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INTERNATIONAL RELOCATION OF PRODUCTION AND GROWTH

Abstract

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JEL Classification: F62, F43, O47

Keywords: Trade, growth, offshoring, Globalization, product shocks

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International Relocation of Production and Growth*

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1 Introduction

The relocation of the production and exports from higher- to lower-income countries has been a central feature of economic globalization in recent decades. This process appears to have significantly influenced the dynamics of output and employment across countries and has generated some visible social and political unrest in some rich countries. For example, the phenomenon has been connected to the loss of more than 3.5 million manufacturing jobs in the US between 2001 and 2007 (Pierce and Schott 2016) and threatens to motivate a return to protectionism. However, despite its importance and the numerous studies analyzing particular aspects of this process on specific industries, regions, and countries,[1] there is no global assessment of its cross-country growth impact. This paper describes the main features of the process over the 1996-2014 period and assesses its impact on cross-country growth using data on approximately 5,000 products and 100 countries.

By international relocation of production (IRP) we specifically mean the shift of global market shares across countries that have different income levels.[2] If lower-income (higher-income) countries gain global market share in a particular good, then we say that the good's production is being relocated towards the South (the North). Our approach to measuring IRP is as follows. For each HS product at the 6-digit level, we calculate the average income of its exporting countries using these countries' shares in the product's global market to weight their incomes. We call this exporters' average income, the product's $AVEX$. Then, we measure the product's international relocation as the change over time in the product's $AVEX$ that is due to changes in the countries' global market shares and call this measure the product's *relocation index*, denoted as R_k for product k. Furthermore, for each country c, we calculate a measure RS_c of how global *relocation shocks* have affected the country's export basket. Then, we use this measure to estimate the cross-country growth impact of the IRP.

The average of the annual R_k indices between 1996 and 2014 was -0.9%, i.e., the $AVEX$ (which is an average of per capita GDPs) decreased approximately 1% per year due to IRP. More importantly, IRP was very heterogeneous across and within industries. As a consequence of this heterogeneity and the diversity of the countries' specialization across and within industries, the IRP had a substantially different impact across countries.

Although the empirical findings of this paper could be explained by various mechanisms,

[1] E.g., Lall, Albaladejo and Zhang (2004); Marin (2006); Sturgeon, Van Biesebroeck and Gereffi (2008); Autor, Dorn, and Hanson (2013); Ebenstein et al. (2014); Dauth, Findeisen and Suedekum (2014); and Pierce and Schott (2016). Autor, Dorn, and Hanson (2016) survey analyses the specific impact of China's exports on US labor markets.

[2] Thus, our concept of international relocation is relative and can take place without the countries actually reducing their production and exports.

we provide a simple theoretical framework that can help interpret the results. According to this framework, the continual IRP process can be explained as the result of technological progress randomly changing the products' factor intensity over time. Technological progress can increase a product's sophistication, thereby increasing its knowledge and skill intensity, and raising the developed countries' comparative advantage. Conversely, technological progress can reduce a product's sophistication, thereby increasing the developing countries' comparative advantage. We follow some literature in calling *innovations* to the first type of technological progress, which leads to relocation towards the North, and *standardizations* to the second type, which leads to relocation towards the South.

We build a simple model that links innovation and standardization shocks to IRP and to cross-country growth disparities. In the model, more sophisticated products are relatively intensive in knowledge (or human capital). Knowledge can be generic (i.e., it is useful to produce any good) or product-specific. Generic knowledge (which is abundant in developed countries) and product-specific knowledge (which is abundant in countries producing a particular product in the previous period) are substitutes. A standardization shock in a product category decreases the comparative advantage of richer countries and of the previous exporting countries, which leads to the relocation of the product towards the South. This depreciates the value of the previous exporting countries' product-specific knowledge and hurts their GDP. Therefore, countries that at the beginning of a period were specialized in the products that subsequently relocate towards the South, experience lower growth. Innovation shocks have the opposite effect.

Besides helping to interpret the data and results, the model highlights some potential econometric identification difficulties. Our relocation shocks indices are intended to capture product shocks that affect all the countries exporting a given product. However, these indices could also be affected by country-specific shocks. To avoid a potential spurious correlation between the country relocation shocks indices RS_c and country growth (which could be caused by country-specific shocks), for each country we construct an instrument of the relocation shocks the calculation of which excludes all data related to this country. Thus, each country's instrumented RS_c is not affected by the country's specific shocks but only by the global shocks to the products in which the country specializes. Our theoretical model also highlights the existence of *other product shocks* (i.e, not leading to production relocation; e.g., demand shocks affecting the prices of particular products), the control of which in the regressions will reduce potential omitted-variable problems.

Our analysis focuses on the 1996-2006 period, when international trade boomed and the relocation of productive activities across countries peaked. However, as an extension, we also consider the Great Recession period and its aftermath (2006-2014). We find that countries that at the beginning of the period specialized in products that, on average, experienced a more intense relocation towards the South over the following years, were negatively affected by this relocation process. This negative impact is statistically robust and quantitatively important. However, it decreases with the country's income and becomes zero for the richest countries. According to our benchmark estimations, one standard negative deviation in a country's RS_c at the median of the countries' income distribution resulted in a 0.3 percentage-point reduction in average annual growth. However, the point estimates of these marginal effects become zero at the top of the distribution of country incomes. Thus, the shift of production towards lower-income countries had a relatively negative influence on the low- and middle-income previous exporting countries. However, on average, rich countries were able to avoid the potentially negative aggregate impact of the IRP of their export baskets by reshaping and upgrading these baskets. The industrial decline in certain areas of developed countries was offset, at the macroeconomic level, by the expansion in other areas.[3]

A few examples can help visualize this process. Bangladesh, the Philippines, Malaysia, and Thailand are large low- and middle-income economies that relatively underperformed during the period of analysis, given their economic fundamentals. Although their economic growth was satisfactory in absolute terms, their residual growth after considering a long list of growth determinants (initial GDPpc, human capital, rule of law, trade openness, GDP size, export diversification, economic complexity, and continental location) was negative and among the largest in the sample. It turns out that these countries specialized in the industries and products that experienced the most intense relocation process towards the South. According to the data described in the next section, electrical equipment (chapter 85 of the HS classification) and textiles, footwear, and leather products (sections 8, 11, and 12 of the HS) featured the most intense relocation towards lower-income countries over the period. Machinery and mechanical appliances (chapter 84) also ranked at the top of the relocation process. Textiles, footwear, and leather products happened to represent 84% of Bangladesh's exports in 1996, whereas electrical equipment and machinery and mechanical appliances represented 57% of the Philippines' exports, 56% of Malaysia's, and 38% of Thailand's. Apparel also represented a large share of these latter countries' exports. Outside Asia, Honduras is a similar case: it features one of the largest negative residuals in the growth regressions that exclude the relocation shocks index, while textiles, footwear, and leather products represented 45% of Honduras' exports in 1996. Among the advanced economies,

[3]It may be noted that our analysis assesses the relative cross-country impact of production relocation, not its absolute global impact. Thus, the IRP could have had a positive overall effect on the world's rate of economic growth and, even, on every country's growth. However, this paper shows that the relocation process was relatively less beneficial (or more disadvantageous) to the developing countries whose export baskets relocated to the South.

South Korea also featured a strong specialization in textiles and electrical equipment in 1996. However, this country does not show a negative but a positive residual in the growth regressions that exclude the relocation shocks index. As with other rich economies (Singapore and Hong Kong are similar cases), South Korea was able to re-specialize and upgrade its exports, thereby overcoming the increased competition from lower-wage exporters. At any rate, the dynamics of relocation were very heterogenous within industries, as already noted, and thus, country specialization at the industry level is not always informative about the potential impact that the IRP had on a country.

This paper is related to numerous strands of the literature on trade and growth. The analysis of the IRP has a long tradition that starts with Vernon (1966). His *product life-cycle theory* provided the first approach to the dynamics of the reorganization of production across countries at different levels of development. According to this theory, new products are invented and developed in the advanced economies, from which they are initially exported. Then, as the production process becomes increasingly standardized, less-developed countries become attractive locations for the production of these products. At this later stage of the product life-cycle, part or all of such production shifts to less-developed countries. These dynamics lead to a continual process of IRP. The analysis of the product life-cycle and the specialization in either innovation or standardized production has been extended in numerous directions, among others, by Krugman (1979), Dollar (1986), Jensen and Thursby (1986), Grossman and Helpman (1991a, 1991b), Antràs (2005), Acemoglu, Gancia, and Zilibotti (2012), Baldwin and Evenett (2015), and Arkolakis et al. (2018). The IRP has recently been reinforced by lower trade barriers and better communication technologies that helped production fragmentation and offshoring. As barriers to trade decrease and information and communication technologies progress, production processes are broken into separate stages and tasks with different factor intensities are relocated to different countries. This process has been explored among many other by Feenstra (1998), Hummels, Ishii and Yi (2001), and Yi (2003)–see Hummels, Munch, and Xiang 2016, for a survey.

The IRP is interpreted here as the consequence of product shocks (standardizations and innovations) that change comparative advantage across countries. Most of the growth literature has ignored product shocks as a potentially important factor explaining cross-country growth differences. However, these shocks had an important role in the pioneering paper by Barro and Sala-i-Martin (1992), who use a variable similar to our product shocks variable. In this paper, Barro and Sala-i-Martin study income convergence across US states, covering the 1880-1988 period. They observe that agricultural products' terms of trade and oil prices had large swings and argue that these and other sectoral shocks could have a common impact on subgroups of states that would lead to biased estimates. Thus, they define a proxy to control for common effects across states related to their sectoral output composition and find that these effects are statistically significant in explaining growth differences across states.

The paper is also related to the literature arguing that the specific products in which a country specializes is important for growth. In this respect, Lall, Weiss, and Zhang (2006), Hausmann, Hwang, and Rodrik (2007), Hidalgo et al. (2007), Hidalgo and Hausmann (2009), and Hausmann et al. (2011) have developed different approaches to export sophistication or complexity. According to this approach, economies with more sophisticated initial exports have better opportunities for further development and, therefore, initial export sophistication help to predict future growth. Our $AVEX$ measure is analogous to the sophistication measures used in those papers. However, instead of focusing on the growth impact of a country's initial export sophistication, we analyze the growth impact of the global relocation of a country's initial export basket (while controlling for initial export complexity). Finally, the present paper is also related to the recent analysis of the stochastic dynamics of comparative advantage conducted by Hanson, Lind, and Muendler (2015). The analysis in this paper could be seen as assessing some of the cross-country growth consequences of the dynamics studied in this latter paper.

The remainder of the paper is organized as follows. Section 2 provides an overview of the dynamics of the IRP at the industry and 6-digit product level over the 1996-2014 period. Section 3 presents a simple theoretical framework that links product shocks to IRP and cross-country differences in growth. Section 4 estimates the impact of the relocation process on cross-country growth and reports the main findings of the paper. It also examines whether the countries whose initial exports were relocated to the South were able to readjust and upgrade their export baskets, and whether this readjusting capability depended on the country's development level. This latter hypothesis connects with our empirical finding that the most developed economies are not negatively affected, at the macroeconomic level, by the relocation of their export basket. Section 5 concludes.

2 The international relocation of production

2.1 Measuring product relocation

We define the product-k *average exporter*'s GDP per capita at time t, $AVEX_{kt}$, as:

$$AVEX_{kt} = \sum_{c=1}^{C} s_{ckt} GDPpc_{ct},$$

where C is the number of countries, $GDPpc_{ct}$ is country c's GDP per capita at time t, and s_{ckt} is this country's share in the global exports of product k. Thus, the $AVEX_k$ is the weighted average of all the countries' GDP per capita, using country shares in the product k's global market as weights. A decrease in $AVEX_{kt}$ indicates that the international production (i.e., the exports) of good k is shifting from richer to poorer countries, and vice versa for an increase. We denote the annual growth rate of product k's $AVEX$ from time $t-T$ to time t, $AG_{k,t-T,t}$, as:

$$AG_{k,t-T,t} = \frac{1}{T}\log\left(\frac{AVEX_{kt}}{AVEX_{k,t-T}}\right).$$

This change over time in a product's $AVEX$ has two components: the change in the exporting countries' shares in the product's global trade and the change in their $GDPpc$. The first component is the *relocation* effect because it solely depends on the shift of production across countries with different income levels, whereas the second component does not involve any migration of production. Denoting by $ciAVEX_{k,t-T,t}$ a *constant income* $AVEX$ that uses the beginning-of-period $GDPpc$s, $ciAVEX_{k,t-T,t} = \sum_{c=1}^{C} s_{ckt}GDPpc_{c,t-T}$, we define the *product k's relocation index* from $t-T$ to t, $R_{k,t-T,t}$, as:

$$R_{k,t-T,t} = \frac{1}{T}\log\frac{ciAVEX_{k,t-T,t}}{AVEX_{k,t-T}} = \frac{1}{T}\log\frac{\sum_{c=1}^{C} s_{ckt}GDPpc_{c,t-T}}{\sum_{c=1}^{C} s_{ck,t-T}GDPpc_{c,t-T}}.$$

Because the $GDPpc$ in the numerator and the denominator are constant and equal to the values at the beginning of the period, $R_{k,t-T,t}$ is positive or negative depending only on the changes in market shares across exporting countries. A negative $R_{k,t-T,t}$ indicates that the international production of good k has relocated, in relative terms, from richer to poorer countries, and vice-versa for a positive index. Relocation measures at the industry level are analogously calculated taking into account that the industry i's average exporter is $AVEX_{it} = \sum_{c=1}^{C} s_{cit}GDPpc_{ct} = \sum_{k\in i}\frac{X_{Wkt}}{X_{Wit}}AVEX_{kt}$, where X_{Wkt} and X_{Wit} are the world's global trade of product k and industry i, respectively.

2.2 Data

To construct the $AVEX$ and $ciAVEX$ indices, we use data from BACI (Base pour l'Analyse du Commerce International, Gaulier and Zignago 2010, accessed on February 1, 2017), which is a database provided by CEPII (Centre d'Études Prospectives et d'Informations Internationales). The original BACI data come from the United Nations Statistical Division (COMTRADE database), over which a harmonization procedure is applied to reconcile the data reported by the exporting and importing countries and generate a single figure consisting of each bilateral flow in FOB values. We use the Harmonized System (HS)-1992 classification, which comprises more than 5,000 goods.

Data on GDP per capita, measured in 2011 PPP prices, are from the World Bank's World Development Indicators (WDI) and were also accessed on February 2017. These data present a number of potential outliers, especially in the mid 1990s, that appear to be the result of large shocks such as civil wars, the traumatic dismemberment of the Soviet Union, and the discovery of new large reserves of natural resources. Including these countries in the calculations of the $AVEX$ and the subsequent econometrics could seriously distort the analysis of the economic determinants of growth. Thus, we check the sample for potential outliers by identifying the countries for which the value of initial and final output gap deviated by more than three times the interquartile range from the sample median of the corresponding variable.[4] We find that the output gap outliers are Azerbaijan, Belarus, Georgia, Guinea Bissau, Equatorial Guinea, Iraq, Kyrgyz Republic, Liberia, Rwanda, Tajikistan, Ukraine, Central African Republic, and Zimbabwe. We also exclude countries with populations below 500,000 inhabitants in 2007. As a result, the initial set of 142 countries that provided trade data throughout the reference period (1996-2014) is reduced to a consistent sample of 129 countries that is used to construct the $AVEX$ indices.[5]

For each year, the $AVEX$s are calculated using average trade data over three years to attenuate the potential distorting effect of atypical values that may arise from unusual exports in a given year. We assign each three-year average index to the central year. Thus, although our analysis draws on data from 1995 to 2015, we refer to 1996-2014 as the period of analysis. Originally, the HS92 classification provides data on 5,036 6-digit products. These 6-digit products are reduced to a consistent list of 4,875 products that were exported every year by at least one country throughout the reference period 1996-2014. This constant sample of products represents 99% of world trade during these years.

In some instances, we consider the dynamics of trade according to an 18-industry classification. This classification is based on the 21 sections in the HS92 classification and is constructed by splitting some sections that are quantitatively very large and by merging into a single industry some other sections that encompass a very small share of international trade. Specifically, we split section 6 (chemicals) into pharmaceuticals and the rest of chemicals; section 15 (metals and their manufactures) into iron+steel and the rest of met-

[4]The output gap is calculated as the actual GDP over the Hodrick-Prescott filtered GDP at the beginning and the end of the period.

[5]As Hausmann et al. (2007) emphasize in their analysis of the growth impact of export sophistication, it is essential to use a consistent sample of countries to avoid index changes that arise from changes in sample composition. Moreover, since non-reporting is likely to be correlated with income, constructing the $AVEX$s using different sets of countries at different points in time could introduce a serious bias into the index.

als; section 16 (machinery) into electrical equipment and mechanical appliances; section 17 (transport equipment) into motor vehicles and the rest of transport equipment. Conversely, we group together sections 8, 11 and 12 (leather, textiles and footwear); sections 9 and 10 (wood and paper); sections 13 and 20 (furniture and other manufactures and stones); and sections 3, 14, 19 and 21 (fats and oils, pearls, arms and works of art). We call this latter industry *miscellanea*.

2.3 Dynamics over the 1996-2014 period

Before analyzing the IRP across the different industries and products, we briefly describe its dynamics at the macroeconomic level. This can be done by calculating the $AVEX$ and R indicators for total exports, i.e., using country shares in total global exports. Figure 1 plots the paths of the aggregate R index. The R index shows negative values at all times and an annual average growth of -0.9% as a result of the persistent increase in the developing countries' weight in global markets.[6] However, the aggregate R could be zero despite an intense IRP across countries. This would be the case if, for example, developed and developing countries grew at similar rates and their world trade shares remained constant, while their international specialization changed with different products relocating in opposite directions, thereby offsetting each others' movements in the aggregate. From the point of view of the cross-country impact of IRP, what matters is not the dynamics of the aggregate R index (whose potential effect is captured in our regressions by the constant and the time fixed effects) but the differences across products in those dynamics. Crucially for our strategy to identify the cross-country impact of IRP, the different industries and products had a very diverse relocation dynamics over the period, whereas countries had a very diverse international specialization across products.

We measure the heterogeneity of the relocation dynamics across industries and products, between time $t-T$ and time t using the mean absolute deviation (MAD) of the R indices, as follows:

$$MAD\left(R_{t-T,t}\right) = \sum_{k=1}^{K} \left| R_{k,t-T,t} - \overline{R}_{k,t-T,t} \right| \frac{\omega_{Wk,t} + \omega_{Wk,t-T}}{2},$$

[6]The changes in the relative overall weight of developed and developing countries in global markets over the last 50 years has been studied by Alcalá and Solaz (2018) using the ratio of the aggregate $AVEX$ over the world's average $GDPpc$ (i.e., the exporters' average income relative to the world's income). This ratio went from a value below 3 in the 1960s to a value above 4 in early 1990s and back to a value of approximately 3 in recent years. This dynamics is broken down into an income-openness correlation component and an income convergence component, with the latter being the driving force of the reduction in the $AVEX/GDPpc$ ratio in recent times.

where $\overline{R}_{k,t-T,t} = \sum_{k=1}^{K} R_{k,t-T,t} \frac{\omega_{Wkt}+\omega_{Wk,t-T}}{2}$.[7] A higher dispersion reflects a more intense IRP at the product level. Because different products within the same industry can move in opposite directions, thereby cancelling each other's movement out when using data at the industry level, the measured intensity of IRP increases when we use more disaggregate data. Figure 2 shows the dynamics of $MAD\left(R_{t-1,t}\right)$ during the 1997-2014 period, using data at different levels of disaggregation: the 18 industries described in the previous subsection, 2-digit (96) industries, 4-digit (1,240) product categories, and 6-digit (4,875) products of the HS-92 classification. The average $MAD\left(R_{t-T,t}\right)$ over the 1997-2014 period when considering 6-digit products roughly doubles the average $MAD\left(R_{t-T,t}\right)$ when considering 96 industries. All the paths in Figure 2 peak in 2003. The aggregate R index reached a minimum this same year (see Figure 1), which suggests that this was the time when the intensity of IRP reached its maximum.

For each industry i, the within-industry MAD of the product Rs is defined as:

$$MAD_i\left(R_{t-T,t}\right) = \sum_{k \in i} \left| R_{k,t-T,t} - \overline{R}_{k|i,t-T,t} \right| \frac{\omega_{Wkt} + \omega_{Wk,t-T}}{\omega_{Wit} + \omega_{Wi,t-T}},$$

where $\overline{R}_{k|i,t-T,t} = \sum_{k \in i} R_{k,t-T,t} \frac{\omega_{Wkt}+\omega_{Wk,t-T}}{\omega_{Wit}+\omega_{Wi,t-T}}$. Table 1 shows the R and AG indices as well as the within-industry $MAD_i(R)$ over the 1996-2006 and 1996-2014 periods for each of the 18 industries described in the previous subsection. Industries are ordered according to their R index for the whole period. The mean absolute deviation of the industry R indices for the 1996-2014 period (which are listed in the second data column of the table) is 0.57, whereas the average of the within-industry $MAD_i(R)$ (which are listed in the last column of the table) is 0.76. Hence, the within-industry dispersion of relocation is at least as important as the cross-industry dispersion. The R and the within-industry $MAD_i(R)$ are highly negatively correlated in both periods (-0.83). Thus, the industries that undergo the strongest relocation to the South, also tend to show the most diverse relocation dynamics within-industry, i.e., even if most products within a given industry relocate to the South, many products within that same industry do not. Meanwhile, the dynamics of the products in the industries with the lowest average relocation to the South tend to be similar. The industries with the most intense relocation towards the South over the period 1996-2014 were electrical equipment and textiles, footwear, and leather, which are well-known industries experiencing intense production fragmentation and offshoring processes. Conversely, pharmaceuticals is the industry showing the lowest relocation. The difference between the average annual R of textiles and of pharmaceuticals was 2.46 percent points. In turn, the largest difference

[7] We use the MAD instead of a more common dispersion measure such as the standard deviation because the latter would give extra weight to the outliers.

between the R and AG indices corresponds to minerals, which is the industry most exposed to changes in commodity prices. Note that price changes are product shocks affecting the exporters' income (and, therefore, the AG index) that do not necessarily lead to production relocation. Consequently, they give rise to differences between the AG and the R paths.

Investigating the stochastic process that characterizes the dynamics of the products' $AVEX$s is an important question for future research. However, for the purpose of this paper, it is sufficient to document the cross-product heterogeneity of the IRP process. Given the diversity of the countries' specialization, this heterogenous relocation process is likely to have a differential growth impact across countries, which is the question we investigate in the following sections.

3 Theoretical and empirical approaches

In this section, we provide a simple model linking product shocks to IRP and cross-country growth differences. Then, we discuss measurement and identification issues that are relevant for the empirical analysis in Section 4. The model helps guide our empirical work in the following section and provides a possible interpretation of the findings. However, the work in the next section should not be taken as a test of this particular model, as our empirical findings stand up by themselves and other mechanisms could also generate similar patterns. In the first subsection of this section, we present a model in which product shocks that reduce the productive sophistication of a good (i.e., *standardizations*) lead to IRP towards the South and negatively affect the countries that previously specialized in the good. In the second subsection, we introduce the cross-country measures of the impact of IRP to be used in the econometric analysis of Section 4, discuss some potential identification problems, and explain the instrumental variable strategy that we use to circumvent these problems.

3.1 A simple theoretical framework

Consider an economy with C countries indexed by c and K products indexed by k. For each product k, there is a set M_k of global firms, each producing a horizontally differentiated variety indexed by m. For each country c, a representative consumer maximizes the following utility function:

$$U_c = \prod_{k=1}^{K} \left(\left[\sum_{m \in M_k} q_{cm}^{(\gamma-1)/\gamma} \right]^{\gamma/(\gamma-1)} \right)^{\sigma_k},$$

where q_{cm} is the consumption of firm m's output, $\gamma > 1$ is the elasticity of substitution between two varieties of any given good k, and $\sigma_k > 0$ is the weight of good k in consumer expenditure ($\sum_{k=1}^{K}\sigma_k = 1$). This representative consumer's budget constraint is $\prod_{k=1}^{K}\sum_{m\in M_k} q_{cm}p_m = Y_c$, where p_m is firm m's price and Y_c is country c's income.

Goods are produced using labor, generic human capital, and product-specific knowledge (or *know-how*). In each country, all the workers have the same generic human capital H_c and, for each country and product, all the firms have the same product-specific knowledge h_{ck} (i.e., any know-how is diffused across all the firms within each country). Generic human capital increases productivity in the production of any good and is relatively abundant in rich countries, whereas product-specific knowledge is the result of learning-by-doing and, therefore, is relatively abundant only in the countries that specialized in the corresponding product in the previous period. For each product, generic human capital and the product-specific knowledge are substitutes.

Goods are ranked according to their productive *sophistication*. More sophistication goods are more intensive in human capital and knowledge. Specifically, every firm $m \in M_{ck}$, where M_{ck} is the set of firms from country c producing good k, has an identical production function as follows:

$$x_{ck} = a_k A_c \left[S_k^{\beta} + (B_c H_c + h_{ck})^{\beta}\right]^{1/\beta} \ell_{ck}, \quad \beta < 0, \tag{1}$$

where x_{ck} is the firm's output, a_k is a product-specific technological parameter common to all the countries, A_c is country c's *neutral* TFP, B_c is country c's *sophistication-biased* TFP, S_k is product k's sophistication, and ℓ_{ck} is the firm's labor input. Generic human capital and product-specific knowledge are perfect substitutes[8] and that, because $\beta < 0$, these two production factors have relatively higher productivity when producing more sophisticated goods. Therefore, human capital and knowledge provide a comparative advantage in the production of more sophisticated goods and determines the countries' international specialization, as we show below in more detail. Countries with high generic human capital are highly productive at producing everything (and relatively more productive at producing any sophisticated product) even if they lack product-specific knowledge, whereas countries with some product-specific knowledge are highly productive at producing those specific products. In turn, the parameter B_c captures the fact that some increases in TFP can affect comparative advantage (e.g. TFP increases due to institutional quality improvement; Nunn and Trefler 2014). An increase in B_c raises country c's productivity in all industries, though the increase is relatively higher in the more sophisticated industries.

[8]This is a useful simplification. However, the model's qualitative implications would be the same if we assumed a more general production function such as $x_{ck} = a_k A_c \left[S_k^{\beta} + [B_c f(H_c, h_{ck})]^{\beta}\right]^{1/\beta} \ell_{ck}$, where the function $f(.)$ satisfies $\partial f/\partial H_c > 0$ and $\partial f/\partial h_{ck} > 0$.

To keep the model as simple as possible, assume that there are no trade costs and suppose that the number of sellers of k is sufficiently large for the market impact of any particular firm to be negligible. Then, for each firm $m \in M_{ck}$, utility and profit maximization lead to the following standard monopolistic competition expressions for prices $p_m = (\gamma/[\gamma-1])\, c_{ck}$ and global market shares $s_m = (p_m/p_k)^{1-\gamma}$, where $c_{ck} = w_c / \left(a_k A_c \left[S_k^\beta + (B_c H_c + h_{ck})^\beta \right]^{1/\beta} \right)$ is firm m's marginal cost, w_c is country c's wage, and $p_k = \left[\sum_{c=1}^{C} \sum_{m \in M_{ck}} (p_m)^{1-\gamma} \right]^{1/(1-\gamma)}$ is product k's global market price index. Moreover, suppose that the number of firms in country c producing good k, $|M_{ck}|$, increases with the size of the country's (inelastic) labor supply L_c and its competitive advantage p_k/c_{ck} according to the expression $|M_{ck}| = L_c \cdot (p_k/c_{ck})^\delta$, where $\delta > 0$. Then, denoting country c's output of k by Y_{ck}, $Y_{ck} = \sum_{m \in M_{ck}} p_m x_m$, country c's share in the product k's global market is $s_{ck} \equiv Y_{ck} / \sum_{d=1}^{C} Y_{dk} = L_c \left[\gamma/(\gamma-1)\right]^{1-\gamma} (p_k/c_{ck})^{\gamma-1+\delta}$.

For each c and k, labor supply L_c, human capital H_c, accumulated product-specific knowledge from past specialization h_{ck}, and technological parameters are exogenous. Then, for any vector of wages $(w) \in R_{++}^{C}$, one wage for each country, the above expressions determine marginal costs c_{ck}, prices p_m and p_k, and market shares s_m and s_{ck} for every c, k, and m. Moreover, county c's income is given by $Y_c = (\gamma/[\gamma-1])\, L_c w_c$, each market k's output value is given by $Y_k = \sigma_k \sum_{c=1}^{C} Y_c$, and county c's labor force used in the production of k is given by $L_{ck} = s_{ck} Y_k \left[(\gamma-1)/\gamma\right]/w_c$. Finally, the model's general equilibrium requires that the wage vector $(w) \in R_{++}^{C}$ is chosen to clear each country's labor market, i.e, $\sum_{k=1}^{K} L_{ck} = L_c$ for each c.

This economy's equilibrium is characterized in terms of relative market shares and comparative advantage as follows. For any two countries c and d, their relative product k's output and labor input is:

$$\frac{s_{ck}}{s_{dk}} = \left[\frac{S_k^\beta + (B_c H_c + h_{ck})^\beta}{S_k^\beta + (B_d H_d + h_{dk})^\beta} \right]^{(\gamma+\delta-1)/\beta} \left(\frac{A_c/w_c}{A_d/w_d} \right)^{\gamma+\delta-1} \frac{L_c}{L_d}; \tag{2}$$

$$\frac{L_{ck}/L_c}{L_{dk}/L_d} = \left[\frac{S_k^\beta + (B_c H_c + h_{ck})^\beta}{S_k^\beta + (B_d H_d + h_{dk})^\beta} \right]^{(\gamma+\delta-1)/\beta} \left(\frac{A_c}{A_d} \right)^{\gamma+\delta-1} \left(\frac{w_c}{w_d} \right)^{-\gamma-\delta}; \tag{3}$$

Similarly, for any two products k and j, these two countries' revealed comparative advantage depends on their relative sophistication-biased TFP, generic human capital, and product-specific knowledge according to the following expression:

$$\frac{Y_{ck}}{Y_{cj}} \Big/ \frac{Y_{dk}}{Y_{dj}} = \left[\frac{S_k^\beta + (B_c H_c + h_{ck})^\beta}{S_k^\beta + (B_d H_d + h_{dk})^\beta} \Big/ \frac{S_j^\beta + (B_c H_c + h_{cj})^\beta}{S_j^\beta + (B_d H_d + h_{dj})^\beta} \right]^{(\gamma-1+\delta)/\beta}. \tag{4}$$

In this economy, we can have the following shocks:

1. *Product shocks*, which affect all the firms producing a particular product k in all the countries. These shocks are of two types:

   (a) *Sophistication shocks*, which are the shocks to S_k. Positive sophistication shocks can be the consequence of skill-biased technical change or the intensification of innovation, and raise the relative productivity of knowledge and skills in the production of k (Nelson and Phelps 1966). Conversely, negative sophistication shocks, standardizations, reduce the relative productivity of knowledge and skills.[9] Because S_k enters expressions (2), (3), and (4), sophistication shocks change comparative advantage and lead to IRP.

   (b) *Other product shocks*, which can be technological shocks affecting a_k or demand shocks affecting σ_k. Because parameters a_k and σ_k do not enter expressions (2), (3), and (4), these shocks are neutral from the point of view of comparative advantage and, thus, do not lead to cross-country relocation of production.

2. *Country-specific shocks*, which are shocks to a country's TFP, i.e., to parameters A_c or B_c.

In the Appendix A, we prove the following proposition:

Proposition. *Consider two countries c and d and suppose that $B_cH_c + h_{ck} \geq B_dH_d + h_{dk}$. Then, (i) $\frac{d[(Y_c/L_c)/(Y_d/L_d)]}{dS_k} > 0$ and (ii) $\frac{d(s_{ck}/s_{dk})}{dS_k} > 0$.*

Point *(i)* implies that an increase in S_k tends to raise the per capita income of the previous exporters of k because these are the countries having a relatively high h_{ck}. This positive relationship between S_k and the previous exporters of k's income is conditional on their development level (i.e., on their B_cH_c) because the more-developed countries also benefit from the increase in S_k. In turn, point *(ii)* implies that increases in S_k tend to raise the global market shares s_{ck} of the countries with relatively high B_cH_c (i.e., the more-developed countries). This will increase the product's $AVEX_k$ and $ciAVEX_k$, and lead to a positive index R_k (i.e, to relocation to the North). The positive relationship between S_k and the more-developed countries' market shares s_{ck} is conditional on their product-specific know-how h_{ck} because countries with a high h_{ck} also benefit from the increase in S_k.

[9] See Acemoglu, Gancia, and Zilibotti (2012) for a dynamic model in which innovation and standardization lead to the use of more or less skilled labor, respectively.

We are mostly interested on the symmetric case of reductions in S_k.[10] The proposition implies that the standardization of a product causes its relocation to the South and a reduction of the relative *GDPpc* of the previous exporters. This is due to the reduction in the relative value of the previous exporters' product-specific knowledge and skills.

The *other product shocks* and country shocks can also affect the relative per capita GDPs. In the next subsection, we introduce the country relocation-shocks measures and discuss our instrumental variable approach to identify the growth impact of these shocks.

3.2 Empirical approach

We define country c's product-shocks index between times $T-t$ and t, denoted by $PS_{c,t-T,t}$, as follows:

$$PS_{c,t-T,t} = \frac{1}{T}\log\frac{\sum_k AVEX_{kt}\omega_{ckt-T}}{\sum_k AVEX_{kt-T}\omega_{ckt-T}}.$$

As we hold constant the shares ω_{ckt-T} in the country c's exports, this index only depends on the change across time in the $AVEX$s. A negative (positive) value of the $PS_{c,t-T,t}$ means that the average exporter of country c's initial export basket tended to be poorer (richer) at the end of the period.[11]

The PS indices capture all types of product shocks: (a) the product shocks that change country market shares s_{ck} and, thus, lead to IRP (i.e., the sophistication shocks to S_k); and (b) the other product shocks that do not lead to relocation (i.e., the demand shocks to σ_k and technology shocks to a_k, which affect the *GDPpc* of all the exporters of a given product but are neutral on comparative advantage). To assess the specific effect of the product shocks that lead to IRP, we define the country c's *relocation-shocks* index between times $T-t$ and t, RS_{ct}, as follows:

$$RS_{c,t-T,t} = \frac{1}{T}\log\frac{\sum_k \omega_{ckt-T} ciAVEX_{k,t-T,t}}{\sum_k \omega_{ckt-T} AVEX_{k,t-1}} = \frac{1}{T}\log\frac{\sum_k \omega_{ckt-T}\sum_{c=1}^{C} s_{ckt}GDPpc_{ct-T}}{\sum_k \omega_{ckt-T}\sum_{c=1}^{C} s_{ckt-T}GDPpc_{ct-T}}.$$

The $RS_{c,t-T,t}$ index only captures changes in world market shares s_{ck} across country income groups and weights those changes according to how important each product k was in country c's export basket (i.e., how high was ω_{ckt-T}). In our econometric analysis of cross-country growth, we use the RS index to capture the impact of relocation shocks and the difference

[10] The reductions in S_k can be thought to be accompanied by simultaneous increases in the productivity parameter a_k so that standardizations never imply a reduction of any country's physical productivity.

[11] Barro and Sala-i-Martin (1992)s' measure of the sectoral shock impacts is somewhat similar the PS index (see expression (16) in their paper). To calculate their measure, they use a breakdown of 9 sectors in the analysis of personal income growth across US states and 54 sectors in the analysis of gross state product growth.

$OPS \equiv PS - RS$ to control for the impact of *other product shocks*.

Although the aim of the PS and RS indices is to only capture the impact of product shocks, could these indices be also affected by country-specific shocks? If there are exporters with a large global market share of a product, the country-specific shocks that affect these countries could also affect the product's $AVEX$. This could in turn affect the country's PS and RS indices (if the products in which the country is an important global exporter represent a significant share of this country's total exports), which would create a spurious correlation between $GDPpc$ growth and the PS and RS indices. To address this potential problem, we calculate specific $AVEXs$ and $ciAVEXs$ for each country that are constructed excluding all data on the country's economy (i.e., data on this country's GDP per capita and exports). Then, we use these country-specific $AVEX$s and $ciAVEXs$ to construct instruments for the country's PS_{ct} and RS_{ct} indices.

Formally, we define country c's specific $AVEX$ and $ciAVEXs$ for good k (which are denoted by adding an ins prefix to indicate that are to be used to build an instrument) as follows:

$$
\begin{aligned}
ins\_AVEX_{kct} &= \sum_{i \neq c} \frac{s_{ikt}}{\sum_{i \neq c} s_{ikt}} GDPpc_{it}, \\
ins\_ciAVEX_{kc,t-T,t} &= \sum_{i \neq c} \frac{s_{ikt}}{\sum_{i \neq c} s_{ikt}} GDPpc_{it-T}.
\end{aligned}
$$

These indices reflect the average $GDPpc$ of the countries other than c exporting product k. Then, the PS and RS indices using the country-specific $AVEX$s and $ciAVEXs$ are:

$$
\begin{aligned}
ins\_PS_{c,t-T,t} &= \frac{1}{T} \log \frac{\sum_k ins\_AVEX_{kct}\omega_{ckt-T}}{\sum_k ins\_AVEX_{kct-T}\omega_{ckt-T}}, \\
ins\_RS_{c,t-T,t} &= \frac{1}{T} \log \frac{\sum_k \omega_{ckt-T} ins\_ciAVEX_{kc,t-T,t}}{\sum_k \omega_{ckt-T} ins\_AVEX_{kc,t-T}}.
\end{aligned}
$$

As the ins_PS_{ct} and $ins\_RS_{c,t-T,t}$ are not affected by country-c specific shocks, we use them as instruments for the PS_{ct} and RS_{ct} indices in our econometric analysis. Similarly, we use $ins\_OPS_{c,t-T,t} \equiv ins\_PS_{ct} - ins\_RS_{c,t-T,t}$ as the instrument for the other product-shocks index OPS. Figure 3 shows the scatter plot of the RS index on its instrument ins_RS. The high correlation between the variable and the instrument is apparent. However, the variable and its instrument are markedly different from each other in a few cases. The most important one is China. China has gained a large global market share in many products whose $AVEX$ is above China's $GDPpc$. Therefore, the measured relocation of its exports is more negative when we include China in the calculations (i.e., when we calculate China's

RS) than when we exclude this country (i.e., when we calculate China's ins_RS).

4 Relocation and growth

We now assess the cross-country growth impact of the IRP. First, we discuss the econometric specification and data; second, we report the econometric results; and third, we briefly analyze whether the countries most affected by the relocation process towards the South exhibit a specially intense reshaping and upgrading of their exports.

4.1 Specification and data

Specification

We conduct the econometric analysis of the link between IRP and economic growth within the framework of cross-country growth regressions (e.g., Barro & Sala-i-Martin 2003). Average GDP per capita growth between $t-T$ and t is regressed on (the log of) initial per capita GDP, relocation shocks RS, the proxy for other product shocks OPS, and a vector of controls X_c^0. The RS variable is also interacted with initial per capita GDP to allow for a changing impact of relocation along country incomes. The OPS variable captures the impact of other (non-relocation) product shocks (e.g., demand and price shocks). These shocks also affect specific groups of exporters and, thus, omitting to control for them could bias the estimates. Denoting the error term by u_c, our econometric specification is:

$$\begin{aligned} \frac{1}{T}\log\frac{GDPpc_{c,t}}{GDPpc_{c,t-T}} &= \beta_0 + \beta_1 \log\left(GDPpc_{c,t-T}\right) + \beta_2 RS_{c,t-T,t} \\ &\quad + \beta_3 RS_{c,t-T,t} * \log\left(GDPpc_{c,t-T}\right) \\ &\quad + \beta_4 OPS_{c,t-T,t} + \beta_5 X_{c,t-T} + u_c, \end{aligned} \tag{5}$$

We always include continent dummies for Africa, America, Asia, and Europe (the dummy for Oceania is the omitted one) and interact them with time fixed effects in the panel regressions.

Data

As noted in subsection 2.2, data on GDP per capita are from the World Bank's World Development Indicators. The relocation shocks indices are constructed using the $AVEX$s and $ciAVEX$s from the Section 2 and the information on each country's export shares from BACI. The dependent variable is average growth over the 1996–2006 period in the cross-sectional regressions and over the 1996–2006 and 2006–2014 periods in the panel regressions.

Besides calculating the RS and OPS indices using data on all the products, as explained, we also calculated them and their instruments excluding the data of natural resources and other non-produced or special items. These indices are called $Nat.\ resource\ excluded - RS$ and $Nat.\ resource\ excluded - OPS$ and are used in robustness checks to show that our results are not driven by the special dynamics of natural resources or of some very peculiar exports. More specifically, we calculate these special indices by excluding the exports in the HS chapters 25-27 (minerals), 71 (precious and semi-precious stones and metals, and pearls), and 97 (art and antiques).

As covariates, we always control for human capital, institutional quality, share of oil in exports, export openness, economy size, export diversification, and export complexity. In robustness checks, we also control for capital intensity, which is defined as the country's capital stock per person engaged in production, from PWT 9.0 (Feenstra, Inklaar, and Timmer 2015). Our measure for human capital is years of schooling from Barro and Lee (2013), although we also consider enrollment in secondary education in robustness checks. We use rule of law from the World Bank's World Governance Indicators as our main measure of institutional quality and consider three other alternatives in robustness checks: regulatory quality, government effectiveness, and corruption control. The share of oil exports is defined as the share of exports from chapter 27 (mineral fuels, mineral oils, and products of their distillation) of the HS with respect to total merchandise exports, and is also calculated using data from BACI (we use the average ratio over 1995-1997 and 2005-2007). As a measure of trade openness we use the *real export openness ratio* advocated in Alcalá and Ciccone (2004): $real\ export\ openness_{ct} = Exports_{ct}/GDP_{ct}$, where the GDP_{ct} is measured in PPP. Real export openness is interacted with the country's GDP, as foreign markets tend to matter more for countries with smaller domestic markets (Alesina et al., 2000). In turn, Lederman and Maloney (2012) among others, have suggested that economic diversification is a potentially important determinant of growth. We control for export diversification by including the percentage of products for which the country has a revealed comparative advantage greater than 1, where country c's revealed comparative advantage in product k in period t is $RCA_{ckt} = \omega_{ckt}/\omega_{Wkt}$ and ω_{Wkt} is the value share of product k in global trade.[12]

We also control for export complexity. Hausmann, Hidalgo, and coauthors (Hidalgo et al. 2007, Hidalgo and Hausmann 2009, Hausmann, et al. 2011) develop a measure of country export sophistication based on the concepts of *complexity* and the *product space*. According to this approach, goods requiring more collective-coordinated capabilities, knowledge, and

[12] We also considered measures of diversification using a threshold of 0.5 instead of 1 for revealed comparative advantage and a Herfindhal index ($diversification_{ct} = \sum_k (\omega_{ckt})^2$) and found almost identical results for the variables of interest.

skills are less ubiquitous (fewer countries export a significant amount of them), whereas more diversified economies have a wider array of these factors. Combining measures of the *ubiquity* of each good's exports and the *diversity* of each country's exports, the authors construct an economic complexity index (ECI) that ranks all the countries' economies. These authors find that initial complexity is positively correlated with future growth, with an impact that decreases with country income. Hence, we also include this ECI measure interacted with income as a control in our regressions.

The sample of 129 countries used to construct the $AVEXs$ is reduced to 96 countries when we consider our covariates because the data on human capital, openness, and the economic complexity index are missing for some countries. Table 11 in Appendix C lists the countries used at different stages of the paper and annotates those for which some data are missing. Tables 2 and 3 report the main descriptive statistics and correlations for our key variables RS, OPS, $GDPpc$ growth, and log$GDPpc$.

4.2 Estimates

We now report the results of estimating equation (5) using different controls and samples. Our focus is on a cross-country analysis of the 1996-2006 period in which IRP peaked and trade was not yet affected by the Great Recession. However, we also conduct panel data regressions for the 1996-2014 period as a robustness check. In all of the regressions, the left-hand-side variable is the average rate of GDP per capita growth in percentage terms, all the correlates correspond to values at the beginning of the corresponding period, except for the PS and RS variables, whose construction has already been explained. Robust standard errors are reported in parentheses. Because of the interaction term between RS and log $GDPpc$, the estimated impact of cross-country relocation shocks cannot be directly assessed from the coefficients in the tables. To facilitate this assessment, the last row of each table shows the impact on the average annual $GDPpc$ growth (in percentage terms) that would result from a one-standard-deviation change in RS at the median income country (as shown in Table 2, the standard deviation of RS in the 96-country sample is 0.54 and the median of log($GDPpc$) is 9.15).

Cross-country regressions

Table 4 displays the results of estimating equation (5) by OLS. Before considering the impact of relocation, columns 1 and 2 show the results of running the growth regression on the benchmark list of controls that we use in almost all the regressions. Each of these controls is statistically significant in some of our regressions but not in all of them. With respect to column 1, the regression reported in column 2 also includes the control for *Other product shocks*, which is statistically significant at the 1-percent level. Figure 4 shows the scatter plot of the residuals from this regression in column 2 on the ins_RS relocation indices.[13] This figure provides a glimpse of the potential explanatory power of international relocation with respect to the growth residuals remaining after accounting for our list of growth determinants. Note that the examples of countries with relatively low growth and more negative RS cited in the Introduction (e.g., Bangladesh, the Philippines, and Honduras) appear on the lower-left side of the figure. Rich economies such as Singapore, Honk Kong, and South Korea also appear on the left side (thus, exhibiting a relatively low RS) but do not show a negative growth residual. In fact, we find a significant negative interaction between the RS and per capita income in all the estimates that follow, implying that rich countries like Singapore, Honk Kong, and South Korea were not negatively affected by the relocation of their exports towards the South. Also on the left side of the figure and between the previous two groups of countries, with relatively low RS but a small negative growth residual, we find Thailand and Malaysia. As discussed in the Introduction, these are medium-income countries whose main exports were also products being relocalized to the South.

Column 3 reports the results when using our benchmark specification. The coefficient on RS is positive and significant at the 1% level, whereas the interaction with $GDPpc$ is negative and also significant at 1%. At the median country income, this implies that a one-standard-deviation increase in RS results in an increase of 0.37 percentage points in annual $GDPpc$ growth. Thus, on average, countries that at the beginning of the period specialized in product categories showing a relocation process towards low-wage economies exhibited significantly lower growth over the following years, although this effect decreases with the country's level of development. Interestingly, adding RS and OPS to the estimated equation raises the statistical significance of the other variables except the one of economic complexity, which only becomes significant again in the panel regressions.

All the remaining tables report 2SLS estimates instrumenting RS, OPS, and $RS * \log(GDPpc)$ using the instruments ins_RS, $ins\_PS - ins\_RS$, and $ins\_RS * \log(GDPpc)$ that we discussed in the previous section. The first-stage regressions show very large F statistics, thereby confirming that these instruments are good predictors of the instrumented variables. Table 10 in Appendix B reports the first-stage regressions for our preferred specifications in the cross-section and panel data regressions (column 1 in Tables 5 and 8, respectively)–the results are similar for the other specifications.

The specification in column 1 of Table 5 is our benchmark specification and includes the

[13] Using ins_RS instead of RS avoids the potential risk of capturing country shocks in addition to product relocation shocks.

same list of controls as in column 3 of Table 4. The coefficient on the relocation-shocks measure RS is positive, its interaction with $GDPpc$ is negative, and both coefficients are significant at the 1% level. Hence, the IRP had a relatively negative effect on the countries whose initial export basket was composed of products in which lower income countries gained global market share (i.e., on the countries with a negative RS). However, this negative impact decreased with the country's income. The point estimate of the relative impact on annual growth resulting from a one-standard-deviation change in RS, at the median income country, is 0.34 percentage points. This is a very sizable impact. The point estimate of the growth impact of a one-standard-deviation change in RS ranges from 0.79 percentage points at the first decile of the distribution of country incomes to 0.07 percentage points at the 3rd quartile. Therefore, the relocation towards the South had a negative aggregate growth impact among low- and middle-income countries and was negligible among the richest countries. Although the IRP appears to have had a negative effect on some specific geographical areas and groups of the labor force in some developed countries, as shown by the literature cited in the Introduction, on average, developed countries were able to offset the losses in some industries with gains in other industries.

In columns 2-4, we check that these results are not driven by the dynamics of natural resource exporters or of some peculiar products. Although we always control for the share of oil products in total exports, in columns 2 to 4 we exclude altogether the oil producers from our sample (see Table 11 in Appendix C for a list of these countries), thereby reducing the sample to 83 countries. In column 3, we add a control for the share of exports in chapters 25-27 (minerals), 71 (precious and semi-precious stones and metals, and pearls) and 97 (art and antiques) of the HS classification and also exclude from the previous 83-country sample those countries for which exports in these five chapters exceed 35% of their total exports. This reduces the sample to 79 countries. Then, in column 4 we use the $Nat.\ resource\ excluded - RS$ and $Nat.\ resource\ excluded - OPS$ indices instead of the regular RS and OPS indices (see the data section for the explanation on how these indices were calculated). In all these regressions, the coefficients on RS and its interaction with $GDPpc$ are significant at the 1% level and show a positive and a negative sign, respectively. Hence, the significance of the estimated growth impact of IRP does not depend on the trade of natural resources and special products.

Overall, the controls included in the estimated equation have the expected signs and are mostly statistically significant. Initial per capita GDP, years of schooling, share of oil exports, export openness, and international diversification all show the expected signs and are significant at least at the 5% level and most of the time at the 1% level. This is the case, for instance, of initial $GDPpc$, whose estimated coefficient is always very close to a value of 2 in line with the *iron-law of convergence* (Barro 2015). Only, rule of law and economic complexity are not significant in these cross-country regressions. Rule of law only becomes significant when the exporters of natural resources are excluded (specially, if we also use the RS and OPS indices that exclude this type of exports), whereas ECI only becomes significant again in the panel regressions. The OPS index, which captures *other product shocks*, is always positive and significant at the 1% level. However, we do not pursue the analysis of this indicator as it can capture different types of (non-relocation) product shocks that are not the focus of our analysis.

Additional robustness tests

Table 6 shows the results of considering some other controls, such as capital intensity, and alternative measures of institutional quality and human capital. We find identical signs and statistical significance for the product and relocation shocks measures, as well as for the interaction with income. Moreover, the point-estimates of the impact of relocation at the median $GDPpc$ are also fairly similar to the one found in our benchmark specification in column 1 of Table 5.

In Table 7, we check whether the significance of relocation shocks is only due to the specific dynamics of the countries belonging to a particular continent. This table reports the results of estimating equation (5) when excluding from the sample, alternatively, the American countries (column 1), the African countries (column 2), the Asian countries (column 3), and the European countries (column 4). RS is always statistically significant at least at the 5% level. The impact at the median income country is lowest (although still positive) when excluding the Asian countries and highest when excluding the African countries. Table 7 also explores the potential asymmetry of the impact of production relocation. We do so by splitting the sample into two groups according to the value of the countries' RS. Column 5 reports the results using the data of the 48 countries with the lowest RS, whereas column 6 does so using the data of the 48 countries with the highest RS. We drop the interaction between RS and log $GDPpc$ in the estimated equation because it becomes statistically insignificant. The two coefficients on RS remain positive and statistically significant at the 5% level and are not statistically different from each other. At any rate, the results of these latter regressions have to be treated with some caution as the number of observations becomes very small and a few observations can have a notable effect on the estimates.

Panel regressions

Our findings so far correspond to a boom period in terms of output and trade: 1996-2006. We now check for the robustness of the findings by conducting panel regressions using data for two periods (1996-2006 and 2006-2014), with the second one corresponding to the Great Recession and its aftermath. Table 9 reports the results. Columns 1 and 4 of Table 8 show the results for the whole sample (192 observations), whereas oil-exporting countries and those for which exports of natural resources represent more than 35% of total exports are excluded in columns 2, 3, 5, and 6. In columns 3 and 6, we use the $Nat.\ resource\ excluded - RS$ and $Nat.\ resource\ excluded - OPS$ measures, which are calculated by excluding all the trade in natural resources and the countries for which these exports represent more than 35% of total exports. In columns 4 to 6, we exclude from the specification export openness and its interaction with $GDPpc$ as these variables are not statistically significant in columns 1 to 3. All the specifications include continent dummies interacted with fixed time effects and are estimated by 2SLS using analogous instruments to those constructed for the cross-country analysis. Standard errors reported in parentheses are clustered by country.

The results confirm the findings of the previous analysis, not only in terms of the sign and significance of the relocation shocks but also in terms of their estimated quantitative impact. In all of the estimations, the RS index shows a positive and significant coefficient at the 1% level and a negative interaction with $GDPpc$ that is significant at least at the 5% level. Excluding export openness and its interaction with $GDPpc$ does not affect the results for RS but increases the statistical significance of rule of law and ECI, and slightly reduces the significance of international diversification. The impact at the median income country of a one-standard-deviation change of RS ranges between 0.28 and 0.24 percentage points of annual growth in columns 4 to 6.

4.3 Adjusting to relocation

Standard trade theory suggests that the loss of comparative advantage in some products and their relocation to other countries do not necessarily lead to lower growth: if a country looses comparative advantage in a particular product, then it will gain comparative advantage in other products. Thus, if a country's exports are relocated to the South, then we will expect that the country relocates its production factors to other industries and start exporting other products. Hence, countries with more negative RSs (i.e., countries more affected by the export relocation to the South) should tend to show a more intensive reorganization towards more sophisticated products (i.e., products with a high $AVEX$ at the end of the period). Moreover, because we found that export relocation to the South had a negligible growth impact on the most developed economies, we expect the correlation between a country's negative RS and the restructuring and upgrading of its exports to be particularly high in the case of richer countries. In this subsection, we explore this issue.

We define country c's *export upgrading* index between time $t-T$ and time t, denoted by $EU_{c,t-T,t}$, as:

$$EU_{c,t-T,t} = \frac{1}{T}\log\frac{\sum_k AVEX_{kt}\omega_{ckt}}{\sum_k AVEX_{kt}\omega_{ck,t-T}}.$$

Thus, this index holds constant the $AVEX$s (using end-of-period values) and measures whether the weights in a country's export basket have changed in the direction of higher or lower sophistication. This index is positive if, on average, the country has increased the weight of products with a higher end-of-period $AVEX$, i.e., products that are being exported by the more-developed countries.

Figures 4 and 6 show the scatter plots of the RS and EU indices calculated for the whole 1996-2014 period. Figure 4 includes the richest half of the sample of 96 countries and Figure 6 includes the other half of the sample with the poorest countries. Relocation shocks and export upgrading are negatively correlated for the richer countries but uncorrelated for the poorer countries. To analyze this relationship in more detail, we regress export upgrading (EU) on the RS index interacted with $GDPpc$, using cross-section (columns 1-3) and panel data (columns 4-6), and instrumenting RS and its interaction with $GDPpc$ as in the previous subsection. The results are reported in Table 9. Except when we include oil and natural resource exporters in the panel regressions,[14] the results confirm that the capacity to reshape and upgrade exports as a result of relocation shocks increases with the country's $GDPpc$. Focusing on the panel results in column 6, we find that the marginal impact of RS on EU is $2.37 - 0.31 * \log(GDPpc)$. Hence, at the median value of $\log(GDPpc)$ of this 152 sample (9.4), the marginal impact is equal to -0.54. Therefore, a more negative RS (i.e., a more intense relocation to the South) leads to a more intense positive revamp and upgrade of the country's export basket. Moreover, this effect increases with the country's income and is insignificant at the lower end of the distribution of country incomes. Hence, the mechanisms by which countries react to the relocation to the South of their traditional exports, thereby changing their exports towards more-sophisticated products, appear to work effectively only in the relatively developed economies.

[14]It seems reasonable to expect that natural resource exporters have difficulties in modifying their international specialization as a result of relocation shocks.

5 Concluding Comments

Technological change regularly modifies comparative advantage and leads to the relocation of production across countries. The importance of this process appears to have intensified over the last two decades, leading to political turbulences in some advanced countries and calls for new protectionism. Although there are numerous studies of the impact of this process on particular industries and population groups, there is not an overall assessment of its cross-country growth effect. This paper conducted such as assessment. It explored how the international relocation of the exports in which each country initially specialized has affected its subsequent growth over the 1996-2014 period.

The main finding is that specialization at the beginning of the period in product categories that relocated to the South had a negative growth impact in the case of lower- and medium-income countries. Thus, even if the process of IRP had an absolute positive effect on the overall world economy, the benefits were significantly smaller in the developing countries exporting products that were relocated towards lower-income economies. In the richer countries, the macroeconomic effect of international relocation tended to be neutral (even if some geographical areas and groups of the workforce suffered a negative impact, as documented by the literature). Generally, advanced economies upgraded their export baskets at the same time that they lost comparative advantage in some of their initial exports, thereby offsetting in the aggregate any potential negative impact of production relocations to the South. Their superior diversification, market flexibility, human capital, and business environment are likely to provide better capability to adjust to changes in the economic environment. The fact that the relocation process did not have a negative macroeconomic impact in advanced economies should allow these economies to reallocate or compensate the workforce that has been displaced or impoverished by the recent dynamics of trade flows. In contrast, low- and medium-income countries are more vulnerable to increased competition from other developing countries.

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Table 1: Relocation (R) and $AVEX$ growth (AG) indices by industry, and within-industry mean absolute deviation of the R indices ($MAD(R)$)

Section (HS-92 classification)	Sector	R index		AG index		MAD (R)	
		1996-2006	1996-2014	1996-2006	1996-2014	1996-2006	1996-2014
Section XVI. Chap. 85	Electrical equipment	-2.37	-2.54	0.02	-0.18	1.27	1.33
Sections 8, 11 & 12	Textiles, footwear, leather	-2.47	-2.48	0.06	-0.01	1.43	1.25
Sections 13 & 20	Furniture, stone, and other manufactures	-2.44	-2.19	-0.10	0.00	1.46	1.11
Section XVI. Chap. 84	Machinery and mechanical appliances	-1.91	-1.75	0.25	0.02	1.65	1.49
Section XV . Chap 72 & 73	Iron and manufactures thereof	-1.24	-1.04	0.96	0.65	0.71	0.77
Sections 9 & 10	Wood and paper	-0.92	-0.96	1.41	0.76	0.68	0.64
Section XV , exc. chap 72 & 73	Metals and manufactures, exc. iron	-1.19	-0.93	0.99	0.63	0.79	0.93
Section VII	Plastics	-0.87	-0.92	1.20	0.71	0.64	0.64
Section II	Vegetable products	-0.78	-0.88	1.39	0.71	0.82	0.64
Section XVII. Chap. 87	Motor vehicles	-0.76	-0.87	1.11	0.57	0.41	0.52
Section XVIII	Instruments	-0.87	-0.77	1.24	0.89	0.92	0.81
Section XVII, exc. chap. 87	Transport equipment, exc. motor vehicle	-0.58	-0.71	1.52	0.84	0.62	0.64
Section VI , exc. chap. 30	Chemicals exc. pharmaceuticals	-0.60	-0.69	1.74	1.00	0.67	0.69
Section IV	Food, beverage and tobacco	-0.49	-0.49	1.65	0.99	0.65	0.52
Section I	Animal products	-0.54	-0.42	1.70	1.13	0.87	0.56
Section V	Minerals	-0.29	-0.12	1.36	1.04	0.40	0.28
Section VI . Chap. 30	Pharmaceuticals	-0.04	-0.08	2.22	1.37	0.19	0.17
Sections 3, 14, 19 & 21	Miscellanea	-0.29	0.33	1.50	1.50	1.01	0.73

Note: The indices are calculated using HS 6-digit product data.

Table 2: Descriptive statistics

Variable	Mean	Median	Std. Dev.	Min	Max	Obs
Relocation shocks (*RS*)	-1.18	-1.15	0.54	-2.50	0.08	96
Other product shocks (*OPS*)	2.16	2.19	0.27	1.26	2.67	96
GDPpc growth	2.87	2.49	1.91	-2.08	8.36	96
log GDPpc	9.11	9.15	1.09	6.12	11.29	96

Note: RS, OPS, and $GDPpc$ growth are annual average over the 1996-2006 period, whereas log$GDPpc$ corresponds to the value at the beginning of the period (1996).

Table 3: Correlations

	GDPpc growth	Relocation shocks (*RS*)	Other product shocks (*OPS*)	log GDPpc
Relocation shocks (*RS*)	-0.16			
Other product shocks (*OPS*)	0.45	-0.69		
log GDPpc	-0.14	0.01	-0.17	
log Human Capital (years schooling)	0.14	-0.07	0.16	0.71
log Capital Intensity	-0.06	-0.08	0.00	0.90
Rule of law	-0.02	-0.15	0.12	0.77
Share of oil exports	-0.11	0.51	-0.79	0.16
log export openness	-0.05	-0.16	0.05	0.71
log GDP	-0.13	-0.11	-0.05	0.54
International diversification	0.26	-0.39	0.45	0.17
Economic Complexity Index (*ECI*)	0.09	-0.14	0.13	0.75

Note: $GDPpc$ growth, RS, and OPS are averages over the 1996-2006 period, whereas all the other variables refer to values at the beginning of the period (1996).

Table 4: Relocation and cross-country growth. OLS estimates

	Dependent variable: Growth rate of GDP per capita		
	(1)	(2)	(3)
Relocation shock (*RS*)			5.81***
			(1.46)
Other Product Shocks (*OPS*)		5.72***	7.28***
		(1.15)	(1.18)
*RS**log *GDPpc*			-0.56***
			(0.17)
log *GDPpc*	-1.56**	-1.31**	-1.90***
	(0.74)	(0.60)	(0.58)
log Human Capital (years schooling)	1.10**	1.10**	1.17***
	(0.49)	(0.43)	(0.40)
Rule of Law	0.42	0.35	0.43
	(0.42)	(0.33)	(0.31)
Share of Oil Exports	2.69	8.47***	9.68***
	(1.75)	(1.91)	(1.80)
log export openness	4.33	4.00	5.94*
	(3.95)	(3.23)	(3.23)
log *GDP*	0.12	0.13	0.34
	(0.39)	(0.33)	(0.33)
log export openness*log *GDP*	-0.17	-0.17	-0.24*
	(0.15)	(0.12)	(0.12)
International diversification	5.68	5.19*	7.85***
	(3.89)	(2.84)	(2.53)
Economic Complexity Index (*ECI*)	5.04**	2.12	0.77
	(2.36)	(2.18)	(1.87)
*ECI** log *GDPpc*	-0.46*	-0.14	-0.03
	(0.24)	(0.22)	(0.18)
Constant	11.08	-4.28	-8.28
	(11.30)	(10.15)	(10.95)
Dummies by continent	*Yes*	*Yes*	*Yes*
Observations	96	96	96
R^2	0.44	0.62	0.68

Notes: Results from estimating equation (5) using OLS. The dependent variable is the average growth rate of GDP per capita over the period 1996-2006 in percentage terms. Robust standard errors are in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

Table 5: Relocation and cross-country growth. IV estimates

	Dependent variable: Growth rate of GDP per capita			
	(1)	(2)	(3)	(4)
Relocation shocks (*RS*)	5.66***	5.71***	5.94***	
	(1.31)	(1.35)	(1.50)	
Other product shocks (*OPS*)	4.97***	3.92***	3.83**	
	(1.21)	(1.50)	(1.54)	
*RS**log *GDPpc*	-0.55***	-0.59***	-0.59***	
	(0.16)	(0.17)	(0.21)	
Nat. resource excluded–*RS*				6.55***
				(1.59)
Nat. resource excluded–*OPS*				3.78**
				(1.59)
Nat. resource excluded–*RS* *log *GDPpc*				-0.66***
				(0.20)
log *GDPpc*	-1.99***	-1.89***	-1.91***	-2.07***
	(0.57)	(0.62)	(0.64)	(0.68)
log human capital (years schooling)	1.18***	0.86*	0.95*	1.05*
	(0.36)	(0.47)	(0.51)	(0.55)
Rule of law	0.45	0.51	0.61*	0.62**
	(0.30)	(0.33)	(0.32)	(0.31)
Share of oil exports	7.38***	8.43**	10.90***	8.45**
	(1.68)	(3.56)	(3.87)	(3.99)
log export openness	5.99**	6.19**	5.40*	5.66*
	(3.05)	(3.08)	(3.16)	(3.21)
log *GDP*	0.33	0.36	0.27	0.31
	(0.31)	(0.33)	(0.36)	(0.37)
log export openness*log *GDP*	-0.24**	-0.25**	-0.22*	-0.23*
	(0.12)	(0.11)	(0.12)	(0.12)
International diversification	7.94***	7.94***	7.96***	7.93***
	(2.65)	(2.76)	(2.84)	(2.80)
Economic complexity index (*ECI*)	1.96	1.55	1.59	1.52
	(1.89)	(1.91)	(2.25)	(2.11)
*ECI**log *GDPpc*	-0.16	-0.14	-0.15	-0.14
	(0.19)	(0.19)	(0.23)	(0.21)
Share of natural resource exports			-1.11	-1.54
			(2.43)	(1.96)
Constant	-1.98	-1.24	1.68	2.14
	(10.12)	(10.07)	(11.04)	(10.57)
Dummies by continents	*Yes*	*Yes*	*Yes*	*Yes*
Observations	96	83	79	79
R^2	0.66	0.61	0.61	0.61
Effect of changing *RS* 1 sd at median of GDPpc	0.34	0.17	0.29	0.28

Notes: Results from estimating equation (5) using 2SLS. The dependent variable is the average growth rate of GDP per capita over the period 1996-2006 in percentage terms. Robust standard errors are in parentheses. Column 1 corresponds to the benchmark estimation, whereas estimations in columns 2-4 check for the robustness with respect to natural resource exports. Specifically, in columns 2 to 4 we exclude the oil producers from the sample (see Table 11 in Appendix C for the list of these countries). In columns 3 and 4, we also exclude the countries for which exports of products in chapters 25, 26, 27, 71, and 97 of the HS classification represent more than 35% of total exports. The RS and OPS used in column 4 were calculated excluding the exports of these five chapters of the HS. The RS, OPS, $Nat.\ resource\ excluded - RS$ and $Nat.\ resource\ excluded - OPS$ variables are instrumented using instruments for each country that are constructed with *country-specific* $AVEX$ and $ciAVEX$ indices that ignore the data of the corresponding country (see the main text for details). Significance levels: *** 1%, ** 5%, * 10%.

Table 6: Relocation and cross-country growth: Additional or alternative controls

	Dependent variable: Growth rate of GDP per capita					
	(1)	(2)	(3)	(4)	(5)	(6)
Relocation shocks (*RS*)	5.62***	4.66***	6.27***	4.66***	5.49***	5.63***
	(1.28)	(1.44)	(1.44)	(1.27)	(1.26)	(1.25)
Other product shocks (*OPS*)	5.00***	4.86***	4.67***	4.74***	4.77***	4.86***
	(1.24)	(1.28)	(1.28)	(1.21)	(1.24)	(1.28)
*RS**log *GDPpc*	-0.54***	-0.41**	-0.63***	-0.44***	-0.54***	-0.55***
	(0.16)	(0.18)	(0.18)	(0.15)	(0.16)	(0.15)
log *GDPpc*	-1.96***	-1.61***	-2.10***	-1.78***	-1.97***	-1.91***
	(0.69)	(0.52)	(0.53)	(0.49)	(0.53)	(0.52)
log human capital (years schooling)	1.19***			1.14***	1.37***	1.31***
	(0.35)			(0.36)	(0.40)	(0.38)
log capital intensity	-0.03					
	(0.28)					
Rule of law	0.46	0.43	0.28			
	(0.30)	(0.31)	(0.31)			
Share of oil exports	7.40***	6.17***	7.56***	6.93***	7.46***	7.11***
	(1.63)	(1.56)	(1.67)	(1.54)	(1.62)	(1.60)
log export openness	5.94*	6.01*	8.63***	6.21**	6.52**	6.52**
	(3.05)	(3.29)	(3.08)	(3.14)	(3.05)	(3.03)
log *GDP*	0.33	0.32	0.68**	0.34	0.35	0.39
	(0.31)	(0.34)	(0.32)	(0.31)	(0.31)	(0.30)
log export openness*log *GDP*	-0.24**	-0.24*	-0.33***	-0.25**	-0.27**	-0.26**
	(0.11)	(0.12)	(0.12)	(0.12)	(0.12)	(0.11)
International diversification	7.90***	7.58***	6.91**	7.79***	8.09***	8.08***
	(2.62)	(2.77)	(2.81)	(2.65)	(2.65)	(2.64)
Economic complexity index (*ECI*)	1.99	2.49	0.67	1.85	1.77	1.86
	(1.82)	(1.98)	(1.93)	(1.79)	(1.83)	(1.91)
*ECI**log *GDPpc*	-0.16	-0.21	-0.05	-0.15	-0.14	-0.16
	(0.18)	(0.20)	(0.19)	(0.18)	(0.18)	(0.19)
log human capital (secondary enrollment)		0.28				
		(0.19)				
log human capital (PWT9)			2.50***			
			(0.83)			
Regulatory quality				0.62**		
				(0.28)		
Government effectiveness					0.58*	
					(0.33)	
Control of corruption						0.37
						(0.25)
Constant	-1.91	-3.00	-9.55	-3.43	-2.44	-4.07
	(9.98)	(11.35)	(10.58)	(9.87)	(10.10)	(9.91)
Dummies by continent	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Observations	96	96	99	96	96	96
R^2	0.66	0.62	0.60	0.66	0.65	0.65
Effect of changing *RS* 1 sd at median of GDPpc	0.37	0.49	0.27	0.34	0.30	0.32

Notes: Results from estimating equation (5) using 2SLS and additional controls (capital intensity in column 1), alternative controls for human capital (columns 2 and 3) and for institutional quality in columns 4-6 (regulatory quality, government effectiveness, and control of corruption, respectively). The dependent variable is the average growth rate of GDP per capita over the period 1996-2006 in percentage terms. Robust standard errors are in parentheses. The RS and OPS variables are instrumented as in Table 5 (see the main text for details). Significance levels: *** 1%, ** 5%, * 10%.

Table 7: Relocation and cross-country growth: Alternative subsamples

	Dependent variable: Growth rate of GDP per capita					
	Excl. America (1)	Excl. Africa (2)	Excl. Asia (3)	Excl. Europe (4)	Low *RS* (5)	High *RS* (6)
Relocation shocks (*RS*)	6.44***	5.06**	7.31***	5.14***	1.79**	2.36**
	(1.28)	(2.28)	(1.86)	(1.91)	(0.88)	(0.97)
Other product shocks (*OP*)	4.98***	6.67***	5.16***	3.62***	4.63**	5.19***
	(1.25)	(2.07)	(1.35)	(1.22)	(1.85)	(1.58)
*RS**log *GDPpc*	-0.63***	-0.42*	-0.79***	-0.50**		
	(0.16)	(0.23)	(0.25)	(0.25)		
log *GDPpc*	-1.85***	-2.15***	-1.74***	-2.06***	-1.54**	-1.18*
	(0.61)	(0.65)	(0.64)	(0.63)	(0.60)	(0.60)
log Human Capital (years schooling)	1.25***	1.26***	0.61	1.27***	1.12	1.19***
	(0.41)	(0.44)	(0.47)	(0.46)	(0.69)	(0.44)
Rule of Law	0.22	0.26	0.83***	0.48	0.18	0.57
	(0.34)	(0.30)	(0.31)	(0.40)	(0.41)	(0.41)
Share of oil exports	6.94***	9.62***	7.41***	7.12***	3.83	7.54***
	(1.83)	(1.88)	(1.66)	(1.95)	(5.66)	(1.85)
log export openness	8.67**	5.73**	4.37	1.05	7.61**	4.08
	(3.51)	(2.91)	(4.16)	(4.26)	(3.57)	(6.68)
log *GDP*	0.55	0.38	0.06	-0.08	0.59	-0.03
	(0.38)	(0.29)	(0.46)	(0.37)	(0.38)	(0.66)
log export openness*log *GDP*	-0.34**	-0.21*	-0.20	-0.04	-0.26*	-0.21
	(0.13)	(0.11)	(0.16)	(0.16)	(0.14)	(0.26)
International diversification	9.21***	7.68***	3.88	14.51***	8.35***	9.38
	(2.99)	(2.26)	(2.75)	(4.09)	(2.85)	(6.62)
Economic Complexity Index (*ECI*)	0.36	2.98	1.70	2.93	3.13	1.41
	(2.01)	(2.38)	(2.14)	(2.12)	(2.54)	(2.97)
*ECI** log *GDPpc*	-0.01	-0.25	-0.12	-0.27	-0.32	-0.02
	(0.20)	(0.23)	(0.21)	(0.22)	(0.24)	(0.30)
Constant	-9.07	-6.23	4.70	10.79	-11.93	3.69
	(12.18)	(11.37)	(13.92)	(11.00)	(10.77)	(20.35)
Dummies by continent	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Observations	75	77	72	66	48	48
R^2	0.68	0.72	0.70	0.59	0.63	0.72
Effect of changing *RS* 1 sd at median of GDPpc	0.36	0.66	0.04	0.30	0.97	1.28

Notes: Results from estimating equation (5) using 2SLS and different subsamples. The dependent variable is the average growth rate of GDP per capita over the period 1996-2006 in percentage terms. In columns 1-4, we alternatively exclude the countries in America, Africa, Asia, and Europe from the sample. In columns 5 and 6, we consider the sub-sample of countries with the lowest and the highest RS, respectively. Robust standard errors are in parentheses. The RS and OPS variables are instrumented as in Table 5 (see the main text for details). Significance levels: *** 1%, ** 5%, * 10%.

Table 8: Relocation and cross-country growth. Panel estimations

	Dependent variable: Growth rate of GDP per capita					
	(1)	(2)	(3)	(4)	(5)	(6)
Relocation shocks (*RS*)	3.61***	4.23***		3.92***	4.75***	
	(1.34)	(1.35)		(1.34)	(1.31)	
Other product shocks (*OPS*)	1.68*	1.73*		1.89**	1.98*	
	(0.92)	(1.04)		(0.93)	(1.04)	
*RS**log *GDPpc*	-0.34**	-0.42**		-0.37**	-0.47***	
	(0.15)	(0.17)		(0.15)	(0.17)	
Nat. resource excluded–*RS*			4.43***			4.98***
			(1.34)			(1.29)
Nat. resource excluded–*OPS*			1.56			1.81*
			(0.99)			(0.98)
Nat. resource excluded–*RS* *log *GDPpc*			-0.44**			-0.49***
			(0.17)			(0.17)
log *GDPpc*	-2.12***	-2.12***	-2.19***	-2.19***	-2.21***	-2.28***
	(0.47)	(0.51)	(0.54)	(0.42)	(0.42)	(0.45)
log human capital (years schooling)	1.62***	1.36***	1.46***	1.67***	1.40***	1.50***
	(0.36)	(0.44)	(0.46)	(0.36)	(0.41)	(0.43)
Rule of law	0.38	0.46*	0.46*	0.45*	0.57**	0.57**
	(0.25)	(0.26)	(0.26)	(0.26)	(0.25)	(0.24)
Share of oil exports	2.91**	5.68**	4.42*	2.90**	6.35**	4.92*
	(1.23)	(2.72)	(2.56)	(1.22)	(2.71)	(2.56)
log export openness	2.02	2.66	2.99			
	(2.27)	(2.52)	(2.50)			
log *GDP*	0.06	0.13	0.19			
	(0.26)	(0.31)	(0.31)			
log export openness*log *GDP*	-0.07	-0.09	-0.11			
	(0.09)	(0.09)	(0.09)			
International diversification	5.76**	6.68***	6.57***	4.08*	4.86**	4.97**
	(2.26)	(2.36)	(2.41)	(2.21)	(2.40)	(2.46)
Economic complexity index (*ECI*)	4.06**	3.14	3.25*	4.21***	3.49*	3.72*
	(1.64)	(1.94)	(1.91)	(1.52)	(1.94)	(1.90)
*ECI** log *GDPpc*	-0.40**	-0.32	-0.34*	-0.42***	-0.36*	-0.39**
	(0.17)	(0.20)	(0.20)	(0.15)	(0.20)	(0.19)
Share of natural resource exports		-1.12	-1.22		-1.72	-1.83
		(2.61)	(2.08)		(2.52)	(2.03)
Constant	12.72*	10.73	10.19	14.84***	15.05***	16.01***
	(7.73)	(8.49)	(8.39)	(4.24)	(4.17)	(4.33)
Time and continent dummies interacted	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Observations	192	152	152	192	152	152
R^2	0.57	0.59	0.59	0.57	0.59	0.59
Effect of changing *RS* 1 sd at median of GDPpc	0.27	0.19	0.19	0.28	0.22	0.24

Notes: Results from estimating equation (5) using 2SLS and panel data and including time fixed effects interacted with the continent dummies. The dependent variable is the average growth rate of GDP per capita, in percentage terms, over the 1996-2006 and 2006-2014 periods. Standard errors clustered by country are in parentheses. The RS, OPS, $Nat.\ resource\ excluded{-}RS$ and $Nat.\ resource\ excluded{-}OPS$ variables are instrumented using the instruments explained in the main text. In columns 2, 3, 5 and 6 we exclude from the sample oil countries and those for which exports of natural resources represent more than 35% of total exports (see Table 11 in Appendix C). Significance levels: *** 1%, ** 5%, * 10%.

Table 9: Relocation and export upgrading

	Dependent variable: Export Upgrading					
	(1)	(2)	(3)	(4)	(5)	(6)
Relocation shocks (*RS*)	4.29***	5.12***	4.69***	0.99	2.02**	2.37***
	(1.21)	(1.39)	(1.35)	(0.67)	(0.86)	(0.76)
*RS**log *GDPpc*	-0.50***	-0.60***	-0.54***	-0.15**	-0.27***	-0.31***
	(0.13)	(0.15)	(0.14)	(0.07)	(0.09)	(0.08)
log *GDPpc*	-0.85***	-0.99***	-0.88***	-0.15*	-0.28**	-0.33***
	(0.22)	(0.27)	(0.27)	(0.08)	(0.12)	(0.12)
Constant	8.01***	9.32***	8.37***	1.03	2.33**	2.70**
	(2.22)	(2.66)	(2.61)	(0.82)	(1.13)	(1.12)
Dummies by continent	*Yes*	*Yes*	*Yes*	-	-	-
Time and continent dummies interacted	-	-	-	*Yes*	*Yes*	*Yes*
Observations	96	83	79	192	163	152
R^2	0.34	0.40	0.41	0.24	0.27	0.36

Notes: Results from regressing Export Upgrading on RS, initial GDP per capita, and the interaction between these two variables using 2SLS. Columns 1-3 report results using cross section data for 1996-2006 and columns 4-6 report results using panel data for the 1996-2006 and 2006-2014 periods. The RS variable is instrumented using the instruments explained in the main text. In columns 2 and 5, we exclude the oil producers from the sample, and in columns 3 and 6, we also exclude the countries for which exports of natural resources represent more than 35% of total exports (see Table 11 in Appendix C). Robust standard errors clustered by country in the panel regressions are in parentheses. Significance levels: *** 1%, ** 5%, * 10%.

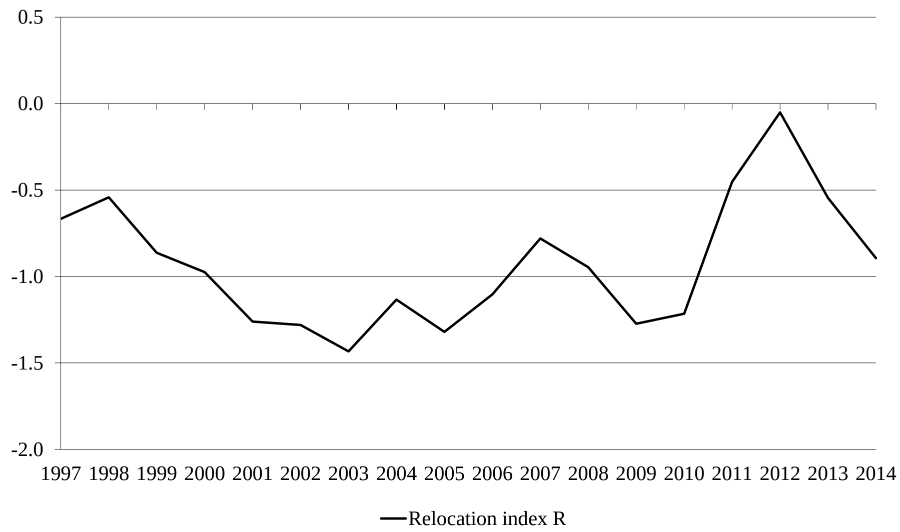

Figure 1: Evolution of the aggregate relocation index R.

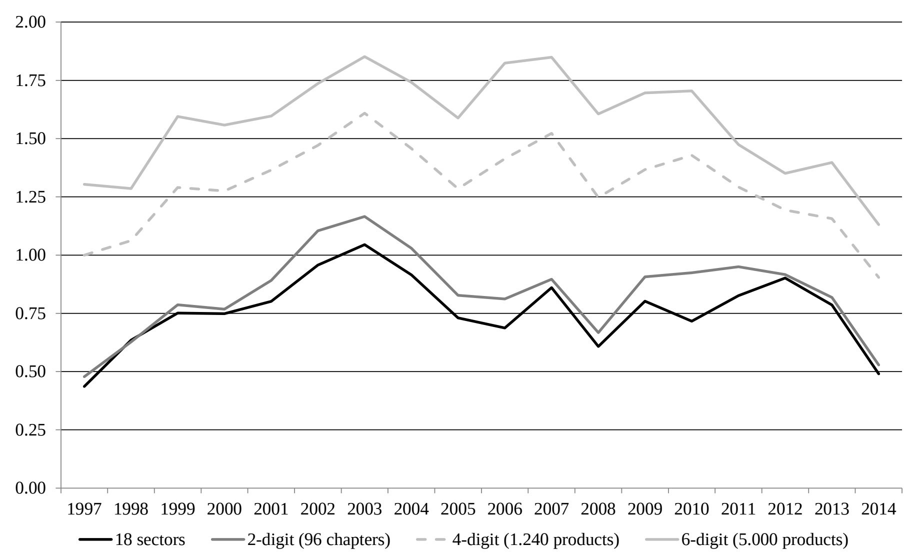

Figure 2: Dynamics of international relocation as measured by the mean absolute deviation of the R indices $MAD(R)$ at different disaggregation levels
Note: The different disaggregation levels are 18 industries (see Subsection 2.2), 96 chapters (2 digits of the HS-92 classification), 1,240 products (4 digits of HS-92), and 4,875 products (6 digits of HS-92).

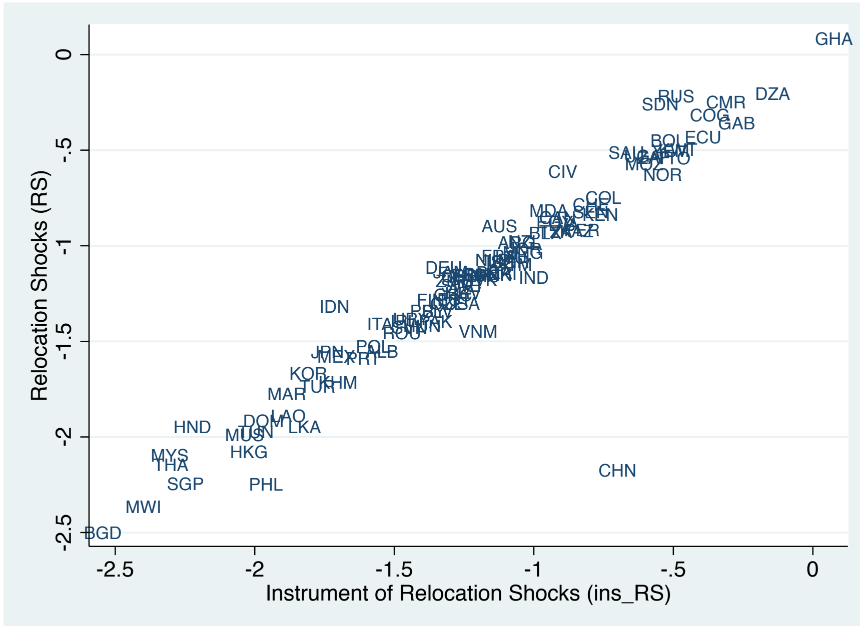

Figure 3: The RS versus its instrument ($insRS$)

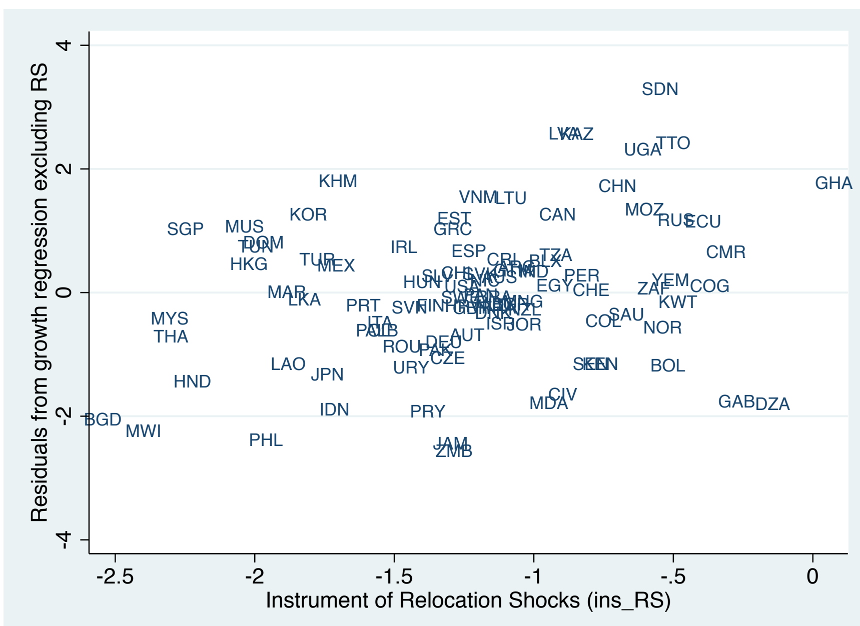

Figure 4: Relocation shocks (as measured by ins_RS) versus the residuals from the growth regression excluding RS and its interaction with $GDPpc$. Hong Kong was slightly shifted downward to avoid overlapping with Tunisia.

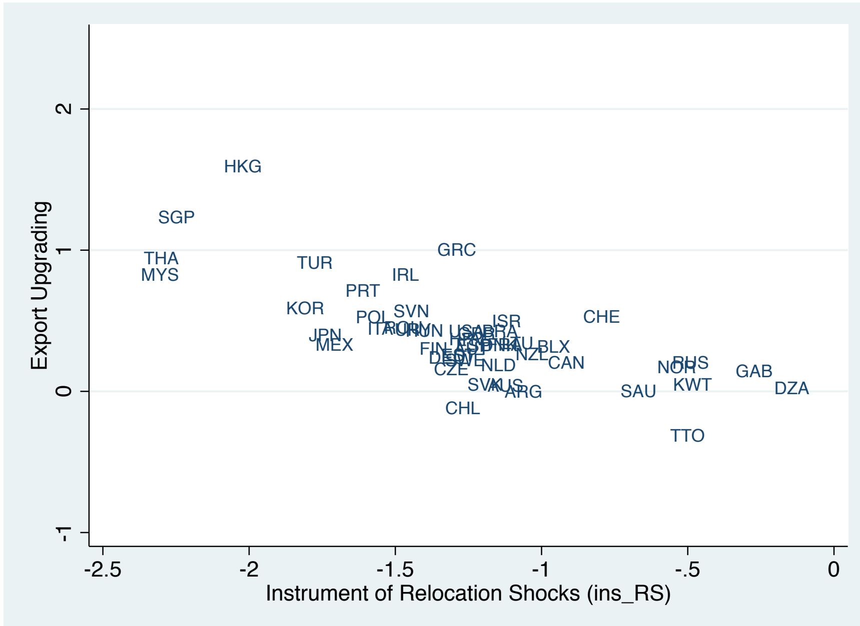

Figure 5: Relocation and export upgrading 1996-2014: richer countries

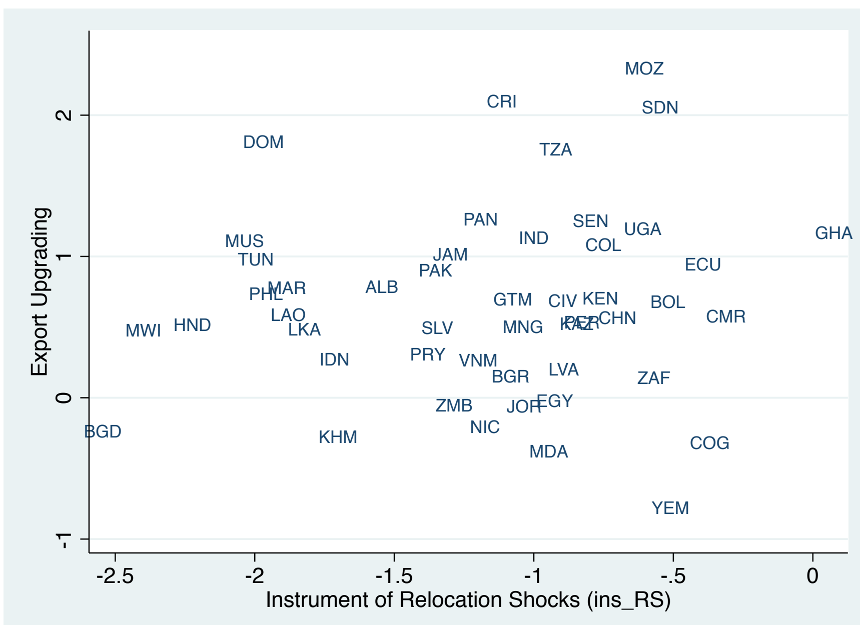

Figure 6: Relocation and export upgrading 1996-2014: poorer countries

Appendix A: Proof of the Proposition

First, we take derivates in (2) and (3) with respect to S_k:

$$\frac{d\left(s_{ck}/s_{dk}\right)}{dS_k} = \left(\frac{A_c/w_c}{A_d/w_d}\right)^{\gamma+\delta-1} \frac{L_c}{L_d} \cdot Z + (1-\gamma-\delta) \cdot \frac{L_c}{L_d} Q \cdot \frac{d\left(w_c/w_d\right)}{dS_k}, \tag{6}$$

$$\frac{d\left(\frac{L_{ck}}{L_c}/\frac{L_{dk}}{L_d}\right)}{dS_k} = \frac{w_d}{w_c}\left[\frac{L_d}{L_c}\frac{d\left(s_{ck}/s_{dk}\right)}{dS_k} + (-\gamma-\delta)\, Q \cdot \frac{d\left(w_c/w_d\right)}{dS_k}\right], \tag{7}$$

where

$$Z = \left[\frac{S_k^\beta + (B_c H_c + h_{ck})^\beta}{S_k^\beta + (B_d H_d + h_{dk})^\beta}\right]^{\frac{\gamma+\delta-1}{\beta}-1} (\gamma+\delta-1)\, S_k^{\beta-1} \frac{(B_d H_d + h_{dk})^\beta - (B_c H_c + h_{ck})^\beta}{\left[S_k^\beta + (B_d H_d + h_{dk})^\beta\right]^2},$$

$$Q = \left[\frac{S_k^\beta + (B_c H_c + h_{ck})^\beta}{S_k^\beta + (B_d H_d + h_{dk})^\beta}\right]^{(\gamma+\delta-1)/\beta} \left(\frac{A_c}{A_d}\right)^{\gamma+\delta-1} \left(\frac{w_c}{w_d}\right)^{-\gamma-\delta} > 0.$$

Hence, recalling that $\gamma > 1$ and $\beta < 0$, we find that Z is strictly positive if and only if $B_c H_c + h_{ck} \geq B_d H_d + h_{dk}$.

Note that changes in S_k only affect the ratios $\frac{L_{cj}}{L_c}/\frac{L_{dj}}{L_d}$ for any product $j \neq k$ by means of its effect on the ratio w_c/w_d (to see this, consider the analogous expression to (3) for a product $j \neq k$). In particular, if an increase in S_k raises (respectively, reduces) the ratio w_c/w_d, then it will reduce (increase) $\frac{L_{cj}}{L_c}/\frac{L_{dj}}{L_d}$ by the same proportion for all $j \neq k$. Moreover, if the increase in S_k raises (reduces) $\frac{L_{ck}}{L_c}/\frac{L_{dk}}{L_d}$, then the equilibrium in these two countries' labor markets will require that w_c/w_d increases so that $\frac{L_{cj}}{L_c}/\frac{L_{dj}}{L_d}$ decreases for the other products $j \neq k$ and the labor markets of c and d can clear.

Now, consider two countries c and d and suppose that $B_c H_c + h_{ck} \geq B_d H_d + h_{dk}$. To prove point *(i)* in the proposition, suppose that $\frac{d(w_c/w_d)}{dS_k} < 0$. Then, expression (6) implies, $\frac{d(s_{ck}/s_{dk})}{dS_k} > 0$ and thus $\frac{d[(L_{ck}/L_c)/(L_{dk}/L_d)]}{dS_k} > 0$. However, $\frac{d(w_c/w_d)}{dS_k} < 0$ and $\frac{d[(L_{ck}/L_c)/(L_{dk}/L_d)]}{dS_k} > 0$ makes impossible the equilibrium in these countries' labor markets as already argued. Therefore, we must have $\frac{d(w_c/w_d)}{dS_k} > 0$. Then, because $\left(Y_c/L_c\right)/\left(Y_d/L_d\right) = w_c/w_d$, we conclude $\frac{d[(Y_c/L_c)/(Y_d/L_d)]}{dS_k} > 0$, as stated in point *(i)* of the proposition.

Now to prove point *(ii)* of the proposition, suppose that $\frac{d(w_c/w_d)}{dS_k}$ is not only positive (which we know, as it was shown in the previous point) but that it is high enough so as to imply $\frac{d(s_{ck}/s_{dk})}{dS_k} \leq 0$ in expression (6). Then, $\frac{d(s_{ck}/s_{dk})}{dS_k} \leq 0$ and $\frac{d(w_c/w_d)}{dS_k} > 0$ in expression (7) imply $\frac{d[(L_{ck}/L_c)/(L_{dk}/L_d)]}{dS_k} < 0$. However, $\frac{d(w_c/w_d)}{dS_k} > 0$ and $\frac{d[(L_{ck}/L_c)/(L_{dk}/L_d)]}{dS_k} < 0$ makes impossible the equilibrium in these two countries' labor markets, as argued above. Therefore, we conclude that $\frac{d(w_c/w_d)}{dS_k} > 0$ cannot be as high as to imply $\frac{d(s_{ck}/s_{dk})}{dS_k} \leq 0$. Hence we must have $\frac{d(s_{ck}/s_{dk})}{dS_k} > 0$, as stated in point *(ii)* of the proposition.

Appendix B: First-stage regressions

Table 10: First-stage regressions

	Cross-section			*Panel*		
	Relocation shocks (*RS*)	Other Product Shocks (*OPS*)	*RS* * log *GDPpc*	Relocation shocks (*RS*)	Other Product Shocks (*OPS*)	*RS* * log *GDPpc*
	(1)	(2)	(3)	(4)	(5)	(6)
ins_Relocation shocks (ins*RS*)	1.10***	0.03	1.02	1.08***	-0.09	0.83
	(0.22)	(0.12)	(1.89)	(0.11)	(0.15)	(1.04)
ins_Other product shocks (ins*OPS*)	0.06	0.96***	0.35	0.05	0.71***	0.51
	(0.13)	(0.07)	(1.09)	(0.09)	(0.12)	(0.75)
ins_*RS**log *GDPpc*	-0.03	-0.00	0.76***	-0.01	0.00	0.88***
	(0.03)	(0.02)	(0.25)	(0.02)	(0.02)	(0.14)
log *GDPpc*	0.09	-0.07*	0.67	0.14*	-0.10**	1.11*
	(0.07)	(0.04)	(0.61)	(0.07)	(0.04)	(0.63)
log human capital (years schooling)	-0.06	0.03	-0.48	-0.06	0.05*	-0.48
	(0.04)	(0.02)	(0.37)	(0.04)	(0.03)	(0.32)
Rule of law	-0.04	0.01	-0.33	-0.05*	0.00	-0.37
	(0.03)	(0.02)	(0.29)	(0.03)	(0.02)	(0.22)
Share of oil exports	-0.03	-0.01	-0.15	-0.17*	-0.18*	-1.25
	(0.14)	(0.11)	(1.23)	(0.10)	(0.10)	(0.85)
log export openness	-0.91*	0.22	-7.92*	-0.62	0.10	-5.45
	(0.52)	(0.24)	(4.24)	(0.42)	(0.22)	(3.49)
log *GDPpc*	-0.11	0.03	-0.91	-0.08	0.03	-0.66
	(0.07)	(0.03)	(0.56)	(0.06)	(0.03)	(0.46)
log export openness*log *GDP*	0.03*	-0.01	0.28*	0.02	-0.00	0.19
	(0.02)	(0.01)	(0.16)	(0.02)	(0.01)	(0.13)
International diversification	-1.02*	-0.11	-8.29*	-0.72	0.04	-5.97
	(0.60)	(0.34)	(4.93)	(0.49)	(0.35)	(4.25)
Economic complexity index (*ECI*)	-0.26	0.22	-1.94	-0.27	0.35**	-2.03
	(0.30)	(0.15)	(2.46)	(0.27)	(0.16)	(2.25)
*ECI**log *GDPpc*	0.03	-0.02	0.25	0.03	-0.04**	0.22
	(0.03)	(0.02)	(0.26)	(0.03)	(0.02)	(0.23)
Constant	2.35	-0.20	20.59*	1.19	0.57	10.46
	(1.44)	(0.63)	(11.84)	(1.20)	(0.58)	(9.95)
Dummies by continent	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Time dummies	*No*	*No*	*No*	*Yes*	*Yes*	*Yes*
Observations	96	96	96	192	192	192
R^2	0.92	0.92	0.93	0.94	0.97	0.95
F-test	165.7	165.7	165.7	380.4	1379.0	426.6

Note: These first-stage regressions correspond to the cross-section estimation of equation (5) in column 1 of Table 5 and to the panel estimation in column 1 of Table 8. Robust standard errors are in parentheses. In the panel regressions (columns 4-6), standard errors are clustered by country. Significance levels: *** 1%, ** 5%, * 10%.

Appendix C: List of countries

Table 11: List of countries

iso3	Country name	iso3	Country name	iso3	Country name
AGO	Angola[a,1,2,*,+]	FRA	France	NER	Niger[b,*,+]
ALB	Albania	GAB	Gabon[1,2,*,+]	NGA	Nigeria[1,2,*,+]
ARE	United Arab Emirates[1,2,*,+]	GBR	United Kingdom	NIC	Nicaragua
ARG	Argentina	GHA	Ghana	NLD	Netherlands
ARM	Armenia[b,*,+]	GIN	Guinea[a,*,+]	NOR	Norway[1,2,*,+]
AUS	Australia[*]	GMB	Gambia[b,*]	NPL	Nepal[b]
AUT	Austria	GRC	Greece	NZL	New Zealand
BDI	Burundi[b]	GTM	Guatemala	OMN	Oman[a,1,2,*,+]
BEN	Benin[b]	GUY	Guyana[b,*,+]	PAK	Pakistan
BFA	Burkina Faso[a,b]	HKG	Hong Kong SAR, China	PAN	Panama
BGD	Bangladesh	HND	Honduras	PER	Peru[+]
BGR	Bulgaria	HRV	Croatia	PHL	Philippines
BHR	Bahrain [b,1,2,*,+]	HUN	Hungary	POL	Poland
BIH	Bosnia and Herzegovina[a]	IDN	Indonesia	PRT	Portugal
BLX	Belgium-Luxembourg	IND	India	PRY	Paraguay
BOL	Bolivia[2,*,+]	IRL	Ireland	ROU	Romania
BRA	Brazil	ISR	Israel	RUS	Russian Federation[1,2,*,+]
BTN	Bhutan[a,b]	ITA	Italy	SAU	Saudi Arabia[1,2,*,+]
CAN	Canada	JAM	Jamaica	SDN	Sudan[2,+]
CHE	Switzerland	JOR	Jordan	SEN	Senegal
CHL	Chile	JPN	Japan	SGP	Singapore
CHN	China	KAZ	Kazakhstan[1,2,*,+]	SLE	Sierra Leone[b,*,+]
CIV	Cote d'Ivoire	KEN	Kenya	SLV	El Salvador
CMR	Cameroon[1,2,+]	KHM	Cambodia	SUR	Suriname[a,b]
COD	Dem.Republic of Congo[b,*,+]	KOR	Korea, Rep.	SVK	Slovak Republic
COG	Congo[1,2,*,+]	KWT	Kuwait[1,2,*,+]	SVN	Slovenia
COL	Colombia[2,*,+]	LAO	Lao PDR	SWE	Sweden
COM	Comoros[a,b]	LBN	Lebanon[a]	TCD	Chad[a,b,2,+]
CRI	Costa Rica	LKA	Sri Lanka	TGO	Togo[b,*,+]
CYP	Cyprus[b]	LTU	Lithuania	THA	Thailand
CZE	Czech Republic	LVA	Latvia	TKM	Turkmenistan[a,1,2,*,+]
DEU	Germany	MAR	Morocco	TTO	Trinidad and Tobago[1,2,*,+]
DJI	Djibouti[a,b]	MDA	Moldova	TUN	Tunisia
DNK	Denmark	MDG	Madagascar[a]	TUR	Turkey
DOM	Dominican Republic	MEX	Mexico	TZA	Tanzania[*,+]
DZA	Algeria[1,2,*,+]	MKD	Macedonia, FYR[a]	UGA	Uganda
ECU	Ecuador[1,2,+]	MLI	Mali[b,+]	URY	Uruguay
EGY	Egypt, Arab Rep.[1,2,*,+]	MMR	Myanmar[b,2,+]	USA	United States
ESP	Spain	MNG	Mongolia[*,+]	UZB	Uzbekistan[a]
EST	Estonia	MOZ	Mozambique	VNM	Vietnam
ETH	Ethiopia[a]	MUS	Mauritius	YEM	Yemen, Rep.[1,2,*,+]
FIN	Finland	MWI	Malawi	ZAF	South Africa[*,+]
FJI	Fiji[b]	MYS	Malaysia	ZMB	Zambia

Note: [a] Countries with no data of human capital; [b] countries with no data of economic complexity; [1] oil exporter in the first period (1996-2006); [2] oil exporter in the second period (2006-2014); [*] natural resource exporter in the first period; [+] natural resource exporter in the second period.