by the US.

The dashed vertical lines in the Exhibit indicate average complexity of exports by China (but not by US) and by the US (but not by China), respectively, *for this particular set of highly technological products*. They show that Chinese exports, even in this group, are more complex. The conclusion is that China is not only roughly as competitive as the US on average, but rather more pronounced in high-tech products; and here, both in the number of effective exports (RCA>1) and their average complexity.

Chinese exports, in this group, include *Lenses; objective, (other than for cameras, projectors or photographic enlargers or reducers), mounted, of any material (excluding elements of glass not optically worked)* (900219) and *Electric accumulators (...)* (850790). US ones include *Cellulose ethers; (other than carboxymethylcellulose and its salts), in primary forms* (391239) and *Steel, alloy; flat-rolled, width 600mm or more (...)* (722591).

5.2. Positioning Brazil.

To position Brazil in the dispute for competitive leadership, we compare Brazilian most technological exports with China's.

Selecting Brazilian and Chinese ten most complex exports, Exhibit 12 presents their $k_{p,6}$ and $k_{p,7}$. The green vertical line indicates average $k_{p,6}$ of Brazilian exclusive exports in this sample of products, while the blue indicates the average for the Chinese exports.

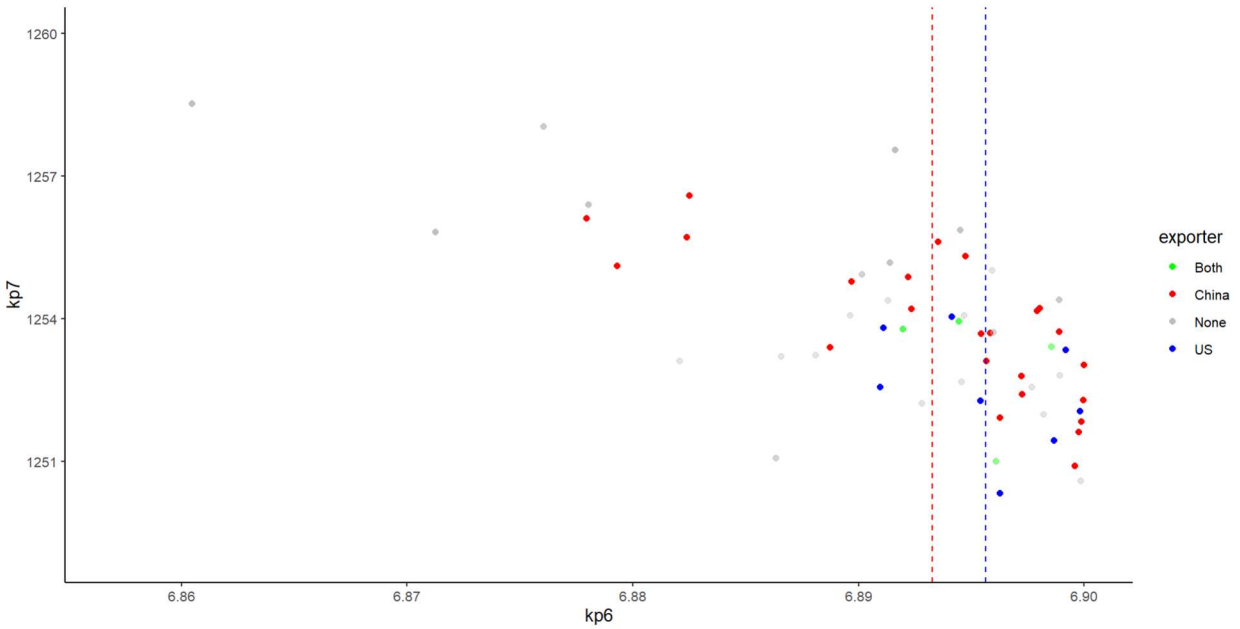

Exhibit 11 - Highly technological goods (data source: COMTRADE)

It is striking that, from the ten less ubiquitous Brazilian exports, China is a competitor in 8, while for the ten most complex exports by China, not only Brazil is not a competitor, but the most complex products exported by Brazil are very far - in terms of $k_{p,6}$ - from the most complex ones exported by China.[8]

The two products exported (effectively) by Brazil but not by China are *Tools, interchangeable; (for machine or hand tools, whether or not power-operated), tools for tapping or threading* (820740) and *Engines; reciprocating piston engines, of a kind used for the propulsion of vehicles of chapter 87, of a cylinder capacity exceeding 250cc but not exceeding 1000cc* (840733).

Brazil and China share the status of exporters for *Turbines; steam and other vapour turbines, (for other than marine propulsion), of an output exceeding 40MW* (840681), *Graders and levellers* (842920) and *Front-end shovel loaders* (842951), among others.

[8] The competitiveness asymmetry between Brazil and China is studied in more detail in The China-Brazil Trade Flows I: Basic Characteristics, **FGV IIU Trade Brief**. (available at www.iiu.fgv.br)

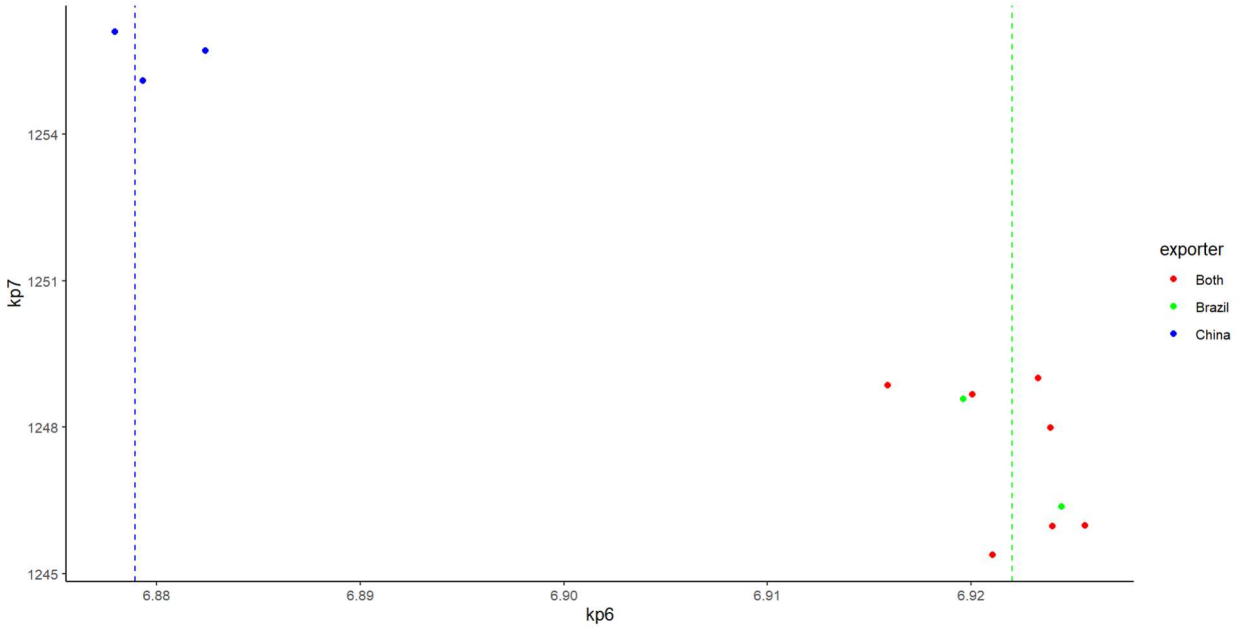

Exhibit 12: Most technological exports by Brazil in comparison to China (data source: COMTRADE)

6. Conclusions.

Hidalgo (2009)[9] mentions a sharp increase in Brazilian competitiveness during the 1963-2000 period. Hidalgo and Hausmann (2009) classifies Brazil as a diversified country producing reasonably exclusive products. In comparative terms nowadays, however, Brazil lies in a concerning position: a not much-diversified country producing standard products.

China still is a few miles away from becoming the most technological country in the planet (an undeniable objective), although the analysis here suggests it is perhaps more technologically advanced than the US. Evidence of the impacts of the current Trade War on Chinese competitiveness should become an object of further study.

The eight ASEAN countries considered present great heterogeneity, from highly developed countries such as Singapore to low diversified and not very complex ones such as Myanmar.

[9] César A. Hidalgo (2009). The Dynamics of Economic Complexity and the Product Space over a 42 Year Period. **CID working paper series**.

The analysis is done under a representative sample of countries and must be considered as a first approach to the problem using the HH methodology. Supplementary analyses must explore other interrelationships and should ideally consider more countries.

Appendix A – Product codes

Codes	
030292	Fish; fresh or chilled, shark fins
071334	Vegetables, leguminous; bambara beans (Vigna subterranea or Voandzeia subterranea), shelled, whether or not skinned or split, dried
080121	Nuts, edible; Brazil nuts, fresh or dried, in shell
080122	Nuts, edible; Brazil nuts, fresh or dried, shelled
090190	Coffee; husks and skins, coffee substitutes containing coffee in any proportion
121130	Coca leaf; of a kind used primarily in perfumery, in pharmacy or for insecticidal, fungicidal or similar purposes, fresh, chilled, frozen or dried, whether or not cut, crushed or powdered
170199	Sugars; sucrose, chemically pure, in solid form, not containing added flavouring or colouring matter
200891	Fruit, palm hearts; prepared or preserved, whether or not containing added sugar, other sweetening matter or spirit
230250	Bran, sharps and other residues; of leguminous plants, whether or not in the form of pellets, derived from the sifting, milling or other workings thereof
252490	Asbestos; other than crocidolite (blue asbestos)
261390	Molybdenum ores and concentrates; other than roasted
261610	Silver ores and concentrates
270720	Oils and products of the distillation of high temperature coal tar; toluol (toluene)
270820	Pitch coke; obtained from coal tar or from other mineral tars
271129	Petroleum gases and other gaseous hydrocarbons; in gaseous state, other than natural gas
284130	Salts; sodium dichromate

284190	Salts of oxometallic or peroxometallic acids; n.e.c. in heading no. 2841
284310	Colloidal precious metals; whether or not chemically defined
290433	Derivatives of hydrocarbons; lithium perfluorooctane sulphonate, whether or not halogenated
290612	Alcohols; cyclanic, cyclenic or cycloterpenic and derivatives, cyclohexanol, methylcyclohexanols and dimethylcyclohexanols
370120	Photographic plates and film; instant print film, in the flat, sensitised, unexposed, whether or not in packs
370790	Photographic goods; chemical preparations other than sensitised emulsions, put up in measured portions or put up for retail sale in a form ready for use
391239	Cellulose ethers; (other than carboxymethylcellulose and its salts), in primary forms
391590	Plastics n.e.c. in heading no. 3915; waste, parings and scrap
400249	Rubber; synthetic, chloroprene (chlorobutadiene) rubber (CR), (other than latex), in primary forms or in plates, sheets or strip
540339	Yarn, artificial; filament, monofilament (less than 67 decitex), single, n.e.c. in heading no. 5403, not for retail sale, not sewing thread
700530	Glass; float glass and surface ground or polished glass, in sheets, wired glass, whether or not having an absorbent or reflecting layer
720250	Ferro-alloys; ferro-silico-chromium
722591	Steel, alloy; flat-rolled, width 600mm or more, n.e.c. in heading no. 7225, electrolytically plated or coated with zinc
740400	Copper; waste and scrap
760200	Aluminium; waste and scrap
844313	Printing machinery; offset, n.e.c. in item no. 8443.1
846140	Machine-tools; gear cutting, gear grinding or gear finishing machines, working by removing metal, sintered metal carbides or cermets
850790	Electric accumulators; parts n.e.c. in heading no. 8507
890610	Vessels; warships
900229	Lenses; objective, (other than for cameras, projectors or photographic enlargers or reducers), mounted, of any material (excluding elements of glass not optically worked)

Codes HS 2017