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Sustainable Competitiveness Observatory: General Methodology

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Abstract

The Sustainable Competitiveness Observatory (SCO) works on three interconnected themes that characterise a country's capacity to integrate into the global economy. These are: (i) "National Attractiveness and Sustainability," which covers non-price determinants of national competitiveness, (geography, infrastructure, energy, human capital and economic policy); (ii) "Price Competitiveness," which provides complementary measures of price competitiveness in the tradable sectors of the economies studied; and (iii) "Revealed Competitiveness," which directly measures each economy's weight in global export markets and reflects the combined effects of the first two blocks. This document sets out the methodology used to construct the indicators for the Price Competitiveness and Revealed Competitiveness blocs.

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I. Methodology for the "Price Competitiveness" Block

The SCO's "Price Competitiveness" block includes several measures of countries' price competitiveness. It distinguishes between external competitiveness (the ratio of domestic to international prices) and internal competitiveness (the ratio of non-tradable to tradable goods).

I.1 External Price Competitiveness

External price competitiveness is measured using two conventional indicators: the nominal effective exchange rate (NEER) and the real effective exchange rate (REER). This section explains the SCO's methodology and data sources.

I.1.1 General definition of nominal and real effective exchange rates

For each reference country i, effective exchange rates are calculated as composite indices based on bilateral nominal exchange rates ij. For REER, they also incorporate the ratio of consumer price indices for each partner country j relative to the reference country i :

$$NEER_{it} = \prod_{j \neq i} \left(N_{ijt}\right)^{\omega_{ijt}} \tag{1}$$

And:

$$REER_{it} = \prod_{j \neq i} \left(N_{ijt} \frac{CPI_{it}}{CPI_{jt}}\right)^{\omega_{ijt}} \tag{2}$$

With:

- N_{ijt} : the bilateral nominal exchange rate between reference country i and partner country j at date t (quoted as units of foreign currency per unit of domestic currency)
- CPI_{it} and CPI_{jt}: the consumer price indices at date t for the reference country i and its partner country j, respectively
- ω_{ijt}: the weight assigned to partner j in country i's trade at date t, where $0 \leq \omega_{ijt} \leq 1$ and $\forall(i,t), \sum_{j \neq i}\left(\omega_{ijt}\right) = 1$

The exchange rates produced by equations (1) and (2) are "effective" because they are the weighted averages of all bilateral exchange rates. The real exchange rate differs from the nominal rate because it incorporates a price-index ratio for each country pair. In theory, several price measures could be used, including the producer price index (PPI), the wholesale price index (WPI), or the GDP deflator. The consumer price index (CPI), used by the SCO, is generally preferred for calculating REERs for three reasons. First, it assigns a higher weight to non-tradable goods and services than other indices, which are heavily weighted toward tradable goods. Prices of tradable goods are generally assumed to be partly determined in international markets (law of one price) and are therefore less relevant than the prices of non-tradable goods when comparing countries' competitiveness in international markets. Second, the goods basket and the weights that make up CPIs are generally more comparable across countries than those used for other indices, making international comparisons easier. Finally, CPI data are widely available, unlike other price measures[1]. Since the aim is to provide exchange-rate measures suited to emerging and developing economies, where producer-price data are less readily available, the REER is built using CPI as the price measure.

Bilateral nominal exchange rates (NERs) and consumer price indices come from the International Monetary Fund (see Table A1 in the Appendix). IMF NER data cover 213 countries and territories[2]. The raw data have been adjusted in instances where a country changed its currency (for example the adoption of the euro) and these adjustments are detailed in Appendix D. CPI data cover 193 countries and are reported as price indices with 2010 = 100.

I.1.2 The weighting system

One of the main differences between existing effective exchange-rate indices lies in the method used to calculate the weights assigned to the reference country's trading partners (parameter ω_{ijt} in equations (1) and (2)). Several methods can be used, each with different strengths and weaknesses (see Appendix B for a more detailed discussion). Here, we propose a method based on the multilateral weighting system, supplemented by a "multisectoral" dimension. Simple multilateral weighting is occasionally used in the economic literature (Beng, 1991; Coudert et al., 2011 and 2015; Ho, 2012), though it is largely absent from the existing databases. It assigns each partner a weight equal to that country's share of world exports, (excluding the reference country). This assumes that countries compete with one another to a similar extent in every third market, so it captures potential rather than actual competition. It also ignores the real structure of economies, which may justify assigning different weights to the same partner for two reference countries, (because countries producing different goods do not compete with the same countries in world markets). The SCO therefore uses a multi-sector version inspired by the IMF approach (Bayoumi et al., 2006)[3]. For each exported product, it calculates the matrix of partner-country multilateral weights for every reference country. It then averages those weights using each good's share in the reference country's exports. Final weights are obtained as follows:

$$\omega_{ijt} = \sum_{k} \left(\frac{X_{ikt}}{X_{it}}\right)\left(\frac{X_{jkt}}{\sum_{\lambda \neq i} X_{\lambda kt}}\right) \tag{3}$$

With:
- X_{ikt}: exports of good k by country i at date t
- X_{it}: total exports of country i at date t, where $X_{it} = \sum_k X_{ikt}$

Values are calculated from the BACI database (Gaulier and Zignago, 2010) (see Table A1 in the Appendix). Goods are classified into the 65 sectors defined in the Standard International Trade Classification (SITC), Revision 3, Level 2 (see Table A2). In line with the literature, crude-oil and natural-gas exports are excluded for two main reasons (see, for example, Bayoumi et al., 2006). First, activities tied to these resources generally result in the formation of enclaves,

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[1]In 2026, the International Monetary Fund provided at least one observation over the preceding ten years for 189 countries for the CPI, compared with only 84 countries for the PPI and 15 for the WPI.

[2]In the IMF's original database, bilateral NERs are reported for each country against the US dollar. Pairwise NERs are thus reconstructed simply as the ratio of each country's NER against the dollar: $N_{ij} = N_{i\$}/N_{j\$}$.

[3]This is the approach described by Bayoumi et al. (2006) for agricultural goods (the double-weighting method is reserved for manufactured-goods exports).

with few upstream or downstream linkages to other sectors. Second, their prices are largely set globally by country cartels, which is unusual even for other natural resources. The prices and export volumes of these hydrocarbons therefore depend only weakly on exporters' exchange rates and external competitiveness.

Compared with conventional approaches, our method offers several advantages. First, it directly measures competition between the reference country and every other country across international markets (excluding country i's domestic market). Unlike bilateral weighting, it captures competition in third markets (treated here as the world market) (Ellis, 2001). Second, because the equation includes X_{ik}/X_i, the partner-country weight matrices vary across reference countries. However, unlike other weighting systems, these cross-country differences do not depend on bilateral trade flows (which are relatively volatile and endogenous to bilateral exchange rates). Instead, they depend solely on the export structure of the reference country, which is assumed to be more stable. Two countries exporting the same goods will therefore have similar weighting matrices even if they trade with different countries. The approach focuses on export competitiveness relative to potential competitors.

I.1.3 Time-varying weights and index chaining

Once the bilateral exchange rates and weights have been estimated for each pair of countries, the final indices are obtained through chaining. Chaining is a common practice in the literature on the construction of time-series indices. Its advantages and limitations compared to other approaches are presented in Appendix C. Chaining involves transforming a set of heterogeneous prices into a single aggregate index. The calculation is performed in two stages. First, for each pair of consecutive years, the growth rate of every bilateral exchange rate is estimated and then averaged across the period using the weights ω_{ijt} described above. Because the weights ω_{ijt} can change between years, we use the Törnqvist index, which weights observations by the average partner weight over the two years (namely $\omega_{i,j,t-1}$ and $\omega_{i,j,t}$). Once NEER and REER growth has been estimated for each consecutive-year pair, annual indices are calculated as the cumulative product of all earlier changes. The final exchange-rate equations are therefore:

$$NEER_{it} = NEER_{it_0} \times \prod_{\tau=t_0+1}^{t} \left(\prod_{j \neq i} \left(\frac{N_{ij\tau}}{N_{ij\tau-1}} \right)^{\left(\frac{\omega_{ij\tau-1} + \omega_{ij\tau}}{2} \right)} \right) \tag{4}$$

and:

$$REER_{it} = REER_{it_0} \times \prod_{\tau=t_0+1}^{t} \left(\prod_{j \neq i} \left(\frac{N_{ij\tau} \dfrac{CPI_{i\tau}}{CPI_{j\tau}}}{N_{ij\tau-1} \dfrac{CPI_{i\tau-1}}{CPI_{j\tau-1}}} \right)^{\left(\frac{\omega_{ij\tau-1} + \omega_{ij\tau}}{2} \right)} \right) \tag{5}$$

Where t_0 is the first year for which data are available for each country, and $TCEN_{it_0}$ and $TCER_{it_0}$ are conventionally set to 100. The indices are then rebased to equal 100 in year 2015. This base year is, of course, arbitrary. Unlike indices using a fixed reference year, however, changes in chained indices calculated from consecutive-year pairs do not depend on the base year selected (see Appendix C).

I.2 Internal Price Competitiveness

In addition to external competitiveness, measured using effective exchange rates (NEER and REER), a country's competitiveness can also be assessed across sectors through the domestic relative price of tradable and non-tradable goods. This ratio of prices, referred to here as the internal real exchange rate (IRER), measures domestic sectoral competitiveness and indirectly captures external competitiveness, because tradable-good prices are partly determined in world markets whereas non-tradable prices are not. The IRER has many economic applications: it complements the REER as a measure of competitiveness (Guillaumont Jeanneney, 1993 and 2015), is used in Salter-Swan models (Salter, 1959; Swan, 1963) and their extensions (Corden and Neary, 1982; Schmitt-Grohé and Uribe, 2021), measures the Balassa-Samuelson effect (Couharde et al., 2019)… Yet despite the ready availability of NEER and REER data, very few databases currently provide IRER measures (Mien, 2025).

I.2.1 General definition of the IRER

The main difficulty when estimating the relative prices of tradable and non-tradable goods lies in the difficulty of distinguishing between the two sectors. Several approaches have been proposed. The first compares consumer prices (CPI) with producer prices (PPI). The CPI is assumed to place greater weight on non-tradables, while the PPI overrepresents tradables. This is the most common approach in the literature, largely because it is easy to calculate and PPI data are available for high-income countries. However, it is an approximation because both indices include tradable and non-tradable goods. Moreover, PPIs are rarely available for developing countries, limiting their value in panel analyses. The wholesale price index (WPI) can also be used as a proxy for the PPI, but it has the same limitations and is available for even fewer countries. The second approach, used for example in CEPII's RPROD database (Couharde et al., 2019)[4], calculates a ratio of sectoral deflators, classifying some sectors as tradable (usually agriculture and/or manufacturing) and others as non-tradable (traditionally services and sometimes construction). This approach is also constrained by the level of data disaggregation. With highly aggregated data (agriculture, manufacturing, services and construction), it can place some tradable activities in the non-tradable category and vice versa (some services are internationally tradable, while some agricultural goods are consumed only locally). Value-added data are rarely available for a large number of countries at a highly disaggregated level. The third approach, adopted by the SCO, uses exported or imported goods as the measure of tradables and the CPI as a proxy for non-tradables. As in the first two approaches, the measure of non-tradables is imperfect because it also includes tradable activities. Unlike the other approaches, however, the sector defined here as tradable includes only goods actually traded in international markets. The IRER is therefore defined as follows:

$$IRER_{it} = \frac{CPI_{it}}{XPI_{it}} \tag{6}$$

where:

[4] The CEPII does not use the term "internal real exchange rate", preferring the more neutral "price ratio". It nevertheless refers to a price ratio between tradable and non-tradable sectors.

- CPI_{it}: the consumer price index for reference country i in t, intended to capture non-tradable goods prices
- XPI_{it}: the export price index for goods exported by reference country i in t, intended to capture tradable goods prices

The CPI comes from the IMF (see Table A1 in the Appendix). The Export Price Index (XPI) is calculated from BACI data (Gaulier and Zignago, 2010), using the methodology described in the next section. Goods follow the Harmonized System (HS) classification at the six-digit level (HS 6).

In addition to the overall IRER, we estimate IRERs for agricultural and manufactured goods separately. Although they are often correlated with the overall IRER, these measures provide additional information on the sectoral competitiveness of the countries studied. Together, they account for each country's position in the process of structural transformation. They are calculated as the CPI divided by the relevant sectoral XPI. These figures are calculated following all the steps of the methodology presented below, but taking into account only agricultural and manufactured goods, respectively (see Tables A3 and A4 in the Appendix for the retained products).

I.2.2 Preliminary data processing

For the remainder of this document, the following notation is used:

- v_{ijkt}: US-dollar value of the trade flow from exporting country i to importing country j for product k in period t
- $v_{ikt} = \sum_{j \neq i} v_{ijkt}$: US-dollar value of exports of product k by exporting country i to the rest of the world in period t
- q_{ijkt}: volume, in tonnes, of the trade flow from exporting country i to importing country j for product k in period t
- $q_{ikt} = \sum_{j \neq i} q_{ijkt}$: volume, in tonnes, of exports of product k by exporting country i to the rest of the world in period t

Preliminary data processing is needed to ensure that the indicators are meaningful. The BACI database contains some errors (especially in reported trade flows). We therefore apply the following processing steps:

(i) Removing flows with no volume information

For some flows, only value v_{ijkt} is reported, not volume q_{ijkt}. These observations are removed from the sample. In 2024, this affected 325,721 of 10,217,242 observations (3.2%). Because electricity has no mass, this notably removes all electricity exports.

(ii) Removing low-value or low-volume flows

In BACI, a trade flow can have a value as low as US$1 and a volume as low as 1 kg[5]. Even at a highly disaggregated level, it is difficult to imagine total annual exports of a product between two countries amounting to only a few dozen dollars, much less 1 dollar. Very low values are therefore likely to reflect reporting errors (for example, inconsistencies in measurement units). In addition, the lower a flow's value or volume, the more likely that a small measurement error (for example, in the reported mass shipped) or rounding of the raw value will produce unit values far from reality. We therefore remove flows worth less than US$100 or weighing less than 10 kg[6]. In 2024, this excluded 1,757,917 observations (17.8% of the remaining observations). Since these are small flows, however, they account for only a negligible share of world trade (about 0.04% by value and less than 0.0002% by volume in 2024).

(iii) Removing flows whose unit value differs excessively from the global unit value

To identify and exclude possible outliers caused by reporting errors, we use the approach of Berthou and Emlinger (2011). First, the global median unit value is calculated for all flows of good k in the year concerned. Flows whose unit value differs too sharply from the median are then removed. The selected threshold is a factor of ten: flows are excluded when their unit value exceeds ten times the global median or is below 10% of that median for the product. Although imperfect, this threshold aims to remove the flows most likely to have been misreported without excluding too much information. It removed 614,234 observations in 2024 (7.6% of the remaining observations).

(iv) Removing hydrocarbon flows

We also remove flows of crude oil and natural gas. There are three main reasons for excluding these goods. First, extracting hydrocarbons requires very little local labour, even compared with other agricultural or mining commodities. Most costs are capital costs, often financed largely by international capital. Domestic workers and investors therefore have little reason to choose between non-tradable sectors and hydrocarbons, while the IRER is intended in part to capture such cross-sectoral allocation. Second, once infrastructure is in place, these costs are largely fixed, so the real competitiveness of domestic production factors has only a marginal effect on annual prices and profits. That runs counter to the IRER's purpose of tracking changes in national competitiveness over time. Finally, hydrocarbon prices in world markets are strongly influenced by policies of the Organization of the Petroleum Exporting Countries (OPEC). They are therefore exogenous and independent of macroeconomic competitiveness for many exporting countries (Bayoumi et al., 2006).

(v) Identifying and removing selected major re-export flows

We also identify the largest goods re-export flows (that is, goods imported into one country and immediately exported to another without any significant transformation). The presence of re-exports can affect estimated IRERs without providing meaningful information about the

[5]This gives a minimum value of 0.001 for variables v_{ijkt} and q_{ijkt}, because trade flows are expressed in thousand US$ and tonnes, respectively.

[6]The choice of this threshold is inevitably somewhat arbitrary. These values were selected to remove the least plausible flows while limiting the number of observations excluded.

reference country's competitiveness. Several points must be noted regarding re-exports in trade data. First, BACI already makes an initial adjustment for re-exports, notably using mirror export and import data (see Gaulier and Zignago, 2010), but this adjustment is incomplete and many re-export flows remain. Second, except in a small number of logistics hubs (where re-export activity represents a substantial part of the economy), such as Singapore and Dubai (Jones et al., 2020), re-exports generally account for a minority of a country's exports. Third, re-exports are not isolated from the rest of the exporting economy; they depend on local activities that generate jobs and income (Jones et al., 2020). It is therefore not necessary to exclude all income from these flows when estimating an index that compares competitiveness in tradable and non-tradable sectors (since re-export activities are internationally tradable). The IRER is not calculated from the absolute level of exported-goods price indices (where re-export prices would not be relevant for domestic value added) but from their change over time. A global structural increase in the price of a re-exported good may increase the value captured by the intermediary country and improve the competitiveness of tradable activity relative to non-tradable activity, as measured by the IRER.

The aim is therefore not to remove every re-export flow, but to identify and exclude the few specific flows whose value is large enough in a given year to affect the reference country's final IRER without being associated with substantial local economic activity. We focus on land, air, and marine vehicles and identify the countries that produce them. Once producer countries have been identified, all exports of these goods by countries classified as non-producers (and therefore assumed to be re-exporters) are removed. Vehicles are used for two main reasons. First, vehicles (including cars, tractors, aircraft, ships and their parts) are among the most commonly re-exported goods (see, for example, Jones et al., 2020) and are associated with substantial values and/or volumes (because they are heavy and have high unit prices). They can therefore have a particularly strong effect on final price indices. Second, only a limited number of countries can generally produce these goods, making it easier to identify producer countries. This approach excludes exports by countries assumed not to produce the goods; it cannot remove vehicle re-exports by countries that are also capable of producing those vehicles. Table A5 in the Appendix lists the flows and countries associated with each category.

(vi) Removing goods exported fewer than three times during the reference period

Finally, we exclude product flows exported in only two distinct years during the period for which data are available for each reference country (across all destinations). This helps remove potentially exceptional re-export flows so that they do not have a lasting effect on a country's IRER. Over a period of at least thirty years, a country that structurally produces a good, or even operates as a re-export hub, should be able to export it in more than two years. Such flows are thus more likely to be exceptional re-exports, which could affect the final IRER without signalling a genuine change in the cost structure or competitiveness of tradable activities. Across 1995–2024, this removes 169,886 of the 12,013,481 observations remaining after the preceding filters (1.4% of the sample).

I.2.3 General procedure for constructing the IRER

After applying the aforementioned filters, the average unit value p_{ikt} of exports of each product k by exporting country i, expressed in domestic currency, is calculated as follows:

$$p_{ikt} = \frac{v_{ikt}}{q_{ikt}} \times N_{i\$t} \tag{7}$$

where $N_{i\$t}$ is the bilateral nominal exchange rate between the reference country i's currency and the US dollar, used to express the product's unit value in local-currency units. Each product k's share in reference country i's total exports is then calculated for each year:

$$s_{ikt} = \frac{\sum_{j \neq i} v_{ijkt}}{\sum_k \sum_{j \neq i} v_{ijkt}} \tag{8}$$

The IRER is ultimately constructed by chaining annual price changes (see Appendix C for a methodological discussion). More specifically, for each sample year t, the change in export prices relative to the previous year $t-1$ is calculated using the Törnqvist index. This uses the average product share in the reference country's exports in $t-1$ and t as the reference:

$$Törnqvist_{it} = \prod_k \left(\frac{p_{ikt}}{p_{ikt-1}}\right)^{\frac{s_{ikt}+s_{ikt-1}}{2}} \tag{9}$$

The Törnqvist index is mathematically equivalent to the simple geometric mean of the geometric Laspeyres and Paasche indices (that is, Laspeyres and Paasche indices calculated geometrically rather than arithmetically):

$$Tornqvist_{it}^{XPI} = \left(\underbrace{\prod_k \left(\frac{\pi_{ikt}}{\pi_{ikt-1}}\right)^{s_{ikt-1}}}_{GometricLaspeyres_{it}}\right)^{\frac{1}{2}} \times \left(\underbrace{\prod_k \left(\frac{\pi_{ikt}}{\pi_{ikt-1}}\right)^{s_{ikt}}}_{GeometricPaasche_{it}}\right)^{\frac{1}{2}} \tag{10}$$

The Törnqvist index is therefore close to the Fisher index, which is calculated as the geometric mean of the arithmetic Laspeyres and Paasche indices. Like the Fisher index, it offsets Paasche's upward bias and Laspeyres' downward bias. The Törnqvist index, however, is built from geometric rather than arithmetic means and gives less weight to extreme values. Since some export unit values can be highly volatile and occasionally very low or very high, the Törnqvist index is preferable to the Fisher index for calculating IRERs.

The final XPI is then obtained by chaining the Törnqvist indices:

$$XPI_{iT} = \prod_{t=T_0}^{T} (Törnqvist_{it}^{XPI}) \tag{11}$$

where T_0 is the first year with available data for each country. The indices are then rebased so that 2015 is the reference year (i.e., $IPX_{it} = 100$ in 2015), as for the NEER and REER. The IRER is then calculated as follows:

$$IRER_{it} = \frac{CPI_{it}}{XPI_{it}} \tag{12}$$

This general chaining method compares IRER changes from one year to the next using observations available in two consecutive years. Therefore, for the calculation in period t, only goods exported in both t and $t-1$ to at least one destination are included. This is usually not a problem: a good should be exported in several consecutive years if it is to represent a country's structural competitiveness. One-off exports are more likely to be (i) extremely small flows of goods produced in limited quantities (which were removed earlier); (ii) re-exports of goods imported from a third country (which should be excluded from the measure of the reference country's competitiveness); or (iii) reporting errors in customs data (which should also be excluded).

I.2.4 Adjustment for the COVID period

The main limitation of chaining is the possibility of chain drift when index components experience very large or frequent changes (see Appendix C). This is generally not a concern for IRERs, which use annual data, as chain drift mainly arises with monthly data (Feenstra and Shapiro, 2003; Ivancic et al., 2011; von Auer, 2024). The COVID crisis was nevertheless a major event that caused substantial movements in international prices, with different impacts on different goods. It could therefore introduce a substantial chain drift and affect the quality of post-crisis values. The series are consequently adjusted for the crisis years. In practice, changes in 2021 and 2022 are calculated relative to 2019, the last pre-crisis year, rather than relative to 2020 and 2021 (respectively). From 2023 onwards, prices are again calculated normally relative to the preceding year. International trade was particularly disrupted during this period, so comparing each year with the last non-crisis year is more coherent than comparing crisis years with one another. Since 2019 remains close to 2022, the adjustment does not suffer from the comparability constraints of approaches based on a fixed reference period.

II. Methodology for the "Revealed Competitiveness" Block

The SCO's "Revealed Competitiveness" block directly measures competitiveness of countries in export markets. Its purpose is to quantify each country's economic weight in world markets. We distinguish between two groups of variables: (i) countries' simple share of total world exports; and (ii) their share of world exports of goods in which they are relatively specialised. These indices range from 0 to 10,000, with higher values indicating greater weight in world markets. Unlike time indices, whose levels are comparable over time for a given country but not across countries in a given year, revealed-competitiveness and world-market-share indices are comparable across both countries and years. In both cases, competitiveness is understood as the ability to withstand competition from the rest of the world in international markets.

For these indicators, we use export data from the OECD's BIMTS database (OECD, 2025) (see Table A1). Built from United Nations COMTRADE data, this database adjusts re-export flows to retain only direct flows from the country of origin to the final destination. The indicators in this section measure the external competitiveness of reference countries through their weight in world export markets, so re-export flows must be excluded to avoid overstating the external competitiveness of global re-export hubs[7]. Because BIMTS's re-export adjustment

[7]The BIMTS database is not used to calculate IRERs for two reasons. First, it contains values but no volume data, so export price indices cannot be calculated. Second, the raw COMTRADE data contain several coexisting revisions of the HS6-digit classification (depending on the reporting country and year). BIMTS uses a flow-reallocation algorithm to convert all data to the Revision 07 of the HS classification. This can introduce inconsistencies and errors into the final classification, limiting the database's use for estimating IRERs, which require product prices to be estimated at a disaggregated level (HS6-digit). This is not a problem for the revealed-competitiveness indices presented here, as they need trade flows aggregated at the wider SITC-3 level (see below).

is incomplete, we also apply the adjustment used for IRERs in step (v) in Section I.2.2 and detailed in Table A5 of the Appendix.

II.1 Global Market Shares

Global market share (GMS) is a simple indice showing each country's share of global exports. They are calculated as follows:

$$GMS_{it} = \frac{X_{it}}{\sum_{\lambda} X_{\lambda t}} \times 10000 \quad (13)$$

where X_{it} is the total value of country i's exports (in US dollars) at date t.

The resulting index expresses each country's share of total world exports in ‱[8]. The final GMS therefore ranges from 0 to 10,000: 0 is the theoretical value for a country with no export to foreign markets, while 10,000 is the theoretical value for a country accounting for all world exports. The index directly captures each country's "weight" in world markets and thus the reference country's ability to compete with foreign firms in foreign markets.

Because the variables are calculated from aggregate data (total exports of country i across all goods at date t), no special transformation is required. Most data-processing operations used for the IRERs (see Section I.2.2, excluding small flows and unit values that diverge sharply from the median) are therefore unnecessary here. However, extractive-resource flows (minerals and hydrocarbons) are still excluded from GMS calculations. In fact, the objective is to measure economies' direct competitiveness in world markets. Extractive resources are assumed to be homogeneous in global markets, so each country's share of world exports of these resources depends less on macroeconomic competitiveness than on geological endowment. Because some resources account for a substantial share of world exports, including them would overstate the actual external competitiveness of resource exporters. GMS are also calculated separately for agricultural and manufactured goods. In each case, equation (13) is applied only to the relevant agricultural or manufacturing export flows (see Tables A3 and A4 in the Appendix).

II.2 Revealed Competitiveness Indices

The Revealed Competitiveness Index (RCI) also measures countries' market shares in world exports. Unlike the simple GMS measure, however, the RCI assesses competitiveness only in markets for goods that countries actually export, weighted by those goods' shares in the total exports of the countries studied. More precisely, the RCI is calculated as follows:

$$RCI_{it} = \prod_{k} \left(\left(\frac{X_{ikt}}{\sum_{\lambda} X_{\lambda kt}} \right)^{\sigma_{ikt}} \right) \times 10000 \quad (14)$$

where σ_{ikt} is the weight assigned to product k for exporting country i. It is calculated as follows[9]:

[8]Ten-thousandths (‱) are used instead of percentages (%) for readability: many countries in the sample account for very small shares of world trade (<0.01%).

[9]This approach is equivalent to calculating, for each country, a weighted average of the world market shares of every good actually exported by the reference country. For goods not exported by exporting country i, variable

$$\sigma_{ikt} = \frac{1}{3} \sum_{\tau = t-1}^{t+1} \frac{X_{ik\tau}}{X_{i\tau}} \tag{15}$$

The weight is the average share of product k in exporting country i's exports in the reference year t, the preceding year, and the following year. A three-year average is used rather than the reference year alone because some exports are highly volatile and individual goods can show large annual movements in the reference country's total exports. The purpose is to weight each product by its structural importance in exporting country i's exports. Goods are classified into the 259 sectors of SITC (Standard International Trade Classification), Revision 3, Level 3. This level of disaggregation is selected to measure competition in reasonably similar markets (requiring detailed categories), while keeping the markets sufficiently distinct to reflect imperfect competition in international trade.

In practical terms, the RCI differs from simple GMS measures, frequently used in the economic literature, because it measures competitiveness only in sectors in which countries have specialised. This matters because the final value of the index does not depend on the reference country's share of world exports represented by each product, but only on its competitiveness in the product's world market. A country that is a small global exporter of a product representing a large share of world trade could have a relatively high GMS, driven by that product. Conversely, a country highly specialised in an activity for which it is the leading global exporter could have a low GMS if the product accounts for only a small share of international trade, even if the country is extremely competitive in that activity. Unlike the simple GMS, the RCI disregards the reference country's product shares in global exports and captures only its direct competitiveness in each product market. The indicator is therefore grounded in the logic of Ricardian comparative advantage.

As for GMS, RCIs are calculated after excluding extractive-resource flows. Separate RCIs are also calculated for agricultural and manufactured goods, retaining only the products listed in Tables A3 (agricultural RCI) and A4 (manufacturing RCI), respectively. Finally, as with IRERs and GMS, RCIs are calculated after removing vehicle flows exported by countries assumed to be non-producers. The methodology is described in Section I.2.2, and Table A5 lists the relevant goods and countries.

One final RCI-specific adjustment is made to BACI data before equation (14) is estimated. For each exporting country i and year t, goods k exported in that year but not in the previous year are removed from the RCI calculation. This prevents an index calculated for year t from falling in the following year simply because a newly exported product enters the export basket (potentially with a lower world market share that year). A product first exported by the reference country in period t is therefore included in the RCI only from year $t+1$. This also excludes goods exported in only one isolated year, which often correspond to very small flows or re-exports.

X_{ikt} equals 0, hence $(X_{ikt}/\sum_{\lambda} X_{\lambda kt})^{\sigma_{ikt}} = 0^0 = 1$. The only assumption required to calculate these indices is that the reference country exports at least one good with a strictly positive value ($X_{it} > 0$).

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Appendix A: Description of data and sectoral classifications

Table A1: Data used and sources

Variable		Unit	Source	Used for
Bilateral Nominal Exchange Rate	NER_{ijt}	LCU / US$	International Monetary Fund	NEER; REER; IRER
Consumer Price Index	CPI_{it}	Index, 2010 = 100	International Monetary Fund	REER; IRER
Bilateral trade flow	v_{ijkt}	1000$	CEPII (Gaulier and Zignago, 2010)	NEER; REER; IRER
	q_{ijkt}	Tonnes		IRER
Bilateral trade flow	v_{ijkt}	$	BIMTS (OECD, 2025)	GMS; RCI

Note: NEER = Nominal effective exchange rate; REER = Real effective exchange rate; IRER = Internal real exchange rate; GMS = Global market share; RCI = Revealed competitiveness index.

Table A2: Classification of sections used to calculate multi-sector NEER and REER weights (SITC Revision 3, Level 2 product codes)

Code	**Description**	**Code**	**Description**	**Code**	**Description**
00	Live animals	32	Coal, coke and briquettes	66	Non-metallic mineral manufactures
01	Meat and meat preparations	33	Petroleum and petroleum products	67	Iron and steel
02	Dairy products and birds' eggs	34	Gas, natural and manufactured	68	Non-ferrous metals
03	Fish, crustaceans, molluscs and their preparations	35	Electric current	69	Manufactures of metal
04	Cereals and cereal preparations	41	Animal oils and fats	71	Power-generating machinery and equipment
05	Vegetables and fruits	42	Fixed vegetable oils and fats, crude, refined or fractionated	72	Specialised machinery
06	Sugar, sugar preparations and honey	43	Processed animal and vegetable oils and fats	73	Metal working machinery
07	Coffee, tea, cocoa, spices, and manufactures thereof	51	Organic chemicals	74	Other industrial machinery and parts
08	Feedstuff for animals	52	Inorganic chemicals	75	Office machines and automatic data processing machines
09	Misc. edible products and preparations	53	Dyeing, tanning and colouring materials	76	Telecommunications and sound recording apparatus
11	Beverages	54	Medicinal and pharmaceutical products	77	Electrical machinery, apparatus, and appliances
12	Tobacco and tobacco manufactures	55	Essential oils, perfumes and cosmetics	78	Road vehicles
21	Hides, skins and furskins	56	Fertilisers (excluding those in group 27)	79	Other transport equipment
22	Oil seeds and oleaginous fruits	57	Plastics in primary forms	81	Prefabricated buildings; sanitary, heating and lighting fixtures
23	Crude rubber	58	Plastics in non-primary forms	82	Furniture and parts thereof
24	Cork and wood	59	Chemical materials and products	83	Travel goods, handbags, etc.
25	Pulp and waste paper	61	Leather, leather manufactures and dressed furskins	84	Articles of apparel and clothing accessories
26	Textile fibres	62	Rubber manufactures	85	Footwear
27	Crude fertilisers	63	Cork and wood manufactures	87	Professional and scientific instruments
28	Metalliferous ores and metal scrap	64	Paper and paper manufactures	88	Photo apparatus, optical goods, watches and clocks
29	Other crude animal or vegetable materials	65	Textile yarn and related products	89	Misc. manufactured articles

Table A3: Goods retained for calculating agricultural indices (SITC Revision 3, Level 3 product codes)

Code	Description	Code	Description
001	Live animals (excluding aquatic animals)	091	Margarine and shortening
011	Meat of bovine animals, fresh, chilled or frozen	121	Tobacco, unmanufactured
012	Other meat and edible meat offal	211	Hides and skins
022	Milk, cream and milk products (excluding butter and cheese)	212	Furskins, raw
025	Birds' eggs, and eggs' yolks	222	Oil seeds and oleaginous fruits (excl. flour)
034	Fish, fresh, chilled or frozen	223	Oil seeds and oleaginous fruits (incl. flour, nes)
036	Crustaceans, molluscs and aquatic invertebrates	231	Natural rubber and similar gums
041	Wheat and meslin	244	Cork, natural, raw and waste
042	Rice	245	Fuel wood and wood charcoal
043	Barley, unmilled	246	Wood in chips or particles and wood waste
044	Maize, unmilled	247	Wood in the rough or roughly squared
045	Cereals, unmilled	248	Wood simply worked
054	Vegetables	261	Silk
057	Fruit and nuts, fresh or dried	263	Cotton
071	Coffee and coffee substitutes	264	Jute, other textile bast fibre, not spun
072	Cocoa	265	Vegetable textile fibres, not spun
074	Tea and maté	268	Wool and other animal hair
075	Spices	291	Crude animal materials
081	Feeding stuff for animals	292	Crude vegetable materials

Table A4: Goods retained for calculating manufacturing indices (SITC Revision 3, Level 3 product codes)

Code	Description	Code	Description
016	Meat and edible meat offal, salted, dried	679	Iron or steel tubes, pipes and hollow profiles
017	Meat and edible meat offal, prepared, preserved	691	Structures and parts of iron, steel or aluminium
023	Butter and other fats	692	Metal containers for storage or transport
024	Cheese and curd	693	Wire products and fencing grills
035	Fish, dried, salted or in brine	694	Nails, screws, nuts, bolts and rivets of metal
037	Fish and aquatic invertebrates, prepared, preserved	695	Tools for use in the hand or in machine
046	Meal and flour of wheat and flour of meslin	696	Cutlery
047	Other cereal meals and flour	697	Household equipment of base metal
048	Cereal preparations	699	Manufactures of base metals
056	Vegetables, roots, tubers, prepared, preserved	711	Vapour generating boilers
058	Fruit, preserved, and fruit preparations	712	Steam turbines and other vapour turbines
059	Fruit and vegetable juices, unfermented	713	Internal combustion piston engines
061	Sugar, molasses and honey	714	Engines and motors, non-electric
062	Sugar confectionery	716	Rotating electric plant and parts thereof
073	Chocolate, food preparations with cocoa	718	Other power generating machinery
098	Edible products and preparations	721	Agricultural machinery (excluding tractors)
111	Non-alcoholic beverages	722	Tractors
112	Alcoholic beverages	723	Civil-engineering and construction equipment
122	Tobacco, manufactured	724	Textile and leather machinery
232	Synthetic rubber	725	Paper mill, pulp mill machinery
251	Pulp and waste paper	726	Printing and bookbinding machinery

266	Synthetic fibres suitable for spinning	727	Food-processing machines
267	Other man-made fibres suitable for spinning	728	Other machinery for particular industries
269	Worn clothing and other worn textile articles	731	Machine-tools working by removing material
411	Animal oils and fats	733	Machine-tools for working metal
421	Soft vegetable oils and fats	735	Parts for metalworking machinery
422	Other vegetable oils and fats	737	Metalworking machinery
431	Processed animal or vegetal oils and fats	741	Heating and cooling equipment
512	Alcohols, phenols and halogenated derivatives	742	Pumps for liquids
513	Carboxylic acids	743	Pumps, gas compressors and fans
525	Radio-active and associated materials	744	Mechanical handling equipment
531	Colouring materials	745	Other non-electric machinery and tools
532	Dyeing and tanning extracts	746	Ball or roller bearings
533	Pigments, paints, varnishes and related materials	747	Appliances for pipes, boiler shells, tanks, vats, etc.
541	Medicinal and pharmaceutical products	748	Transmission shafts
542	Medicaments (incl. veterinary)	749	Non-electrical parts of machinery
551	Essential oils, perfumes and flavour materials	751	Office machines
553	Perfumery, cosmetics and toilet preparations	752	Automatic data-processing machines
554	Soap, cleansing and polishing preparations	759	Parts for office and data-processing machines
562	Fertilisers	761	Television receivers
571	Polymers of ethylene, in primary forms	762	Radio-broadcast receivers
572	Polymers of styrene, in primary forms	763	Sound recorders or reproducers
573	Polymers of vinyl chloride or halogenated olefins	764	Telecommunications equipment
574	Polyethers, epoxide resins	771	Electric power machinery
575	Other plastics, in primary forms	772	Electrical-circuit apparatus
579	Plastic waste	773	Equipment for distributing electricity
581	Tubes, pipes and hoses of plastics	774	Medical and radiological equipment
582	Plates, sheets, films, foil and strip of plastic	775	Household type equipment
583	Monofilaments of plastics	776	Cathode valves and tubes
591	Insecticides and similar products	778	Electrical machinery and apparatus
592	Starche, wheat gluten	781	Motor vehicles for the transport of persons
593	Explosives and pyrotechnic products	782	Motor vehicles for the transport of goods
597	Mineral-oil additives	783	Other road motor vehicles
598	Miscellaneous chemical products	784	Parts and accessories of road motor vehicles
611	Leather	785	Motorcycles
612	Leather manufactures	786	Trailers and semi-trailers
613	Tanned or dressed furskins	791	Railway vehicles and associated equipment
621	Materials of rubber	792	Aircraft and associated equipment; spacecraft
625	Rubber tyres	793	Ships, boats and floating structures
629	Articles of rubber	811	Prefabricated buildings
633	Cork manufactures	812	Sanitary, plumbing and heating fixtures
634	Veneer, plywood, and other wood	813	Lighting fixtures and fittings
635	Wood manufactures	821	Furniture and bedding articles
641	Uncut paper and paperboard	831	Travel goods and handbags
642	Cut paper and paperboard	841	Men's clothing of textile fabrics, not knitted
651	Textile yarn	842	Women's clothing of textile fabrics, not knitted
652	Cotton fabrics, woven	843	Men's clothing of textile, knitted
653	Fabrics, woven, of man-made fabrics	844	Women's clothing of textile, knitted
654	Other textile fabrics, woven	845	Articles of apparel, of textile fabrics
655	Knitted or crocheted fabrics	846	Clothing accessories, of textile fabrics

656	Tulles, trimmings, lace, ribbons and other small wares	848	Articles of apparel, excluding textile
657	Special yarns and fabrics	851	Footwear
658	Made-up articles, of textile materials	871	Optical instruments and apparatus
659	Floor coverings	872	Medical and dental equipment
661	Lime and construction materials	873	Meters and measuring instruments
662	Clay construction materials	874	Other measuring and controlling apparatus
663	Other mineral manufactures	881	Photographic apparatus and equipment
664	Glass	882	Cinematographic and photographic supplies
665	Glassware	884	Optical goods
666	Pottery	885	Watches and clocks
671	Pig iron	891	Arms and ammunition
672	Ingots of iron or steel	893	Articles of plastics, not elsewhere specified
673	Flat-rolled products, iron, non-alloy steel, not coated	894	Baby carriages, toys, games and sporting goods
674	Flat-rolled products, iron, non-alloy steel, coated, clad	895	Office and stationery supplies
675	Flat-rolled products of alloy steel	897	Jewellery and articles of precious material
676	Iron and steel bars, rods, angles, shapes and sections	898	Musical instruments
677	Rails and railway track materials	899	Other manufactured articles
678	Iron or steel wire		

Table A5: Vehicle categories and countries classified as producers

Categories	**SITC-3 codes**	**Producer countries**
Automotive industry	722, 781, 782, 783, 786	Algeria, Argentina, Australia, Austria, Azerbaijan, Bangladesh, Belarus, Belgium, Brazil, Canada, China, Colombia, Croatia, Czechia, Ecuador, Egypt, Finland, France, Germany, Ghana, Greece, Hungary, India, Indonesia, Iran, Italy, Japan, Jordan, Kazakhstan, Kenya, Korea, Malaysia, Mexico, Morocco, Myanmar, Nigeria, Pakistan, Philippines, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, South Africa, Spain, Sweden, Thailand, Tunisia, Türkiye, Ukraine, United Kingdom, United States, Uruguay, Uzbekistan, Vietnam
Aviation and aerospace industry	792	Brazil, Canada, China, France, Germany, Italy, Japan, Russia, Spain, Sweden, Switzerland, United Kingdom, United States
Naval industry	793	China, France, Germany, India, Italy, Japan, Korea, Netherlands, Romania, Russia, Saudi Arabia, Singapore, United Kingdom, United States

Appendix B: Alternative partner-country weighting systems for constructing effective exchange rates

This appendix examines how a reference country's partner countries are weighted, that is, how coefficients ω_{ij} are constructed in the equations above. Ideally, partner-country weights should reflect both the intensity of competition between the two countries in their respective domestic markets and the competition they face in third markets. Three main methods are traditionally used in the economic literature and international databases (Ellis, 2001; Chinn, 2006):

Method 1: The Bilateral weighting scheme

This method calculates the weights of different partners from each country's share in the reference country's foreign trade, as follows:

$$\omega_{ij} = \frac{X_{ij} + M_{ij}}{\sum_{\lambda \neq i}(X_{i\lambda} + M_{i\lambda})} \qquad (B1)$$

where X_{ij} denotes exports from the reference country i to its partner j, and M_{ij} denotes imports by i from j. Weights can also be estimated using only exports or only imports, although combining both is more common.

This approach is generally considered more intuitive and easier to interpret (Coudert et al., 2011). Its main limitation is that it measures only direct competition between the reference country and its partner (i.e., competition in the two countries' domestic markets) and ignores competition in third markets. This is particularly problematic for commodity exporters, whose products are highly homogeneous and substitutable across countries[10]. Weights based on bilateral trade therefore do not truly capture the intensity of competition between countries. International institutions (including the IMF, UN, OECD and BIS) have largely abandoned this method, although theoretical studies still occasionally use it for its simplicity of estimation (e.g., Lane and Milesi-Ferretti, 2004; Nouira et al., 2011; Combes et al., 2012; Nouira and Sekkat, 2012; Carrera et al., 2021).

Another limitation is the high volatility of bilateral trade flows and their endogeneity, since bilateral trade between two countries depends in turn on their bilateral nominal exchange rate.

Method 2: The Double weighting scheme

This approach was originally developed by Turner and Van't dack (1993) and has since been widely adopted by international institutions and central banks (albeit with variations across institutions): the International Monetary Fund (Bayoumi et al., 2006)[11], the Bank for International Settlements (Klau and Fung, 2006), the European Central Bank (Schmitz et al.,

[10]For example, Côte d'Ivoire and Ghana are among the leading global exporters of cocoa beans, most of which are exported to Europe, and both countries import refined petroleum products. Under bilateral weighting, Côte d'Ivoire's REER would assign high weights to European countries and petroleum-product exporters, but a very low weight to Ghana, with which Ivorian trade is limited (and vice versa for Ghana's REER). Yet Ivorian producers compete primarily with Ghanaian producers, not European firms.

[11]The IMF distinguishes among the various types of exported goods, using double weights for manufactured goods and services and multilateral weights (see below) for commodities, then aggregating the sectoral weights to obtain final weights.

2012), the US Federal Reserve (Loretan, 2005), the Bank of Canada (Barnett et al., 2016), and the Bruegel database (Darvas, 2012), among others.

In its original form, it estimates three parameters:

(i) Direct competition between i and j in country i's domestic market:

$$\omega_{ij}^{M} = \frac{M_{ij}}{\sum_{\lambda \neq i} M_{i\lambda}} \qquad (B2)$$

(ii) Direct competition between i and j in country j's domestic market:

$$\omega_{ij}^{X1} = \left(\frac{X_{ij}}{\sum_{\lambda \neq i}(X_{i\lambda})}\right)\left(\frac{Y_j}{Y_j + \sum_{\lambda \neq j} M_{j\lambda}}\right) \qquad (B3)$$

where Y_j is domestic output of partner country j.

(iii) Competition between i and j in third markets:

$$\omega_{ij}^{X2} = \sum_{\lambda \neq i,j} \left(\frac{X_{i\lambda}}{X_i}\right)\left(\frac{M_{\lambda j}}{Y_\lambda + \sum_{\theta \neq \lambda} M_{\lambda\theta}}\right) \qquad (B4)$$

Once these three parameters have been estimated, each country's final weights are calculated as follows:

$$\omega_{ij} = \eta^{M}\omega_{ij}^{M} + \eta^{X}\left(\omega_{ij}^{X1} + \omega_{ij}^{X2}\right) \qquad (B5)$$

where η^M and η^X are the weights assigned to imports and exports, respectively. They are generally set either to the share of imports and exports in the reference country's total trade (BIS, IMF), or to ½ (US Federal Reserve, Central Bank of Canada).

This approach accounts for competition between i and j in third-country markets as well as direct competition in domestic markets. It is more complex to estimate, however, and requires a measure of countries' domestic output (so it cannot be calculated from trade data alone). Production data are often less available and of lower quality than export data in developing countries. Including GDP also introduces non-tradable activities into the calculation. To address this issue, the US Federal Reserve uses a slightly modified approach that excludes Y_j and Y_k from equations (15) and (16).

Beyond GDP data availability, this approach has two other limitations. First, choosing weights η^M and η^X is inherently arbitrary: theory provides no basis for assigning equal (or unequal) importance to competition in domestic markets and competition in all other markets. Second, problems related to the volatility and the endogeneity of measured bilateral flows remain, which complicates the interpretation of the estimated effective exchange rates.

***Method 3*: The Multilateral weighting scheme**

This approach assigns to every country a weight equal to its share of world GDP or world exports, excluding the reference country. For exports (the approach adopted by the SCO), the equation is:

$$\omega_{ij} = \frac{X_j}{\sum_{\lambda \neq i} X_\lambda} \qquad (B6)$$

This approach directly measures competition between the reference country and every other country in international markets (excluding country i's domestic market). As with bilateral weights, one major advantage is its simplicity. Unlike bilateral weights, however, multilateral weighting also captures competition in third markets (understood here as the world market) (Ellis, 2001). Countries' world market shares are less volatile than bilateral flows, so the resulting partner weights are also less volatile in the short run than those produced by other systems. This makes the approach more compatible with time-varying weights. Finally, it has a distinctive feature rarely discussed in the literature: the partner-country weighting matrices are almost identical across reference countries[12]. This has several advantages:

- Changes in effective exchange rates are immediately comparable across countries (a difference between the effective exchange-rate changes of two countries cannot be attributed to a change in their weighting systems but rather only to a change in their bilateral exchange rates).
- The estimated REER/NEER no longer suffers from the endogeneity issues affecting other real exchange-rate methods when time-varying weights are used (because partner weights are no longer determined by bilateral exchange rates).
- Omitting a partner country from the calculation (for example, because data are missing for a country in a given year) affects every reference country in the same way.

The main limitation of multilateral weighting is its assumption that all countries compete with one another to a similar degree in every third market, which means treating the entire world as a single market. It therefore implicitly overlooks structural determinants of bilateral trade (such as distance and cultural preferences).

Equation (18) is presented using aggregate trade flows. Weights can also be estimated separately for each good or product category. Final country weights can then be reconstructed as an average of product-specific weights, weighted by each product's share in the reference country's total exports. This multi-sector approach calculates each country's weights as follows:

$$\omega_{ijt} = \sum_{k} \left(\frac{X_{ikt}}{X_{it}}\right)\left(\frac{X_{jkt}}{\sum_{\lambda \neq i} X_{\lambda kt}}\right) \qquad (B7)$$

where:

- X_{ikt}: exports of product k by country i at date t.
- X_{it}: total exports of country i at date t.

Although this method adds some complexity to the original multilateral approach, it accounts for differences between product markets and introduces cross-country heterogeneity in weights through export structure (rather than bilateral flows). It is therefore preferable to an approach

[12]More specifically, because the denominator is the sum of world exports excluding the reference country, partner weights vary only with the reference country's share in the world economy. The partner-weight matrices for two "small" countries are therefore virtually identical. Partner-country rankings by weight are likewise identical for all reference countries.

that treats all exports as a single sector. This explains why several exchange-rate databases, including the IMF's (Bayoumi et al., 2006), use multi-sector approaches.

The SCO adopts multi-sector multilateral weights. Compared with the other methods presented here, this approach balances a focus on direct competition between countries in world markets with a calculation method that is straightforward and easy to interpret. The SCO's NEER and REER are therefore deliberately designed as measures of the export competitiveness of the economies studied.

Appendix C: Methods for constructing time indices

Constructing a time index, such as a price or exchange-rate index, requires selecting a reference year or period against which values for all other years will be calculated (in other words, each year's price change is calculated relative to the selected reference period). Four main methods can be used to determine this reference period.

(i) Indices with a fixed reference year or period

This approach selects one year, or a group of consecutive years, and calculates the change in the index for every sample year relative to that reference period. For exchange rates, each country's rate in year T would be set to 100, and rates for all other years would be calculated as the ratio of current-year bilateral rates to the rate in year T. The main advantage of this approach is the perfect symmetry in index movements following symmetric shocks[13]. The reference period can also cover several years (for example, 2012–2016), using the period's average bilateral exchange rates.

However, this approach has a critical limitation that makes it ill-suited to calculating exchange-rate indices over long periods. Because all indices are calculated as price changes relative to one reference year, the final value, and even annual changes, in the estimated composite index are influenced by that year. In other words, choosing 2010 rather than 2015 as the reference year yields different exchange rates throughout the period. The choice of the reference year is therefore decisive, but also arbitrary. Furthermore, in the specific case of exchange rates, the structure of each country's exports tends to change over time, both in terms of the goods exported and the partner countries. This was particularly noticeable during the 2000s and 2010s, which saw, among other developments, the emergence of China as a global exporter and importer. For many countries, export structures in 2015 (or in any other reference year) differ greatly from those in 1995, making comparisons between the two years less meaningful. It is also possible in case of some small global exporters that none of the goods exported in 2015 were being exported in 1995, making it impossible to calculate the IRER for that year (because the index includes only goods traded in both years). Conversely, a good produced and exported for the first time after the year 2015 would never be included in the exchange-rate calculation, even if it later accounted for a substantial share of exports. With trade data, where products emerge and disappear over the medium and long term, a fixed-reference-period index becomes progressively less relevant as the sample length increases (Ivancic et al., 2011).

(ii) Full-period indices

Another approach estimates an average index over the entire period for which data are available (for example, 1995–2024), then compares each year's average price level with that average value. It has the advantage of using an average reference period, which is considered less arbitrary than a fixed reference year. It also allows for every good exported in at least one sample year to be included in the exchange-rate calculation for years in which it is exported. In practice, however, it is rarely used for three main reasons. First, all past index values must be recalculated every time the database is extended by another year (i.e., whenever an additional

[13] If, between years T_0 and T_N, the prices of all goods fluctuate but return to their initial level, the price indices in T_0 and T_N will be equal.

year is added). Second, if data are missing for some countries, their reference period differs from the others. South Sudan, for instance, was created only in 2011, so its average reference period would be 2011–2023 (compared with 1995–2023 for most countries), preventing a direct comparison with other countries. Finally, where export structures change substantially over time, using average exports across the whole period may not give a truly representative measure of price movements in a particular year.

(iii) Chained indices

The third approach, used here, estimates exchange-rate changes for each pair of consecutive years and then chains the calculated values into a final index. For every year, the reference year for calculating the index change is simply the preceding year. This resolves the issues described for the two other approaches. In fact, it captures medium- and long-term changes in the export structures of the countries studied. Price changes are calculated against nearby reference prices, and the associated weights are consistent with the importance of each product in the country's exports in the year studied. If a good begins to be exported only from year t, it is included in the index only from $t + 1$ (because the index in t is calculated from price changes between t and $t - 1$, when the good had not yet been exported). This approach is generally considered the most appropriate for indices using trade data (Gaulier et al., 2008).

Nevertheless, there are drawbacks to using chained indices as well. In practice, they can introduce chain drift into data series. This occurs when price movements systematically pull an index downward or upward, causing under- or overestimation. The problem is primarily associated with highly volatile, high-frequency series (daily, weekly, or monthly data) and rarely with annual series (Feenstra and Shapiro, 2003; Ivancic et al., 2011; von Auer, 2024). Fisher and Törnqvist indices, calculated as averages of Laspeyres and Paasche indices, can reduce the problem by dampening price and weight movements. Empirical research suggests that Fisher and Törnqvist indices are less sensitive to this type of bias than other indices (Hill, 2006; Gaulier et al., 2008).

(iv) Multilateral indices

Multilateral approaches have been developed to address chain drifts, particularly in high-frequency series. The principal example is the GEKS approach, now widely used for monthly consumer price indices (Bialek, 2024). In essence, for every sample year the change in prices between the year of interest t and every other year in the database are estimated, then the final index is calculated as the average of all resulting indices. Every year in the database thus serves as a reference year. Although this approach has many advantages and interesting mathematical properties (Vartia, 2019; Bialek, 2024), it faces several technical constraints similar to full-period indices. It requires comparing years that may be far apart and involve very different exported goods, making the resulting coefficients difficult to interpret. It also requires exchange rates to be estimated from different reference years across countries, depending on data availability.

One way to address this problem is to apply the method to several sub-periods using moving averages. However, chain drift can still arise because the sub-periods must themselves be chained (Vartia, 2019). Multilateral methods therefore do not appear to be the best fit for the exchange-rate indices developed by the SCO.

For the SCO, the preferred approach is chaining with Törnqvist indices. It makes price movements between two consecutive periods easier to interpret and is particularly well-suited to the trade data used here. Several methods can also mitigate the chain-drift issues inherent in this approach.

Appendix D: Necessary adjustments when constructing exchange-rate indices

Several issues not detailed in the methodology above can arise when calculating exchange-rate indices. This appendix presents those issues and the solutions adopted.

(i) Countries absent from the database in certain years

In the raw BACI database, country-level disaggregated data are not available for a few specific cases for certain years, where data are reported only for a bloc of countries (rather than for individual countries). For example, the Belgium-Luxembourg area until 1998 and the Southern African Customs Union (comprising South Africa, Botswana, Namibia, Lesotho and Eswatini) until 1999. Similar issues arise when countries dissolve or territories become independent, such as the State Union of Serbia and Montenegro, which became Serbia and Montenegro in 2006, and the Republic of the Sudan, which became Sudan and South Sudan in 2011. In every case, aggregate values (for the period before separation) are assigned to one country in the area only if that country represented at least 90% of the area's exports in the first year with disaggregated data. All other countries' exchange-rate series begin in the first year of disaggregated data. If no country accounts for more than 90% of the area's total exports, every country's series starts in the first year with available data. Thus, the Belgium-Luxembourg area is assigned to Belgium, the Southern African Customs Union to South Africa, Serbia and Montenegro to Serbia, and pre-2012 Sudan to post-2012 Sudan.

Although this lack of data affects all exchange rates, it is especially problematic for IRER indices because their price indices are constructed from trade data (for NEERs and REERs, trade data are used only to estimate partner-country weights). IRERs are calculated from changes in exported-goods prices rather than their level, using goods exported in the current and preceding years. Moving from area-level data to country-level data therefore does not create a problem when estimating the IRER in the transition year, even if countries in the area produce and export different goods. The IRER change that year is calculated using the unit values of goods exported before and after the transition by the country to which the area's aggregate values have been assigned.

(ii) Currency changes

Some countries experienced a currency change during the period covered. This includes the introduction of the euro in the member states of the European Monetary Union. Using a bilateral nominal exchange rate based on the old currency in $t-1$ and the new currency in t would create an inconsistency in the exchange-rate value in t.[14]. For these countries, and for price-change indices between $t-1$ and t, we therefore introduce a factor equal to the product of the new currency's bilateral NER in t and the conversion rate used between the old and new

[14]For example, if the exchange rate is n:1 in t−1 and m:1 in t solely because the currency unit changed (with no real change in relative prices), ignoring the currency change would incorrectly imply an appreciation/depreciation of the exchange rate by n/m between t−1 and t. This affects not only NEERs and REERs but also IRERs, because export prices in US dollars in the BACI database are multiplied by the NER to be expressed in domestic-currency units when calculating IRERs.

currencies when the new currency was introduced. Table D1 lists currency changes and the factors used.

Table D1: Conversion factors used for currency changes

Country	Former currency	New currency	Conversion factor	Year
Germany	German mark	Euro	1,95583	1999
Austria	Austrian schilling	Euro	13,7603	1999
Belgium	Belgian franc	Euro	40,3399	1999
Spain	Spanish peseta	Euro	166,386	1999
Finland	Finnish markka	Euro	5,94573	1999
France	French franc	Euro	6,55957	1999
Ireland	Irish pound	Euro	0,787564	1999
Italy	Italian lira	Euro	1936,27	1999
Luxembourg	Luxembourg franc	Euro	40,3399	1999
Netherlands	Dutch guilder	Euro	2,20371	1999
Portugal	Portuguese escudo	Euro	200,482	1999
Greece	Greek drachma	Euro	340,75	2001
Slovenia	Slovenian tolar	Euro	239,64	2007
Cyprus	Cypriot pound	Euro	0,585274	2008
Malta	Maltese lira	Euro	0,4293	2008
Slovakia	Slovak koruna	Euro	30,126	2009
Estonia	Estonian kroon	Euro	15,6466	2011
Latvia	Latvian lats	Euro	0,702804	2014
Lithuania	Lithuanian litas	Euro	3,4528	2015
Croatia	Croatian kuna	Euro	7,5345	2023
Ecuador	Sucre	US dollar	25000	2000
El Salvador	Salvadoran colón	US dollar	8,755	2001
Myanmar	Kyat	Kyat	0,00654167	2012
Zimbabwe	US dollar	Dollar RTGS	0,39971637	2019
Zimbabwe	Dollar RTGS	Zimbabwe Gold	2498,7242	2024

Note: Conversion factors are based on official documents from the reference countries (using the conversion rate between the old and new currencies on the date the new currency was issued). Although euro banknotes and coins entered circulation in 2002, the euro was already used by central banks from 1999 and the IMF's NER series use the euro from that year. Myanmar is a special case: its abrupt shift from a fixed exchange rate to a floating rate in April 2012 caused a sharp break in the NER. We used IMF monthly NER data to calculate a conversion factor as the ratio between the NER for the first three months of 2012 (US$1 = 5.57576667 MMK) and the NER for the final nine months (US$1 = 852.34596667 MMK). For Zimbabwe, because no official data were available, the conversion factor is the monthly NER for the first available observation in 2019 (February 2019).

(iii) Missing observations

In some cases, bilateral nominal exchange rate (LCU/US$) and/or CPI observations are missing. The strategy on what to do depends on the variable concerned and the number of missing observations.

When the NER is missing for a single year, IMF's monthly NER data are used to estimate the annual NER. The IMF's annual NER is the simple average of all monthly NERs in the year concerned. A single missing monthly observation is therefore enough to make annual data unavailable. This applies to Mauritania in 2004 and Iraq in 2003. In both cases, the annual average NER is the arithmetic mean of the available monthly NERs for that year (nine months for Iraq and five for Mauritania).

When the NER or the CPI is missing for a sequence of consecutive years, those years are excluded and indices are calculated only for the years with data. Zimbabwe is a special case: no CPI data are available before 2009 (during the hyperinflation episode), and no NER data are available from 2009 to 2019 (when the country had no effective official national currency). Because a price index is difficult to interpret during hyperinflation, data before 2009 are treated as missing and Zimbabwe's IRER is estimated from that year. In subsequent years, Zimbabwe mainly used the US dollar, so an NER of 1:1 is assigned throughout the period. The transition to 2019 is then estimated using the conversion factor displayed in Table D1.

"Sur quoi la fondera-t-il l'économie du monde qu'il veut gouverner ? Sera-ce sur le caprice de chaque particulier ? Quelle confusion ! Sera-ce sur la justice ? Il l'ignore."

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