UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT

November 2018

UNCTAD Research Paper No. 16
UNCTAD/SER.RP/2017/16/Rev.1

Revealed Factor Intensity of Products: Insights from a New Database

Alain Mclaren
United Nations International Computing Centre
mclaren@unicc.org

Mesut Saygili
Division on International Trade and Commodities, UNCTAD
Mesut.Saygili@unctad.org

Miho Shirotori
Division on International Trade and Commodities, UNCTAD
Miho.Shirotori@unctad.org

Abstract

The present paper provides descriptive statistics of the updated database of the RFI indicators of products classified at the HS 6-digit level, and the factor endowments consisting of physical capital, human capital and arable land. The RFI indicators and the endowment database can contribute to research in a wide array of topics such as export diversification patterns, export survival of firms, and natural-resource curse.

Key words: International trade, factor endowments, factor intensities, product classifications

The findings, interpretations, and conclusions expressed herein are those of the author(s) and do not necessarily reflect the views of the United Nations or its officials Member States. The designations employed and the presentation of material on any map in this work do not imply the expression of any opinion whatsoever on the part of the United Nations concerning the legal status of any country, territory, city, or area or of its authorities, or concerning the delimitation of its frontiers and boundaries.

This paper represents the personal views of the author(s) only, not the views of the UNCTAD secretariat or member States. The author(s) accept sole responsibility for any errors. Any citation should refer to the author(s) and not the publisher. This paper has not been formally edited.

UNITED NATIONS

© 2019 United Nations

Contents

Acknowledgements

The authors are grateful to: Alessandro Nicita, Marco Fugazza, Samuel Rosenow and Julia Seiermann for their comments on an earlier draft; Steve MacFeely and Onno Hoffmeister for uploading the RFI Indicators on UNCTADstat; Jenifer Tacardon-Mercado for processing and formatting the document; and Bonapas Onguglo for his support and guidance.

Any mistakes or errors remain the authors' own.

1. Introduction

Cadot, Shirotori et Tumurchudur (2010) developed a time-series database of a revealed factor intensity (RFI) indicators for over 5,000 products, classified at the 6-digit level of the Harmonized Commodity Description and Coding System (HS). Based on the idea that "a product exported predominantly by countries that are richly endowed with human capital is "revealed" to be intensive in human capital"), the RFI indicators of a product are estimated as a trade-weighted average of the factor endowments of countries that export the given product.

With the release of the Penn World Table (PWT) version 9.0 in 2017, UNCTAD has updated the RFI indicators to cover the period from 1988 up to 2014, and made them available on the UNCTADStats for download.[1]

This paper first presents descriptive statistics of the updated factor endowment data and the RFI indicators, then discusses areas of trade analysis where the RFI indicators could be a useful variable.

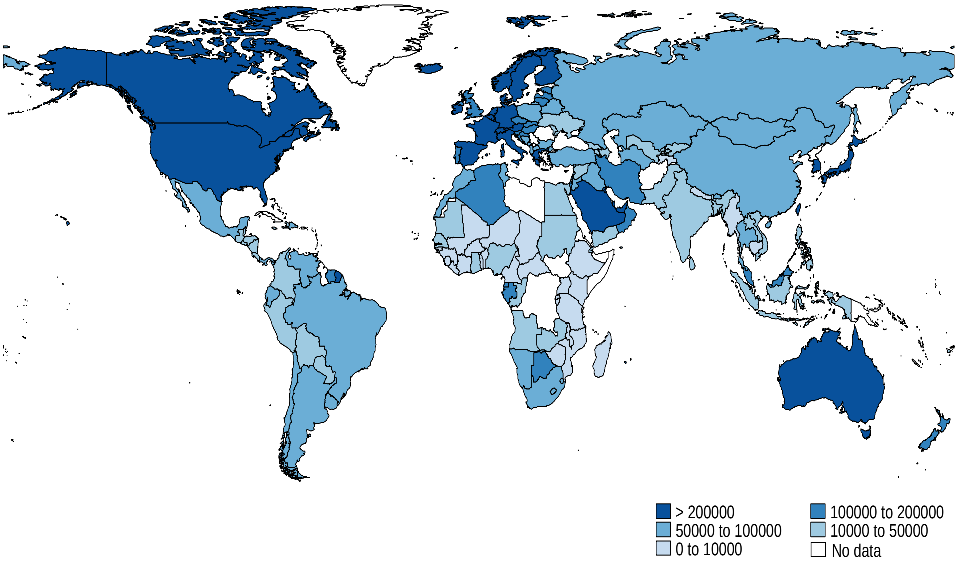
2. The Endowment data

The RFI indicators are based upon three factor endowments: (i) physical capital stock per worker; (ii) human capital stock; and (iii) arable land per worker. Annex 1 provides the source and technical information on endowment data.

Figure 1.1 presents the level of physical capital stock per worker in United States dollars based on 2011 purchasing power parity (PPP). Figure 1.2 compares the change in physical capital across countries between 1994 and 2014 and reveals a significant accumulation of physical capital in many developing countries, particularly those in Asia. Some of the Commonwealth of Independent States (CIS) and conflict-stricken countries in Africa however revealed a fall in capital stock.

2.1 Physical capital

Figure 1.1 Capital stock per worker in 2014 in United States dollars (PPP 2011)



[1] for the period 1962-2014. The RFI indicators using the United Nations Standard International Trade Classification (SITC, Revision 1) at the 5-digit level and the endowment data, can be requested by writing to UNCTAD (TAB@unctad.org).

Figure 1.2 Percentage change of physical capital (1994- 2014)

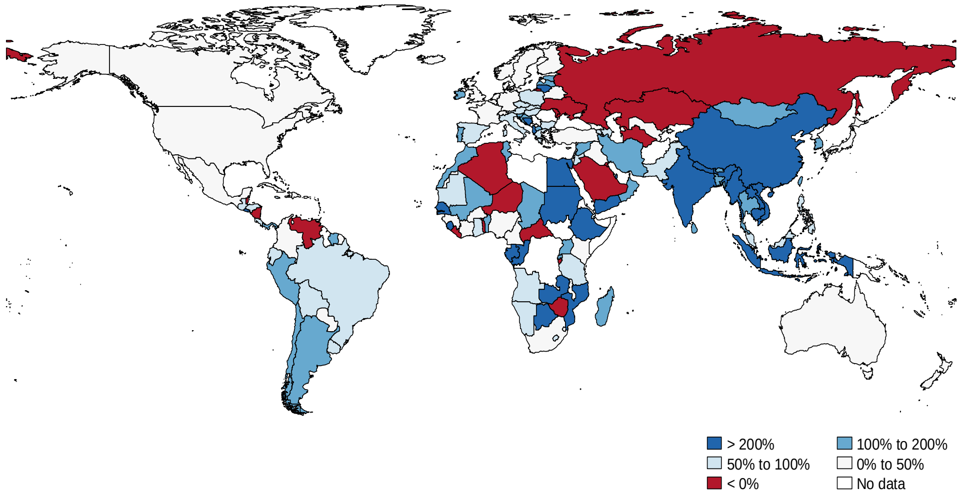
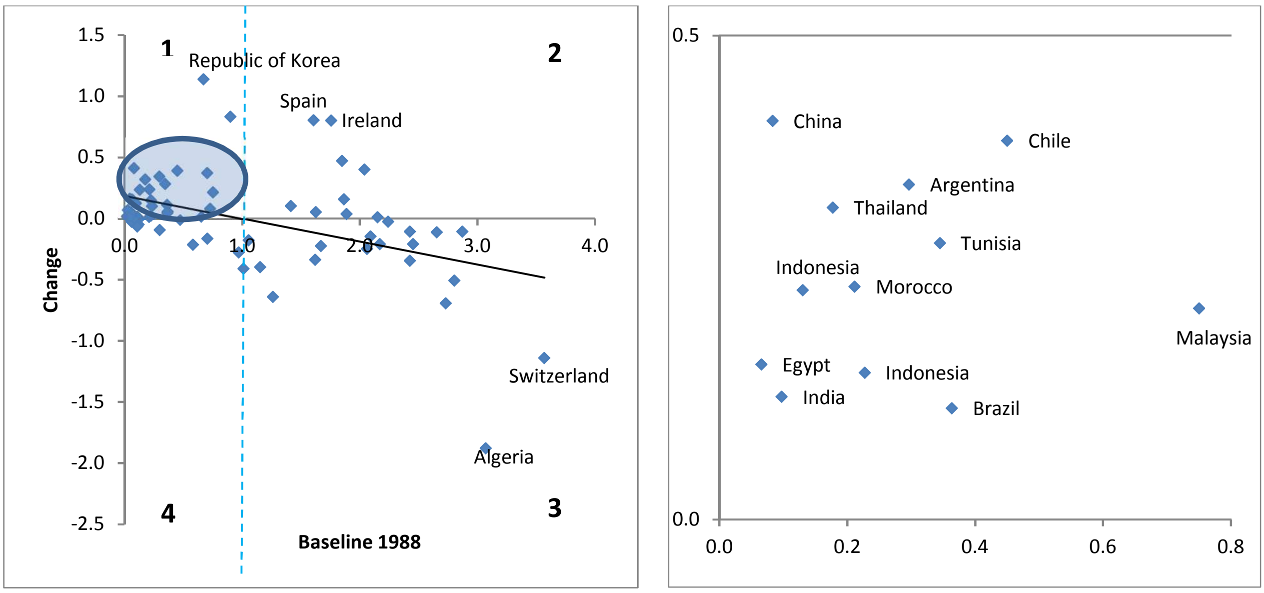


Figure 2 plots the change in the relative size of physical capital stock against the baseline level of relative endowment, during the period between the base year (1988) and 2014.

The relative size of a factor endowment of each country is calculated by dividing the value of actual factor endowment of a country by the world average. For example, if a country's "baseline" relative size of physical capital is 1.5 and the "change" is -0.2, it means that: (i) the country's physical capital stock in the year 1988 was 1.5 times greater than the world average; and (ii) the relative size has decreased by 0.2 to become 1.3 in 2014.

Figure 2. Relative changes in physical capital stock (1988-2014)

(a): Physical Capital (all countries) (b) Physical capital (emerging economies)



The baseline level of physical capital stock and the subsequent changes are negatively related (Figure 2 (a)). That is, the smaller the relative size of factor endowment is in the baseline year, the greater the increase in the factor endowment relative to other countries.

Countries in Figure 2 (a) can be separated into four groups. **The first group** in the upper left quadrant consists of countries whose relative size of physical capital in the baseline period was smaller than the world average, then had a greater-than-average increase in the subsequent period. Among those countries, the Republic of Korea's relative size of physical capital increased by 1.13 from the baseline value of 0.67, which was the highest increase among all countries. Then there are countries whose relative size of physical capital increased by the values between 0.1 and 0.5 as shown in Figure 2 (b), which gives a magnified view of the blue circle in Figure 2(a). China experienced the highest increase in the relative physical capital stock within the group by 0.41 points from its baseline value of 0.08. China is followed by Chile whose relative capital stock increased by 0.39 points, then Argentina (0.35), and Thailand (0.32).

The countries in **the second group** in the upper-right quadrant are those whose relative physical capital stock in the baseline year was above average, then had a greater-than-average increase in the subsequent period. The relative capital stock of Spain in the baseline year was 1.60, which then increased by 0.83 points in the subsequent period. Other countries in this group include Ireland (1.76, 0.80), Austria (1.85, 0.47) and Italy (2.04, 0.40) which increased their capital stock significantly after the establishment of the European Single Market in 1993.

Countries in **the third group** in the lower-right quadrant had a less-than-average increase in the relative size of physical capital stock from the above-average level in the baseline year. Switzerland for example experienced a fall in the relative size of physical capital stock by 1.14 from the baseline value of 3.57.

The fourth group in the lower-left quadrant consist of African countries, whose baseline physical capital level was below average, and had a less-than-average growth in the subsequent period. Countries in this group include Niger, Cameroon, Côte d'Ivoire, Malawi, Kenya, Ghana, and the United Republic of Tanzania.

2.2 Human capital

Human capital is measured as a composite of average schooling years and the return on education. Figure 3.1 suggests that countries in Africa reveal relatively low levels of human capital in 2014. The growth pattern of human capital (Figure 3.2) however is much more homogeneous than that of physical capital stock. The majority of African countries showed an increase of human capital of over 20 per cent between 1994 and 2014.

The change in the relative size of human capital is presented in Figure 4. The relative size of human capital has been converging to 1, indicating that the difference in human capital case across countries has become less pronounced than it had been in the baseline year. Countries that had lower-than-average (i.e. less than 1) baseline level of human capital made a greater-than-average increase in the subsequent years. This is only natural as the definition of human capital used for the RFI estimation includes the years of schooling, which has the maximum value of around 20 years. That is, countries whose baseline average years of schooling was low, say 6 years, have a greater potential to increase the relative size of human capital in the subsequent years than countries whose baseline schooling years was already high, say over 10 years.

Figure 3.1 Human capital index per person in 2014

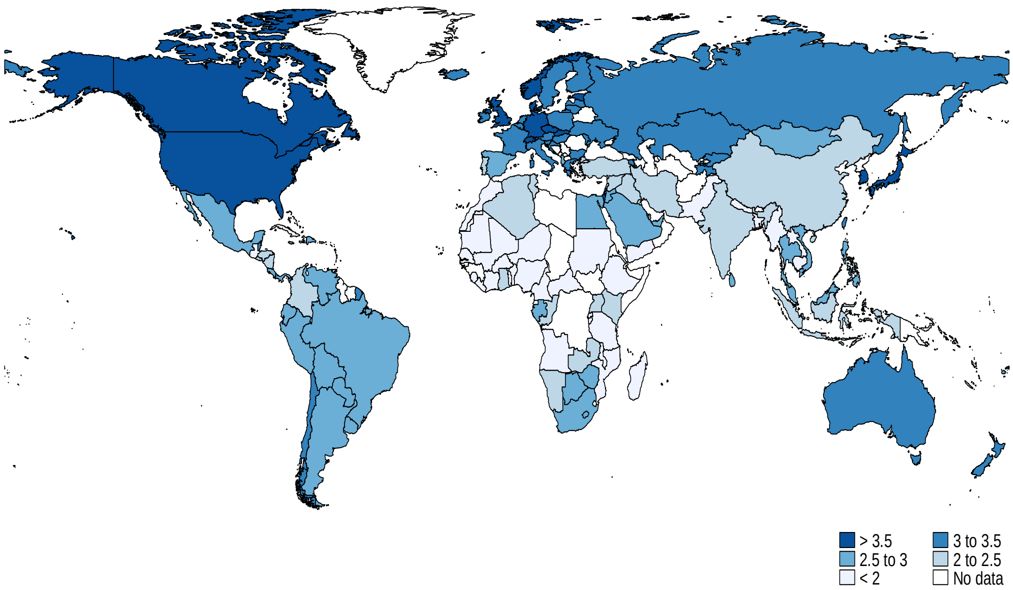


Figure 3.2 Percentage change of human capital (1994-2014)

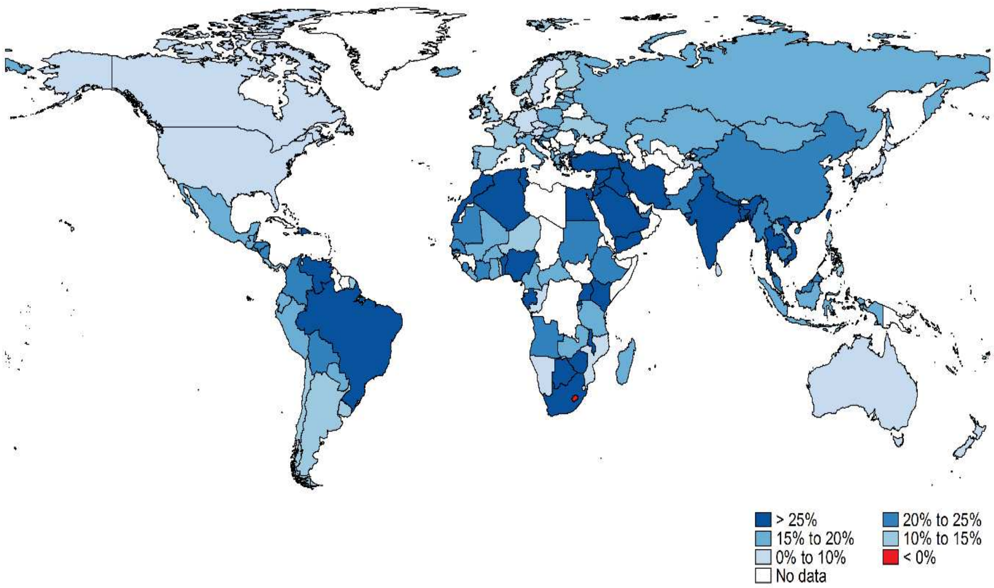
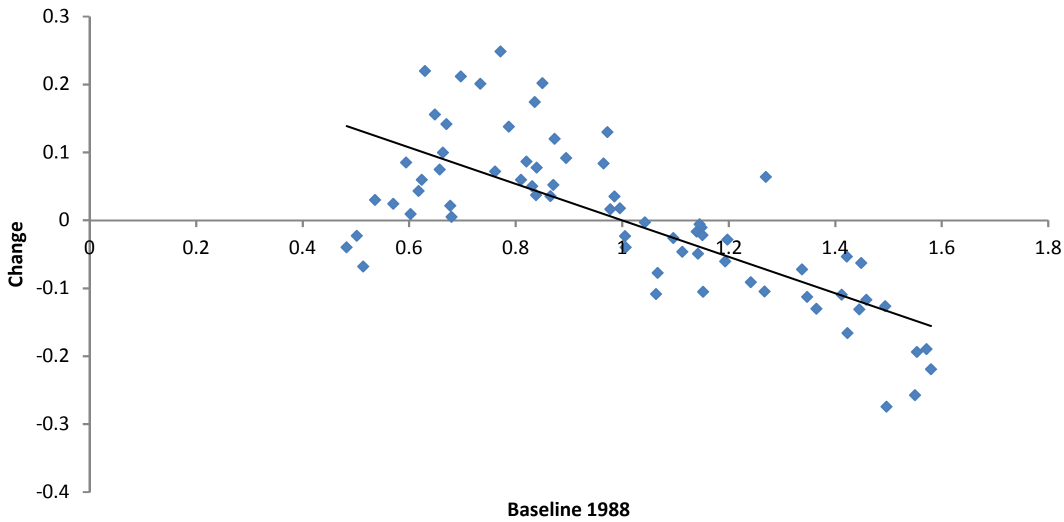


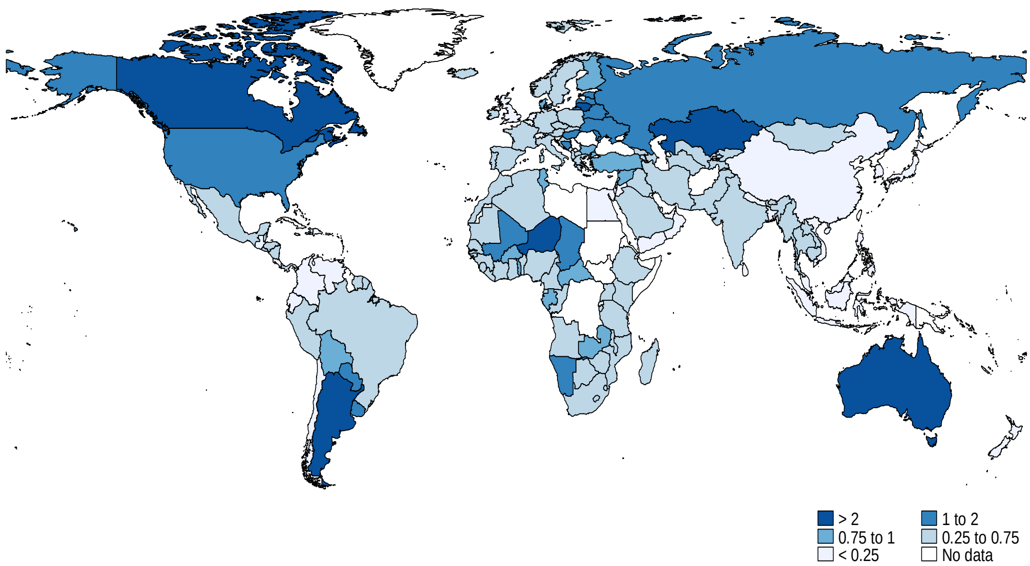
Figure 4. Relative changes in human capital stock (1988-204)



2.3 Arable land

Figure 5.1 presents arable land in hectares per worker in 2014. Between 1994 and 2014, the size of arable land per worker has fallen in most countries (Figure 5.2). This may be due to population increases against the total size of arable land, which is mostly fixed.[2] The highest decrease is observed in the Middle East, Northern Africa, and the Pacific rim of South America. We observe less of a relationship between the baseline level of arable land and the subsequent change (Figure 6).

Figure 5.1 Arable land in hectares per worker in 2014



[2] This may not be the case if the number of workers stayed perfectly stable when population size changes, or that the workforce decreased simultaneously to a population increase, both of which would be highly unlikely.

Figure 5.2 Percentage change in arable land per worker (1994- 2014)

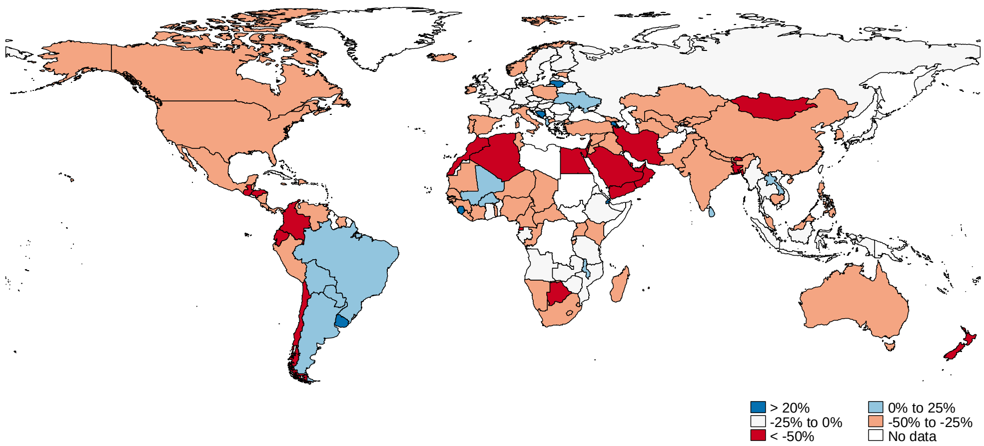
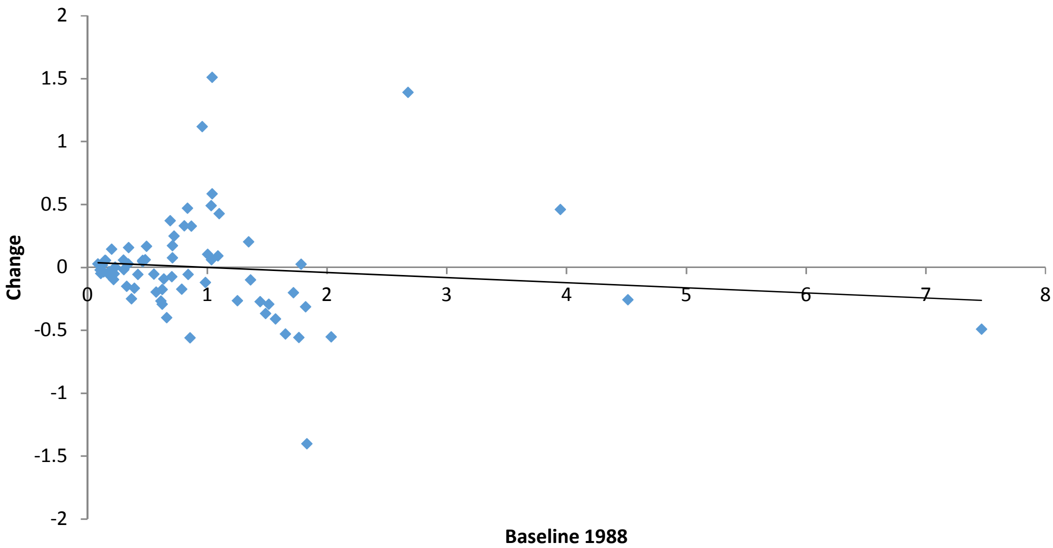


Figure 6. Relative changes in arable land per worker (1988-204)



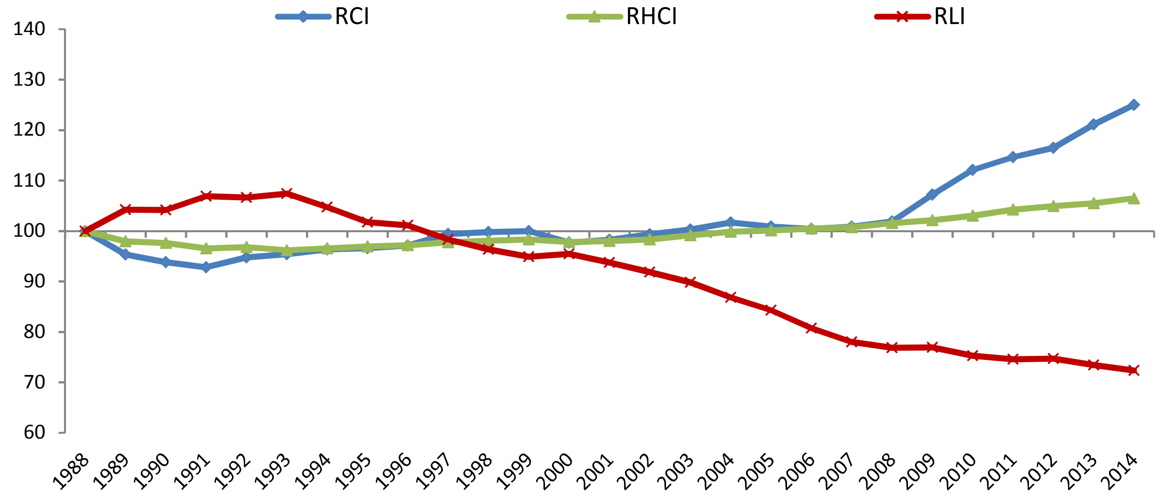
3. The RFI Indicators

The following section presents descriptive statistics of the RFI indicators, including changes in the values over time, difference across product groups, among others.

3.1 Average RFI indicators through years

Figure 7 presents changes in the trade-weighted averages of the revealed physical capital intensity (RCI), the revealed human capital intensity (RHCI) and the revealed land intensity (RLI). The average annual RFI indicators are compared to the baseline level in 1988, which is set at 100.

Figure 7. Changes in the Average RFI Indicators through Years (1988=100)



The changes in the average FRI indicators are driven by a compound of changes in world trade flows, including the composition of traded products in the world, the composition of countries which trade a given product, and the level of factor endowments in countries that participate in trade.

The changes in the average RCI and RHCI can be broken into three phases. In the initial phase (1988 – 1997), the average RCI and RFCI declined from the 1988 baseline level, then strayed at around the baseline level (1997-2007). From 2008 onwards, the average RCI continued to increase at a much higher rate than the average RHCI. This may be triggered by a relative increase in foreign direct investment inflow experienced by emerging economies after the financial crisis (UNCTAD, 2013), as well as by an expansion of developing countries' share in international trade.

The average RLI (revealed land intensity) has declined steadily since the mid-1990s, reflecting the fact that the average arable land per worker has been falling in almost all countries.

The average RFI indicators by stages of processing

The data on RFI indicators can be disaggregated into different product groups e.g. according to stages of processing. Figure 8 presents the changes of the average RFI indicators of intermediate goods, capital goods, and consumer goods.[3]

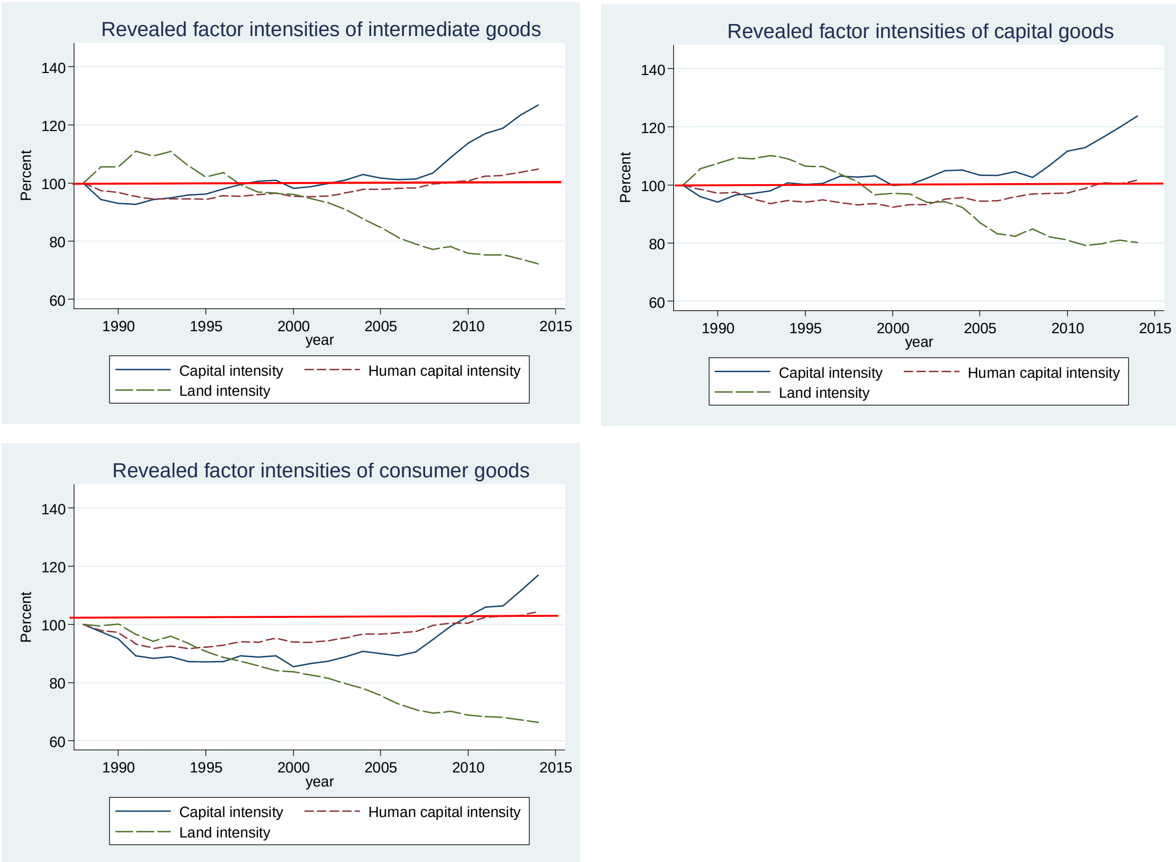
The change in the average RFI indicators of consumer goods remained significantly below the benchmark in the years between 1989 and 2009, unlike that of intermediate and capital goods. The difference in the changes in the average RHCI and the average RLI is less pronounced.

It may be interesting to assess if the above observation on consumer goods was triggered by the expansion of global value chains, that started in the 1990s and flourished particularly in the early 21st century until the 2008 financial crisis (World Bank, 2017). The fall of RCI and of RHCI in consumer goods corresponds to the period during which many developing countries started to participate in the assembly segment of global value chains. A rise in the export share of countries with relatively low level of physical capital and human capital may have caused the fall in the average RCI and RHCI of consumer products. The average RCI of intermediate goods started to increase in the late 1990s, then surpassed the benchmark level around the year 2000. This may

[3] The grouping of the products into different stages of processing is based on the broad economic classification (BEC).

suggest an increase in the exports of intermediate goods by high income developed countries such as Germany, Japan, and the United States of America during this period.

Figure 8. Changes in the Average RFI indicators, by stage of processing (1988=100)



3.2 Average RFI Indicators across products

Figure 9 presents the distribution of the values of the RFI indicators across products classified at the HS 6-digit level. The value of different RFI indicators is normalized by dividing them by the average of the year, in this case 2014.

The patterns of the distribution are significantly different across RFI indicators. The distribution of RHCI is skewed around the average, i.e. the value of 1, with all products fall within the range of 0.5 and 1.3. The distribution of RLI values (blue line) shows a weak bell-shaped distribution, with 83 per cent of products falling within the range of 0.5-1.5. The distribution of RCI values are widely dispersed with no significant concentration.

Table 1 compares the degree of concentration in the year 2014 with that in the year 1988. It suggests that the distribution of the values of RHCI and RLI in 2014 was more concentrated around the mean than was in 1988, while the values of RCI got more dispersed: only 68 per cent of products fell in the normalised RCI values of 0.5 and 1.5 in 2014, compared to 77 per cent in 1988. The increasing convergence of RHCI values around the mean corresponds well with the trend of human capital endowment across countries, i.e. converging around the mean, as we saw in Figure 4 above.

Figure 9. Frequency distribution of the RFI Indicators across Products (2014)

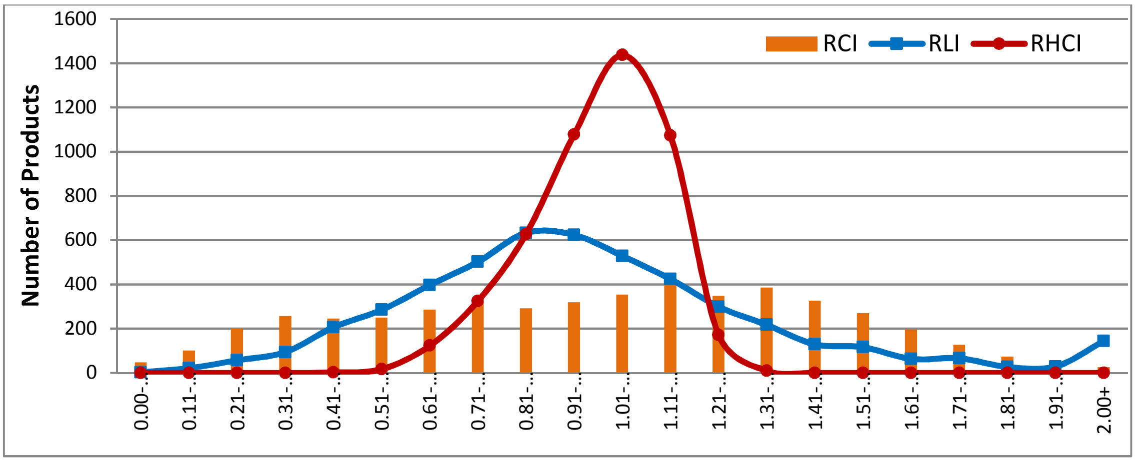


Table 1. Changes in the concentration of the products around the average RFI indicators (%)

	Physical Capital (RCI)		Human Capital (adjusted)		Land	
range	1988	2014	1988	2014	1988	2014
0.5-1.5	77.4	67.7	99.6	100.0	80.9	83.0

3.3 Combining average RFI indicators by product

Next, the RFI indicators of a product is combined and are scattered on a three-dimensional plane. Figure 10 presents the scatter of all the products according to a combination of two RFI indicators in 2014.[4] In Figure 10, the brown dots illustrate the RCI-RHCI combination, the blue dots the RCI-RLI combination and the green dots the RHCI-RLI combination.

The values of the RCI and the RHCI indicators are positively corelated with an estimated correlation value of 0.69. This suggests that a product that requires a high level of physical capital tends to require a high level of human capital. The other two combinations, the RLI-RCI and the RLI-RHCI, does not reveal much correlation, with the value of correlation being 0.03 for the former and 0.19 for the latter.

[4] Products in this graph are classified according to SITC at the 4-5 digit level, with a view to giving simpler visualization of the spread of products than otherwise when using the HS classification.

Figure 10. Spread of products when two RFI indicators are combined (2014)

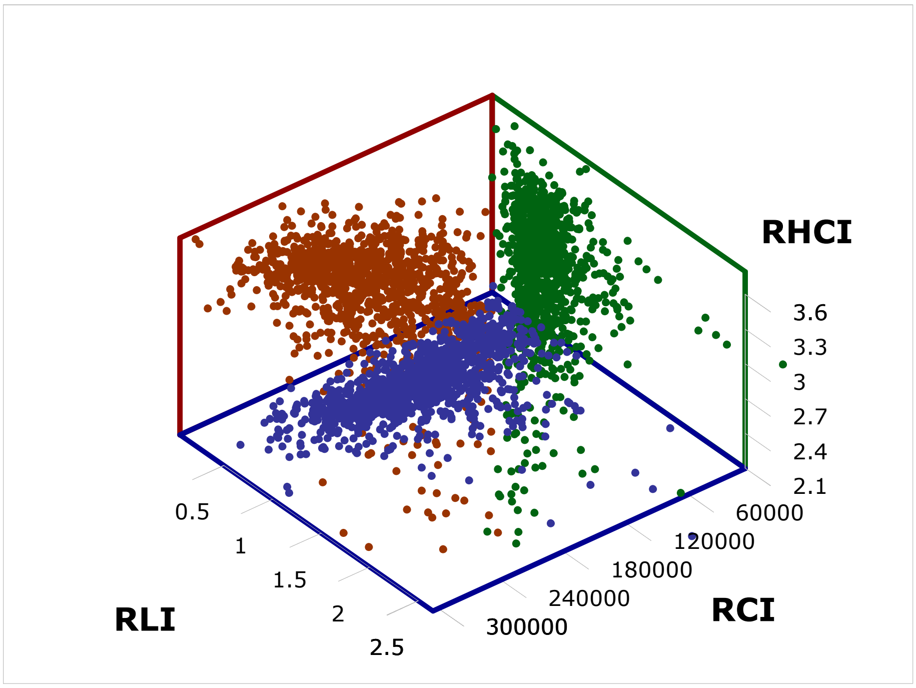


Figure 11 present the spread of products when all three RFI indicators in 2014 are combined. The fitted line in red loosely follows the positive correlation between RCI and RHCI, but the majority are concentrated within the values of RLI ranged between 0.4-1.

The products in Figure 11 are then grouped into ten product sectors by taking the simple average of the combined RFI Indicators of products within each group. The sectoral distribution is presented in Figure 12.[5]

The manufacturing sectors, which include machinery and transport, manufactured products and the chemical sectors, are positioned in the area (near the top left-hand-side corner) that suggests high RCI and RHCI, and not too high RLI. At the opposite end is the food and agricultural sectors with relatively low levels of RCI and RHCI while high RLI. The position of the mineral fuel sector suggests that the sector is relatively high in RCI and RLI, but not in RHCI.

[5] These product sectors, as defined according to the SITC classification, are: animal and vegetable oils; beverages and tobacco; chemical products; chemicals and related products not elsewhere specified (n.e.s.); commodities and transactions (n.e.s.); crude materials inedible, except fuels; food and live animals; machinery and transport equipment; manufactured goods; and mineral fuels, lubricants and related materials.

Figure 11. Spread of products when three RFI indicators are combined (2014)

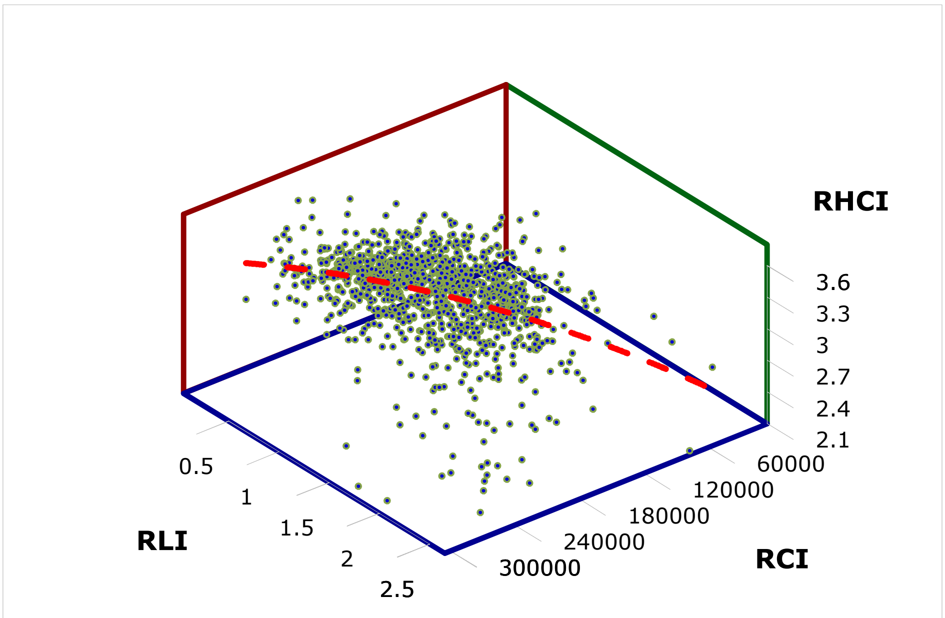
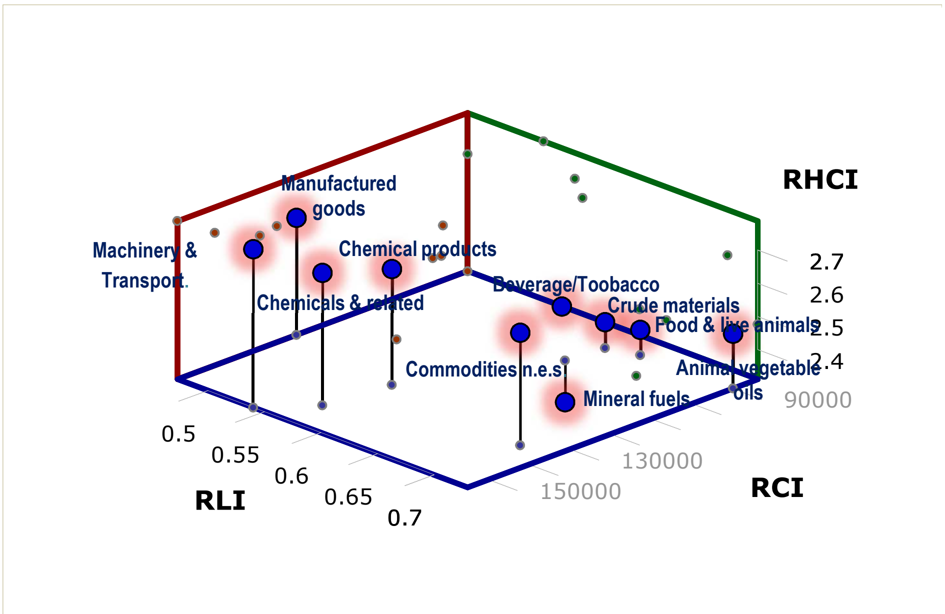


Figure 12. Spread of products groups with three RFI indicators are combined (2014)



4. The RFI-Endowment Ratio

Since they were made available in 2010, the RFI Indicators have fostered research in a wide array of topics related to comparative advantage, product export diversification, persistence of export patterns, and export survival of firms among others. Box 1 provides some of the studies that used the RFI indicators as a variable.

Box 1

Cadot et al. (2011) note that factor endowments cannot be neglected as one of elements that influence countries' trade flows. Using the 2010 RFI indicators, they assess changes in what they call "diversification cones" and find that developed countries tend to continue exporting products that would no longer correspond to their current factor endowments. They suggest that this may be due to hysteresis, or leftovers from their old export pattern, but that this finally gives way to a catching up of the comparative advantage.

Nicita et al. (2013) assess the interaction between the comparative advantage of a country as seen by the Heckscher-Ohlin-Vanek model and the probability of survival of the exports of least developed countries (LDCs) by focusing on the distance between a country's endowment and the RFI of its exports. Their results suggest that the greater this distance between the endowment and the RFI of an exported product, the lower is the probability of survival on the export market.

Parteka and Tamberi (2013) observe that, as countries develop, they increase the exports and imports of previously exported goods, but they vary in terms of quality characteristics. Using the RFI indicators, they explore the human capital content of exports and imports which they use as a proxy for quality and find that the human capital content tends to be higher for imported goods, and this for nearly all levels of development.

Maggioni et al (2016) use the RFI indicators to determine to what extent human capital, amongst other factors, drives firm product complexity on the one hand and firm output volatility on the other. Overall, they find that higher levels of firm product complexity are associated with lower levels of volatility, and that the link between complexity and volatility strongly reflects the contribution of the human capital content of the product basket of firms.

In addition, the dataset of national endowments, initially prepared by Cadot, Shirotori and Tumurchudur (2010) for estimating the RFI indicators has the advantage of covering three endowments in one same source, in the same format, for over 100 countries and with a long-time span. The endowment dataset has been used by some researches. For instance, Bahar et al (2014) uses the endowment dataset to study how a country's new exports are affected by exports of same products in neighboring countries. Regolo (2013) uses the dataset and finds that exports between similarly endowed countries ("South-South" and "North- North") are more diversified than exports between differently endowed countries ("South-North" and "North-South").

Hausmann et al. (2007) suggests that countries that export sophisticated goods - the types of goods that are exported by richer countries – tend to achieve high economic growth. The study also measures the "income/productivity level", or the sophistication of a product, as a weighted average of per-capita GDPs of the countries that export a given product and call it PRODY.

The weights are determined by the revealed comparative advantage of each country in that product. Using PRODY, the study estimates EXPY, a trade-weighted average of PRODY of all the products that a country exports, as a proxy for the "productive capacity" of a country given its exports. They find that countries whose export baskets exhibited high EXPY compared to what their income levels predicted experienced higher GDP-per-capita growth than others. In other words, countries which exported products that were exported by "richer" countries tend of exhibit relatively higher income growth than otherwise.

By estimating EXPY based on PRODY, the study assumes that all the factors that influence the productivity level of a country, including physical capital and human capital, are implicitly captured by a country's GDP per capita.

In this section, we replace PRODY with the RFI indicators and estimate a trade-weighted RFI of a country's export basket. Following the study by Hausmann et al. which treats human capital as a complementary variable that improves the productivity-enhancing power of investment, we primarily focus on revealed physical capital intensity, and use the RCI-endowment ratio to replace EXPY.

Then we measure if the trade-weighted RCI of a country is commensurate with the county's actual endowment of physical capital. This is done by taking a ratio between the two, with the endowment as the denominator. When the ratio is above 1, it means the country's exports are more physical capital intensive than the actual endowment level suggests.[6]

To estimate the gap in a country's factor endowment and the RCI indicator, we first calculate the factor intensity of the country's export basket by excluding the considered country, say country *c*, as shown in equation (1). This is the sum of all countries *i* for good *j*. Country *c* is excluded to avoid variations in its exports and export policies from changing the factor intensity.[7]

$$k_j^c = \sum_i \omega_j^i \frac{K^i}{L^i} \quad , with\ i \neq c \tag{1}$$

Then we can compute the trade-weighted average RCI of all products exported by country *c* as shown in equation (2).

$$A_c = \sum_j k_j^c \frac{X_j^c}{X^c} \tag{2}$$

Since the weights add up to one, the result is a number of the same order of magnitude as the actual endowment of the country. This enables us to compare the RCI of a country's exports to its endowment stock. This is done here using a ratio:

$$Ratio_c = \frac{A_c}{k_c/l_c} \tag{3}$$

If the ratio is above 1, the country is exporting products that are more physical capital intensive than the actual capital endowment.

4.1 The RCI-endowment ratio and the productivity

In this section, we run simple regressions to check how the ration of the average RCI to the actual capital endowment of a country is related to its productivity and economic growth.

[6] For example, if the average RCI of a country's export basket in a given year is US$ 100'000 and its physical capital stock in the same year is US$ 80'000, then the country's RCI-endowment gap is 100'000/80'000 = 1.2.

[7] The correlation between the RFI data with and without the exclusion of the given country is very high. In 2014 for the balanced sample it was of 99.8 percent for both human and physical capital and 99.6 percent for arable land. This is due to the fact that many products are exported by many countries, which means that excluding one doesn't change so much. Besides, the modified weighting we use with respect to the standard RCA is such that the country gets a higher weighting if its export share of that product is high in its overall exports relative to other countries, and not simply because it exports a high share of world worlds.

Figure 13 plots countries according to the RCI-endowment ratio of their export baskets and their real GDP per worker in 2014, which we use as a proxy to a country's productivity. The size of each bubble indicates the relative size of a country's GDP.

Considering high correlation between our definition of the productivity and the GDP per capita (Table 2), Figure 13 suggests that exports of lower income countries reveal higher capital intensity than their endowment predicts. It also suggests that as the productivity improves, the gap between the RCI and the actual endowment disappears.

Figure 13. Physical capital: RCI-endowment ratio against productivity (2014)

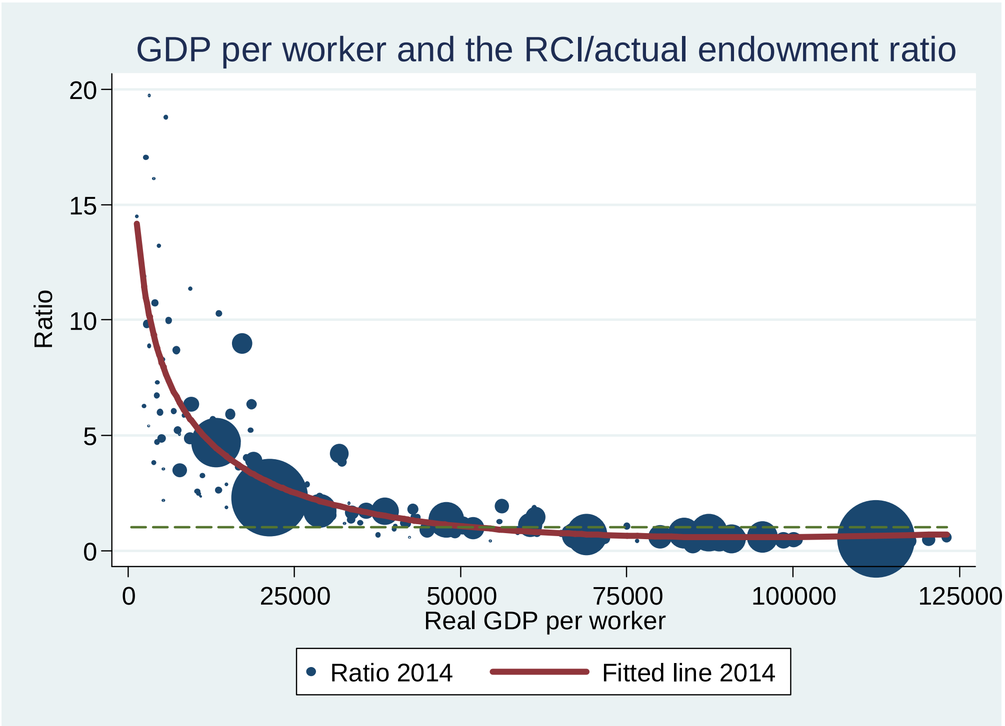


Table 2. GDP-per-Worker and GDP-per-Capita

	GDP per worker (constant 2011 PPP $)	GDP per capita, PPP (constant 2011 international $)
High income	90'309.2	42'123.4
Upper middle income	13'823.4	3'655.4
Lower middle income	8'353.7	2'677.2
LDCs	6'062.5	2'348.9

Source: World Bank, World Development Indicator.

The above observation is confirmed by the result of an ordinary least squares (OLS) regression of a function (4) which was run separately for two groups: (i) low, middle and upper-middle income countries; and (ii) high-income countries.[8]

[8] Based on the World Bank's data revised on July 1st, 2016, high income countries are those with a GNI per capita of US$12,476 or more, calculated using the World Bank Atlas method.

(4) $$\mathrm{Ratio}_{ct} = \alpha + \beta\,(\mathrm{RGDPpw}_{ct}) + \gamma\,(\mathrm{RGDP}_{ct}) + \lambda_c + \lambda_t + \varepsilon_{ct}$$

The term RGDPpw_{ct} stands for real GDP per worker in country c in year t, and RGDP_{ct} stands for real GDP. λ_c is used to control for anything specific to country c which does not vary over time, which is important as we want our link to be independent of such characteristics. Also by including time fixed effects λ_t we can control for factors affecting all countries in the same way in a given year, which helps us avoid effects such as changes in world oil prices from affecting our results. Finally, ε_{ct} is the error term.

Table 3. OLS regression on the RFI-endowment ratio

RCI-endowment ratio	Low- and middle-income	High income
Real GDP per worker	-0.1349***	-0.0039***
Real GDP	-0.0002	-0.0000
Constant	5.3505*	0.8587***
Year fixed effects (λ_t)	YES	YES
Country-specific effects (λ_c)	YES	YES
R squared	0.72	0.80
N	2890	1418

*p<0.05, ** p<0.01, *** p<0.001

The result of the regression (Table 3) confirms a negative relationship between the RCI-endowment ratio of a country and its productivity (real GDP per worker). The coefficient of real GDP is statistically insignificant. The coefficient of RGDPpw_{ct} for the lower-income group, -0.13, is significantly greater than that for the higher income group. That is, as the productivity rises, the RCI-endowment gap is reduced at a bigger magnitude in lower income countries than higher income countries.

One reason for this outcome is because exports of lower income countries tend to be concentrated in one or two sectors which are relatively capital intensive. Exports of countries in the top left corner of Figure 13, exhibiting high RCI-endowment gap and low overall productivity, are concentrated in primary commodities such as petroleum, aluminium, uranium, diamonds, natural gas or gold. It may be that phyaical capital stock of these countries largely consists of those used in extractive industries, their key export sectors. As GDP per worker increases, the factor endowments increase (as seen in Section 2) and countries' exports may become more diversified, reducing the gap between the trade-weighted average RCI and the country's actual capital endowment.

As a reference, Figure 14 presents the relationship between the RHCI-endowment gap – the gap between the RHCI and the actual human capital - and productivity. The fitted trend suggests a negative relationship as in the case of Figure 13. However, the range between the highest and the lowest ratio is much narrower - between 1.5 and 0.5 – as RHCI of products do not vary much compared to physical capital, as seen in the previous section.

As in the case of the RCI-endowment ratio, as the productivity rises, the gap between the RHCI and the actual endowment is reduced faster among lower income countries than higher income countries (Table 4). The value of coefficient of RGDPpw_{ct} however is much smaller in the case of the RHCI-endowment gap.

Figure 14. Human capital: RHCI-endowment ratio against productivity (2014)

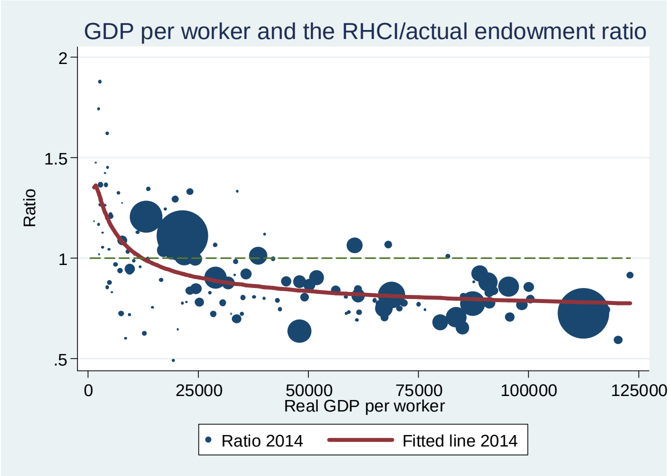


Table 4. OLS regression on the RHCI-endowment ratio

RHCI-endowment ratio	Low- and middle-income	High income
Real GDP per worker	-0.0035***	-0.0005***
Real GDP	-0.000	-0.0000
Constant	1.2019*	0.7672***
Year fixed effects (λ_t)	YES	YES
Country-specific effects (λ_c)	YES	YES
R squared	0.86	0.89
N	2890	1418

*p<0.05, ** p<0.01, *** p<0.001

4.2 The RFI-endowment ratio and economic growth

We now estimate if countries that export "sophisticated" products, i.e. those products whose RCI indicator exceeds the actual capital endowment, would achieve higher income growth. Equation (5) estimates the impact of the RCI-endowment gap upon a short-term income growth by replacing EXPY in the specification used by Hausmann et al. (2007) with the RCI-endowment gap.

$$RGDPGpw_{ct} = \alpha + \beta log(Ratio_{ct}) + \lambda_c + \lambda_t + \varepsilon_{ct} \quad (5)$$

The dependent variable $RGDPGpw_{ct}$ is the 5-year moving average of the growth rate from period t to t+5. $Ratio_{ct}$ is the ratio of the RFI-endowment ratio of country c in time t. We control for country-specific and year-specific effects by adding λ_c and λ_t in the equation.

Table 5. OLS regression on the 5-year average growth rate of GDP per worker (1988-2014)

	RCI (physical capital)	
	Low- and middle-income	**High income**
logRatio	2.549442***	3.743967***
Constant	-.7767777	3.150706***
Year fixed effects	Yes	Yes
Country fixed effect	Yes	Yes
R-squared	0.3958	0.3816
Adj R-squared	0.3586	0.3367
N	2330	1138
	RHCI (human capital)	
	Low- and middle-income	**High income**
logRatio	-4.132294***	-2.057797
Constant	.7774971	2.350029*
Year fixed effects	Yes	Yes
Country fixed effect	Yes	Yes
R-squared	0.3149	0.3444
Adj R-squared	0.2720	0.2963
N	1902	1026

*p<0.05, **p<0.01, ***p<0.001

Table 5 shows that the coefficient of log of the RCI-endowment ratio is positive and statistically significant at 0.1 per cent level for both income groups. This confirms that an increase in the RCI-endowment ratio of a country boosts the country's income growth in the next 5 years. For low income countries, 1 per cent increase in the RCI-endowment ratio leads to 2.5 per cent rise in income growth in the subsequent 5 years.

In the case of RHCI (human capital intensity), the results are mixed. The estimated coefficient for the low- and middle- income countries are negative and statistically significant, while that for the high-income group is insignificant at 5 per cent level. A negative coefficient suggests that a country which exports products whose RHCI is higher than their human capital would have slower income growth in the subsequent 5 years.

To obtain a better insight, we plot the countries against log of the RCI-endowment ratio in 2009 and the 5-year average income growth rate from 2010 to 2014 separately for three income groups (Figure 15-17). The size of a bubble indicates a relative size of real GDP per worker in 2009 within the group.[9]

For the cases of low- and middle-income countries, when the RCI of their exports exceeds their actual capital endowment, they are likely to achieve higher income growth in the subsequent years.

As regards higher income countries, while there is a positive relationship between the RCI-endowment ratio and economic growth, the RCI-endowment ratio of their exports is less than 1, i.e. log of the ratio is below zero. This means that higher income countries export goods that are "less sophisticated" than what their capital endowments suggest.

In summary, we observe a positive relationship between the RCI-endowment ratio and the short-term income growth for all income groups, and the coefficient of RCI-endowment ratio is bigger for higher income countries

[9] The relative size of the bubble is measured within a given income group. The size of the bubbles thus is not comparable across different income groups, e.g. between Figure 9.a and Figure 9.c.

than that of lower income countries. However, the pattern of sophisticated exports and higher economic growth only applies to the log of the RCI-endowment ratio of higher income countries is below zero.

Figure 15. Five-year average income growth rate against log of the RCI-endowment ratio: Low income countries

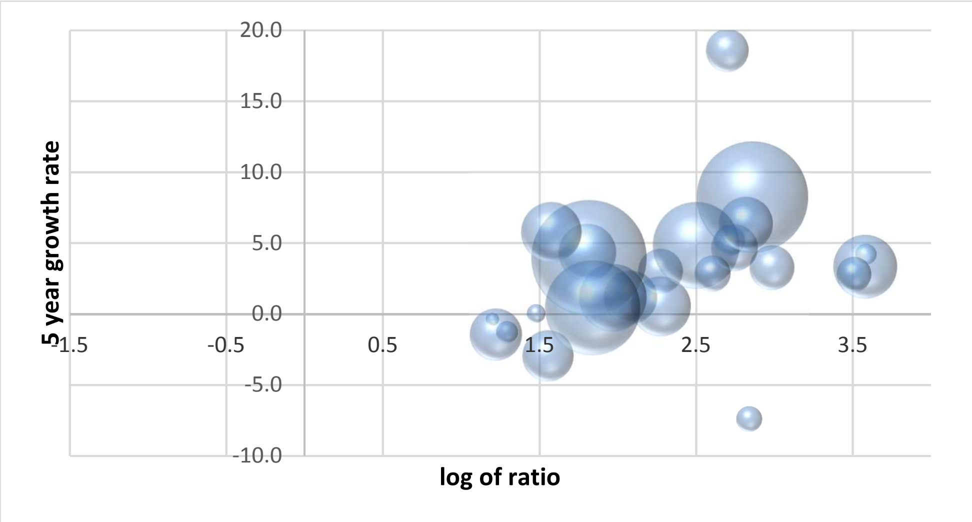


Figure 16. Five-year average income growth rate against log of the RCI-endowment ratio: Middle income countries

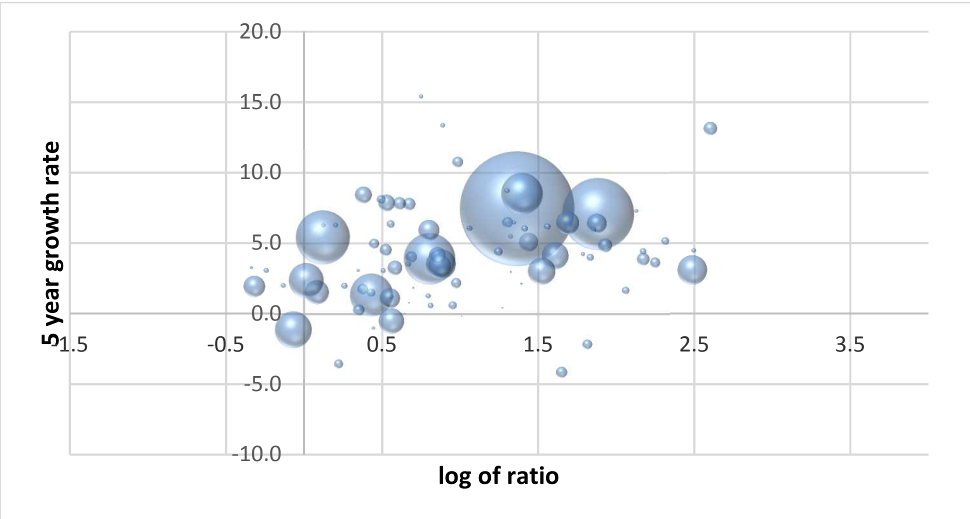
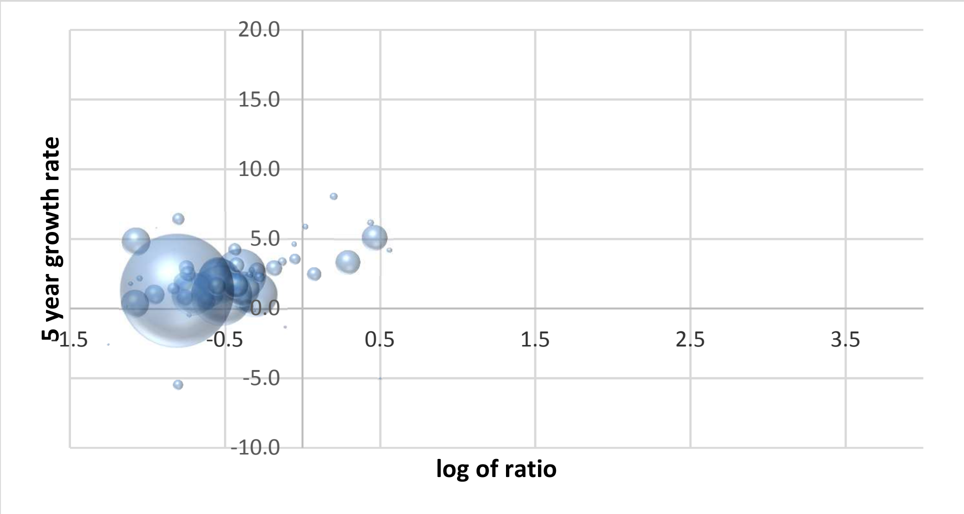


Figure 17. Five-year average income growth rate against log of the RCI-endowment ratio: High income countries



Hausmann, Hwang and Rodrik (2005) estimated the impact of EXPY upon the income growth in the period between 1992 and 2003. Let us now use the same cross-national specification used by them but with EXPY being replaced by the RCI-endowment ratio.[10]

(6) $$RGDPGpw_{c1988-2014} = \alpha + \beta log(Ratio_{c1988}) + \delta \log(RGDPpw_{c1988}) + \delta \log(HC_{c1988}) + \varepsilon_c$$

The term $RGDPGpw_{c1988-2014}$ is the average of the real GDP per worker growth rate in the years between 1988 and 2014. This is regressed against the log of baseline (i.e. 1988) RCI-endowment ratio $(Ratio_{c1988})$, log of the baseline real GDP per worker ($RGDPpw_{c1988}$), and the log of initial human capital (HC_{c1988}).[11] The result is presented in Table 6.

The estimated coefficient for the baseline RCI-endowment ratio is positive and statistically significant at 5 per cent level (Table 6). That is, a country whose exports in 1988 were more capital intensive than its capital endowment achieved a higher level of income growth than others during the 1988-2014 period.

The estimated coefficient of logRatio – log of the RCI-endowment ratio in the year 1988 - is higher for high-income countries (2) than that of low- and middle-income countries (1). For high-income countries, 1 per cent increase in the baseline RCI-endowment ratio boosted the income growth between 1988 and 2014 by over 1.40 per cent, compared to 0.80 per cent for low-and middle-income countries.

For lower income countries, the coefficient of logHC – log of the baseline human capital - is much higher than that of the baseline RCI-endowment ratio. In other words, countries which had higher level of human capital than other low- and middle-income countries in the year 1988 experienced higher income growth in the subsequent period. The coefficient of logHC for high-income countries, on the other hand, is negative (and statistically significant at 1 per cent level). This in fact agrees with the findings by Hausmann et. al. (2007), that the coefficients of logHC were often negative among higher-income countries, particularly among the OECD members, while the coefficient was positive for low-income countries.[12]

[10] It is the OLS specification given in Table 8 of Hausmann et al. (2007).

[11] Note that we did not add the log of capital-labour ratio and the rule-of-law index in the specification. The equation in this study is hence equivalent to (2) and (8) of Table 8 of Hausmann et al. (2007).

[12] See the breakdown of the regression results by income sub-groups is given in Table 10 of Hausmann et al. (2007).

We also note that the coefficient of logGDPpw – log of the baseline real GDP per worker - is insignificant for both income groups. When this explanatory variable is dropped (Table 7), it improves the statistical significance of the coefficient of logRatio while does not influence the coefficient of logHC.

Table 6. OLS regression on 1988-2014 growth rate of GDP per worker

	RCI (physical capital)	
	Low- and middle- income	**High income**
logRatio	0.7982577*	1.426619*
$logGDPpw_{1988}$	-0.1157625	-0.3076345
$logHC_{1988}$	2.679434*	-3.03281 **
Constant	0.481447	6.935935*
R-squared	0.1519	0.5010
Adj R-squared	0.1171	0.4594
N	77	40

*p<0.05, **p<0.01, ***p<0.001

Table 7. OLS regression on 1988-2014 growth rate of GDP per worker

	RCI (physical capital)	
	Low- and middle- income	**High income**
logRatio	0.84989***	1.627238***
$logGDPpw_{1988}$		
$logHC_{1988}$	2.511386*	-3.089819**
Constant	0.256227	5.854716***
R-squared	0.1511	0.4987
Adj R-squared	0.1281	0.4716
N	77	40

*p<0.05, **p<0.01, ***p<0.001

In Figures 18 and 19, countries are plotted according to the long-term income growth (on the y axis) given the baseline RCI-endowment ratio.

The slope is more gradual for lower income countries (Figure 18) but the countries are scattered more widely – between -1 and 4 – than high-income countries (Figure 19). The latter group of countries are concentrated around zero both in terms of the baseline RCI-endowment ratio and the subsequent income growth.

In Figure 19, we see that countries which had a high RCI-endowment ratio in the base year and experienced high-income growth in the studied period include developing countries such as Qatar, and the Republic of Korea, Singapore, as well as countries such as Hungary and Poland that joined the European Union after the 2004 enlargement.

Figure 18. Partial relationship between logRatio (RCI) and the income growth: Low- and middle-income countries (Table 6)

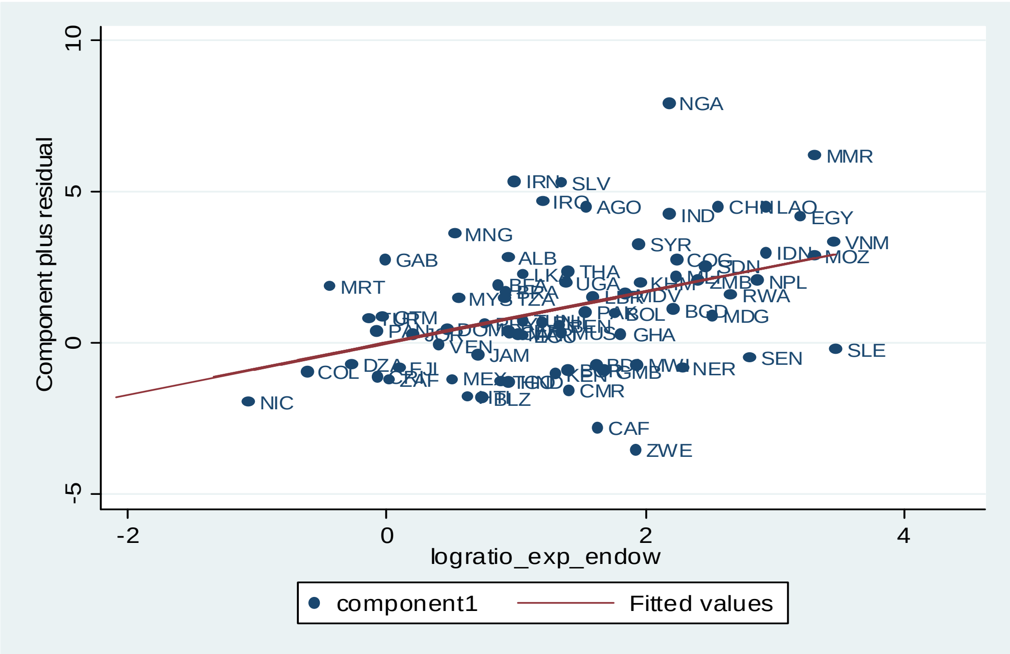
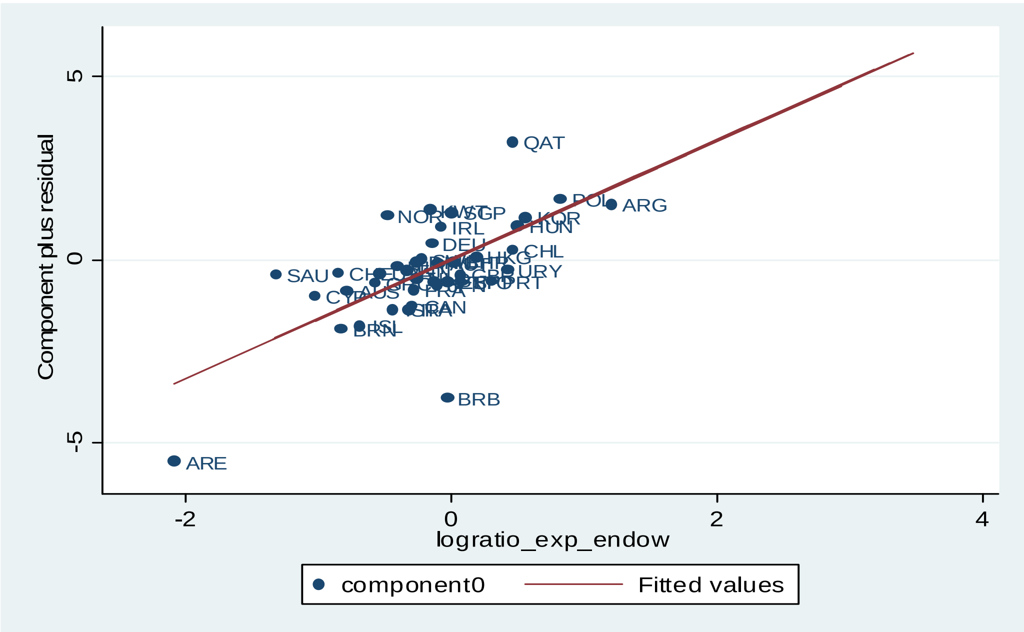


Figure 19. Partial relationship between logRatio (RCI) and the income growth: High-income countries (Table 6)



5. Conclusion

The present paper provides descriptive statistics of the updated database of the RFI indicators of products classified at the HS 6-digit level, and the factor endowments consisting of physical capital, human capital and arable land. It is hoped that the RFI indicators and the endowment database contribute to research in a wide array of topics such as export diversification patterns, export survival of firms, and those related to natural-resource curse.

The descriptive statistics in this paper point to some interesting areas for future research. One may be to integrate technological differences between countries to better understand how endowments determine trade patterns. The paper also looks into the gap between the RFI of a country's exports and its actual endowment, as a possible variable to assess whether "what they export matters" for economic growth as suggested by Hausmann et al. (2007).

According to the product space theory developed by Hidalgo, Klinger, Barabàsi and Hausmann (2007), "countries tend to move to goods close to those they are currently specialized in, allowing nations located in more connected parts of the product space to upgrade their exports basket more quickly". Based on the assumption that the underlying productive factors are relatively specific to a set of products, they suggest that countries diversify into products that are "proximate" or "similar" to what they are currently exporting. The proximity among products they use is measured by the conditional probability of having revealed comparative advantage (RCA). The RFI indicators and the database of factor endowments may be used to substantiate the product-space analysis that have been used in many developing countries to assess export competitiveness (World Bank, 2009).

Bibliography

Balassa B (1965). "Trade Liberalisation and "Revealed" Comparative Advantage", The Manchester School, 33(2), 99-123.

Bahar D, Hausmann R and Hidalgo C A (2014). "Neighbors and the Evolution of the Comparative Advantage of Nations: Evidence of International Knowledge Diffusion?", Journal of International Economics, 92(1), 111-23.

Barro R and Lee,J-W (2010). "A New Data Set of Educational Attainment in the World, 1950-2010", NBER Working Paper No. 15902.

Cadot O, Carrere C and Strauss-Kahn V (2011). "Export Diversification: What's Behind the Hump?", Review of Economics and Statistics, 93(2), 590-605.

Cadot O, Shirotori M and Tumurchudur B (2010). "Revealed Factor Intensities at the Product Level, UNCTAD (UNCTAD/ITCD/TAB/46).

Caselli F (2005). "Accounting for Cross-Country Income Differences", In Aghion, P. and Durlauf, S. N. editors, Handbook of Economic Growth, Amsterdam: Elsevier, Volume 1A, 679-741.

Easterly W, Kremer M, Pritchett L and Summers L (1993). "Good Policy or Good Luck? Country Growth Performance and Temporary Shocks", *Journal of Monetary Economics,* 32, 459-83.

Easterly W and Levine R (2001). "It's Not Factor Accumulation: Stylized Facts and Growth Models", The World Bank Economic Review, 15(2), 177-219.

Hausmann R, Hwang J and Rodrik D (2007). "What You Export Matters", *Journal of Economic Growth,* 12(1), 1-25.

Hidalgo C A, Klinger B, Barabási A.-L, Hausmann R (2007). “The product space conditions the development of nations”, *Science* 27 July: Vol. 317, Issue 5837, pp. 482-487 DOI: 10.1126/science.1144581.

Laursen K (2000). "Specialization, Trade and Growth", Routhledge.

Maggioni D, Alessia L and Gallegati M (2016). "Does Product Complexity Matter for Firms' Output Volatility?", Journal of Development Economics, 121, 94-109.

Nicita A, Shirotori M, Tumurchudur B (2013). “Survival analysis of the exports of LDCs: The role of comparative advantage”, Policy issues in international trade and commodities study series No. 54, UNCTAD.

Parteka A and Tamberi M (2013). “Product Diversification, Relative Specialisation and Economic Development: Import-Export Analysis", *Journal of Macroeconomics,* 38(PA), 121-35.

Proudman J and Redding S (1988). "Openness and Growth". The Bank of England.

Psacharopoulos George (1994). "Returns to Investment in Education: A Global Update", World Development, Elsevier, 22(9), 1325-43.

Regolo J (2013). “Export Diversification: How Much Does the Choice of the Trading Partner Matter?”, WPS 13-07-2 Working Paper Series, July, University of Geneva.

UNCTAD (2013). *World Investment Report 2013.*

UNCTAD (2018). *Key Statistics and Trends in International Trade 2017.*

Vollrath T (1987). "Revealed Competitiveness for Wheat", Economic Research Staff Report, No AGES861030, U.S. Dept. of Agriculture, Economic Research Service. Washington, D.C.

Vollrath T (1989). "Competitiveness and Protection in World Agriculture", Agriculture Information Bulletin, 567, United States Dept. of agriculture, Economics Research Service. Washington, D.C.

World Bank (2009). Mapping the Lao Product Space.

World Bank (2017). Global Value Chain Development Report 2017: Measuring and analyzing the impact of GVCs on development.

ANNEX: Methodology and data used

To calculate the RFI indicators for all the products for each year from 1988 to 2014, UNCTAD has generated a database of national factor endowments of a cross-section of 112 countries. The factor endowments included here are: physical capital (as defined as capital stocks per worker); human capital (built upon the average years of schooling and return on education); and arable land per worker.

This section discusses the general methodology and changes that were made to the previous version of the data, found in Cadot, Shirotori and Tumurchudur (2010) which constructed the indices as follows.

- First, it constructed a panel database of factor endowments at the country level, based on raw data on the presence of physical capital, human capital and natural resource endowment for countries for which data was available.

- Second, it calculated the "revealed" factor intensity for each product at a disaggregated level of product classification, by calculating the weighted average of the factor endowments of countries that export the concerned product.

Based on these modalities and the latest national endowments data, we have re-constructed the country endowments' database and recalculated our database on RFI. The updated database contains three indices of RFI, on one hand at the SITC 4-5 digit[13] level for the period 1962 to 2014 and on the other at the HS 6-digit level (version HS 88/92) for the period 1988 to 2014. The three RFIs are respectively the revealed physical capital intensity index (RCI), revealed human capital intensity index (RHCI) (which are now presented in two versions, reflecting quantity of schooling on one hand and a mix of quantity and quality on the other) and revealed natural resource intensity database.

Factor endowments

To update the country-endowment data we used: (a) the Penn World Table (PWT) database - version 9.0[14] for constructing capital stocks per worker; (b) Barro and Lee (2010) for yearly data on average years of schooling,[15] PWT 9.0 for an index of human capital per person mixing years of schooling from Barro and Lee (2013) and returns to education from Psacharopoulos (1994); and (c) arable land per person was obtained from the World Development Indicators 2014 (WDI).[16]

In constructing the database, we faced a trade-off between "width" and "consistency" in country-endowment data. On the one hand, we are interested in having indices for as many countries as possible, to give a width to the database. On the other hand, to track the evolution of RFI indices for each good over several years, we need to have a complete (i.e. balanced) panel of data on endowments of a given set of countries for the same length of years, to ensure that the indices are constructed in comparable ways. However, if there is systematic bias in the selection of countries in the panel (say, if low-income countries are underrepresented in the data), RFI indices will be biased against factors of which low-income countries are poorly endowed. This may not necessarily alter the ranking of goods by RFI, but will affect the relative intensities. In order to minimize this bias, the wide-coverage (unbalanced) panel includes, each year, all the countries for which data are available

[13] Though the finest level of the SITC is a 5 digit, not every 4 digit is divided into five digits. Therefore our SITC database consists of a mix of 4 and 5 digits in order to cover all the products.

[14] The version 9.0 of PWT has 2011 as the base year and provides the share of output-based real GDP per capita that is represented by capital formation (investment) 182 countries, of which 55 cover the full period from 1950 to 2014, which goes beyond our sample period.

[15] We have interpolated the five-yearly (quinquennial) estimates of average years of schooling from Barro & Lee (2010) to obtain yearly measures of human capital for 146 countries from 1950 to 2014.

[16] Using Arable Land per person from the World Bank's WDI (for 205 countries for which 174 have data for the full period of 1961 to 2014), we have calculated Arable Land per worker.

in that year. In other words this means that for the unbalanced version all available data is used in the computation of the indices.

The general steps used to compute the endowments and factors are outlined below and can be found more in detail in Cadot, Shirotori and Tumurchudur (2010). The physical capital stock $K_{i,t}$ is computed using the perpetual inventory method (PIM) using investment flows I_{it} for country *i* in year *t* as in equation (1), where δ is the depreciation rate assumed to be equal to 7 per cent as in Easterly and Levine (1993).

$$K_{i,t+1} = (1-\delta)K_{i,t} + I_{i,t} \quad (1)$$

Assuming that a country is at its steady-state capital-output ratio one can write the steady-state growth rate g_i^* as in equation (2) with ι_i^* the investment rate and κ_i^* the ratio of capital over output.

$$g_i^* = \frac{\iota_i^*}{\kappa_i^*} - \delta \quad (2)$$

Re-writing this as in equation (3) enables us to isolate the capital-output ratio at its steady state.

$$\kappa_i^* = \frac{\iota_i^*}{g_i^* + \delta} \quad (3)$$

As in Cadot, Shirotori and Tumurchudur (2010), the steady state growth rate is computed as being a weighted average of the growth rate of country *i* ($\overline{g_\iota}$) and the world growth rate ($\bar{g}^w$) during the first 10 years of the sample[17] and choosing weights to be 0.75 and 0.25 respectively as noted in Easterly et al. (1993) and Easterly and Levine (2001). The average world growth rate is computed here from the available sample of countries in PWT 9.0 as a simple average of country growth rates and its value is 0.0427.[18] Then, the country steady state growth rate can be computed as in equation (4).

$$g_i^* = \lambda\overline{g_\iota} + (1-\lambda)\bar{g}^w = 0.75\overline{g_\iota} + 0.25 * 0.0427 \quad (4)$$

The same is done for investment and the initial capital stock is then computed as the average real output between 1950 and 1952, therefore reducing the potential influence of business cycles, multiplied by the capital-output ratio as in equation (5) where $\widetilde{Y_0}$ is the average real output value between 1950 and 1952.[19]

$$K_0 = \kappa_i^*\widetilde{Y_0} \quad (5)$$

This enables us to compute the entire time series of capital stocks in equation (1).

For the human capital stock two different but related measures are used. The reason for doing this is to have one that is comparable to what was used in the previous version of the data in Cadot, Shirotori and Tumurchudur (2010) but also take use of a more comprehensive measure now available in PWT 9.0. As suggested in Caselli (2005), solely accounting for quantity of schooling neglects the quality. Using the variable on returns to schooling and mixing it with years of schooling will enable us to have a variable mixing quantity and quality of schooling. The current country-endowment database contains a measure related to quantity, which is the average years of schooling calculated in Barro and Lee (2010) and available in PWT 9.0. As initial data is available every 5 years, yearly data is estimated through linear interpolation. The values for 2011 to 2014 are computed based on the average change that took place during the 5 previous years. The second

[17] This is usually from 1950 to 1959 but when data is only available later the first available 10 years are used.

[18] This is very close to the figure calculated in Easterly and Levine (2001) who obtain 0.0423 using the version 5.6 of PWT.

[19] If only subsequent years are available, it is the first 3 available years that are used.

variable that now mixes quantity and quality is an index of human capital per person found in PWT 9.0 and based on years of schooling from Barro and Lee (2013) and returns to education from Psacharopoulos (1994).

3.2 Revealed factor intensities

Following Cadot, Shirotori and Tumurchudur (2010), the RFI indices for a given product are computed as an average of the factor endowments of countries exporting the product, weighted as in equation (6) by Hausmann, Hwang and Rodrik's (2007) modified version of the Revealed Comparative Advantage (RCA) presented in Balassa (1965). The method used here has the advantage of avoiding cases where the RCA becomes very large due to some products only representing a small share of world trade and making the denominator very small. Although several alternative methods are possible to calculate RCA indices, we decided as in Cadot, Shirotori and Tumurchudur (2010) to use this version. Two criticisms addressed by Vollrath (1987, 1989) are that countries and commodities are being counted twice and the fact that they are based on gross and not net exports.

Cadot, Shirotori and Tumurchudur (2010) find however that alternative methods to overcome these issues could be rejected either because differences were small or were not suitable for our purposes. Other variants of RCA approaches can be found in Proudman and Redding (1998) or Laursen (2000). In the first, they stabilize the average value of a country by using a normalization to focus on changes in RCAs across sectors. The approach of Laursen (2000) corrects for the asymmetry of the RCA which arises when using Balassa's (1965) approach, as it has a lower bound of zero. These alternative approaches could be interesting as alternative measures but for consistency we use the one already used in Cadot et al. (2010), which can also be seen as an improvement of the Balassa (1965) version with certain advantages.

For capital, the revealed intensity $RCI_{j,t}$ is computed as in equation (7)[20] and the weighting in equation (6), where K_t^i is the capital stock of country *i* at time *t* as computed above, and L_t^i is the stock of labour of country *i* at time *t*.

$$\omega_{j,t}^i = \frac{X_{j,t}^i / X_t^i}{\sum_i \left(X_{j,t}^i / X_t^i \right)} \tag{6}$$

$$RCI_{j,t} = \sum_i \omega_{j,t}^i \frac{K_t^i}{L_t^i} \tag{7}$$

Where the weights $\omega_{j,t}^i$ are a function of $X_{j,t}^i$ which are the exports of good *j* in country *i*, and of X_t^i the total exports of country *i*. The numerator of equation (6) is the share of country *i*'s exports of product *j* in its total

[20] In Cadot et al. (2010), there was a correction for agricultural distortions, which was due to the fact that certain products are subsidized essentially by richer countries. This outcome was therefore not the outcome of comparative advantage. For this reason, using World Bank data on agricultural distortions, some product-country pairs were omitted in the computation of the indices. However, in this updated version observations with potential agricultural distortions are no longer omitted. The reasons for this are twofold. First, distortions may also take place in other sectors, therefore omitting those variables would bias the indices. Second, the database on agricultural distortions does not cover all countries in the sample, introducing a second bias. Nonetheless when comparing the indices with and without this correction the correlation remains high, using an updated version of World Bank data on agricultural distortions (version of June 2013) to correct for distortions in agricultural prices.

exports. The denominator is the sum of shares of all countries' exports of good *j* in their total exports. $\omega_{j,t}^{i}$ therefore indicates whether a country's share of exports of a good is beyond or below the average of all countries' share.

The values we get for the factor intensity are product specific, done separately at the HS 6 digit and the SITC 4-5 digit level. Since the weights ω_{j}^{i} add up to 1 when summed over *i*, the order of magnitudes of the indices are the same as the endowment stocks themselves. This comes from the fact that the factor intensities are weighted averages of endowment stocks, which is useful to have insights on the magnitude of the indices across products as well as for comparing general levels of intensities of export baskets to endowment levels, as done later on.