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Measuring the Quality of Economic Activities: Reinert's Quality Index and World Trade, 1995–2024

Paulo Gala[1]

Abstract

Erik Reinert argued that economic activities differ in their capacity to make nations rich. Some, protected by increasing returns, learning and barriers to entry, turn productivity gains into higher wages; others, closer to perfect competition, pass them on to buyers as lower prices. Nations are rich or poor according to which they specialize in. He ranked activities on this scale but never measured it. This paper measures it for 1,241 products in world trade, 1995–2024, reading each activity's association with high wages from the income of its exporters. The ladder is the one Reinert described: commodities at the bottom, pharmaceuticals and precision instruments at the top, and processed goods above the raw materials they are made from. It also offers an economic interpretation of the complexity index: the dominant pattern of who exports what in world trade is, very nearly, an ordering by the income of exporters, as Reinert's theory predicts. Two contributions concern measurement itself. Judging an activity by its poorest serious exporters rather than by the average suits Reinert's idea that poor countries are much less likely to enter high-quality activities competitively; on that measure the ladder grows longer and his characteristics far more predictive. And two of his characteristics, the stability of trade values and the growth of demand, are far less recoverable from the trade matrix than his other characteristics. Poor countries lead world markets in a quarter of the least complex products and in one percent of the most complex.

Keywords: quality of economic activities, Schumpeterian underdevelopment, economic complexity, correspondence analysis, economic development, international trade

JEL classification: B52, C38, F14, F63, O14, O33

1 Introduction

The idea that economic activities differ in their capacity to make nations rich is the oldest proposition in development economics and the one the modern discipline most consistently set aside. Antonio Serra argued in 1613 that Venice was rich and Naples poor because Venice engaged in activities subject to increasing returns. Henry VII built English policy on the observation that wool producers were poor and woollen-cloth producers rich. List (1841), the cameralists and the American System made the distinction the basis of industrial policy, and the structuralists of the twentieth century, from Prebisch (1950) and Singer (1950) to Kaldor (1967), gave it a theory of the terms of trade and of manufacturing as the engine of growth. Neoclassical trade theory, built on constant returns and perfect competition, made all activities alike and the distinction disappeared (Reinert, 2007).

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Erik Reinert's contribution was to restate the distinction as a scale. His Quality Index of Economic Activities, first presented in Reinert (1994a) and reproduced in the appendix of *How Rich Countries Got Rich* (Reinert, 2007), places every activity on a continuum running from perfect competition to monopoly. The score reflects the degree to which an activity can support a high wage for the individual and a high standard of living for the nation that exports it. High-quality activities have steep learning curves, rapid technological progress, high research content, large economies of scale and scope, imperfect information, investment in large indivisible chunks, high barriers to entry and branded products. Low-quality activities have the opposite characteristics. Nations that specialize at the bottom of the scale suffer what Reinert called Schumpeterian underdevelopment: they can be the most efficient producers in the world in their activities and still be poor, because the gains from their productivity growth are passed on to buyers as lower prices rather than retained as higher wages (Reinert, 1994b).

The index was a conceptual device. Reinert ranked activities by their characteristics and illustrated the ranking with cases, Cuban tobacco and sugar, Haitian baseballs and American golf balls, Dominican pyjamas, and with a historical table for the United States between 1899 and 1937 in later editions of the book. He did not measure the index across the economy, and the obstacle was the data: most of the characteristics he named, learning curves, R&D intensity, the indivisibility of investment, are not observed for most activities in most countries.

In the three decades since, a different literature has turned the same question into measurement. Hausmann, Hwang and Rodrik (2007) attached to each product the income of its exporters; Hidalgo and Hausmann (2009) extracted from the country–product matrix of revealed comparative advantage an index of the complexity of countries and of products, and the *Atlas of Economic Complexity* (Hausmann et al., 2011) made the index a standard tool. The indices have since been correlated with growth, inequality, emissions, health and much else. What they measure has been less clear than what they predict, and a line of work that begins with Kemp-Benedict (2014) and the Fitness–Complexity school (Tacchella et al., 2012; Cristelli et al., 2013), and continues with Mealy, Farmer and Teytelboym (2019), van Dam et al. (2021) and Nomaler and Verspagen (2024), has established what the indices are not and what they are. They are not generalized measures of diversity and ubiquity. They are the leading axis of a correspondence analysis of the trade matrix, a summary of which countries export the same things, orthogonal to the counts by construction, and uninterpretable without information brought in from outside the matrix. That literature draws the conclusion that the interpretation of complexity has been ad hoc, resting on ex post correlation with whatever country variable is at hand, and proposes to bring the external variables in ex ante.

This paper measures Reinert's index with international trade data and argues that the index provides an economically grounded interpretation of what those reinterpreted measures capture. It rests on two observations. The first is that the score that defines the index, the capacity of an activity to support high wages, has a revealed counterpart in who exports it. A product exported mainly by high-income countries is one that economies with high wages manage to sell abroad; a product exported mainly by low-income countries is one in which low wages are typically the condition of competing. The counterpart is the income of the exporting countries, not the wage paid in the activity, and the paper treats the link between the two as Reinert's hypothesis rather than as a measured fact. What the paper constructs is therefore a revealed indicator of the quality of economic activities, conditional on the international pattern of specialization, rather than a direct observation of their technological properties. The second is that several of the

characteristics Reinert attributes to high-quality activities leave traces in the structure of world markets that trade data do record: the number of countries that manage to export a product at scale, the breadth of their other capabilities, the links between products, the stability of trade values and the growth of demand.

The results are seven. First, the ladder exists in the data and has the shape Reinert described: commodities occupy the bottom, fine chemicals, pharmaceuticals and precision instruments the top. Second, the observable characteristics explain about 30 percent of the variation in exporters' income, and the leading axis of the trade matrix explains 56 percent. Third, the properties the recent literature proves about that axis hold on these data: the index coincides with the first non-trivial correspondence axis and carries only 3.8 percent of the matrix's inertia, yet that small share of the matrix accounts for about half of the variation in exporters' income. Fourth, the lower tail of exporters' incomes is a measure of the score especially suited to Reinert's reading: scoring an activity by the income floor of its exporters steepens the ladder, raises the explanatory power of Reinert's characteristics from 0.30 to 0.49, and dissolves the resource-rent anomalies. Fifth, trade-value volatility and demand growth are much less recoverable from the matrix's axes than the other characteristics: even with all the axes, linear fits account for about a third and a fifth of their variation, against two thirds for ubiquity, which, in the linear specifications examined here, bounds what a matrix-based measure of quality can capture. Sixth, nine pairs of raw materials and their processed forms reproduce Henry VII's wool-and-cloth observation on all three measures. Seventh, Schumpeterian underdevelopment is visible directly, and countries' export quality tracks their income, changes slowly over three decades and is modestly associated with faster subsequent growth, an association rather than an estimated effect.

Section 2 presents Reinert's index and its theory. Section 3 places it in the literatures on technology gaps, structural change and economic complexity, and sets out, in plain terms, the reinterpretation of complexity on which the paper builds. Section 4 defines the measures and states how the index and the score relate. Section 5 describes the data. Sections 6 to 9 present the substantive results: the ladder, the counterpoints, Schumpeterian underdevelopment and countries. Section 10 takes the measures back to the geometry of the trade matrix and reports the tests the reinterpretation calls for. Section 11 discusses what the data cannot show, and Section 12 concludes.

2 Reinert's Quality Index of Economic Activities

2.1 Activities are not alike

Reinert's starting point is a contrast between two traditions. In the Anglo-Saxon tradition that runs from Ricardo to modern trade theory, perfect information and constant returns to scale make all activities equally suited to promote welfare, and the location of production has no consequence for wealth. In the German tradition of List, Roscher, Marx and Schumpeter, which Reinert traces back to Serra and the cameralists, growth is activity-specific: it happens in some activities and not in others, and a nation's wealth depends on which ones it hosts (Reinert, 1994b). The difference lies in two assumptions. Once fixed costs, indivisible investment and imperfect information are admitted, activities acquire a minimum efficient scale, increasing returns, barriers to entry and imperfect competition, and they acquire them in very different degrees.

Reinert illustrates the point with Robert Reich's (1991) distinction between high-quality and low-quality jobs. Within any country, a mediocre lawyer earns far more than the most efficient dishwasher, and no economist advises a child to stay at the sink because factor prices will one day equalize. Yet the same economists advise nations to specialize according to comparative advantage whatever the activity. The Quality Index extends the individual's intuition to nations: an activity's score measures the industry rent it can sustain, the margin above the competitive return that is shared among capital, labour and the state.

2.2 The index

The index places each activity on a continuum from perfect competition to monopoly. At the top are activities that Reinert calls Schumpeterian: increasing returns, dynamic imperfect competition, steep learning curves, rapid technical change, high R&D content, learning by doing, investment in large indivisible chunks, imperfect information protected by patents or internal know-how, large economies of scale and scope, high barriers to entry, branded products, stable prices, skilled labour and large synergies with other activities through linkages and clusters. At the bottom are activities he calls Malthusian: diminishing returns, perfect competition among sellers of a commodity, flat learning curves, little technical change, divisible investment, perfect information, low barriers to entry, unskilled labour, few linkages and extreme price fluctuations.

The scale has its origin in the contrast between industry and raw materials, and Reinert never treats that contrast as incidental. The genealogy he gives the index is industrialist throughout: Serra (1613) located increasing returns largely in manufacturing; the first edition of Marshall's *Principles* (1890) proposed taxing goods produced under diminishing returns in order to subsidize those produced under increasing returns; Charles King (1721) counted the exchange of manufactures for manufactures among the good trades; and mercantilist and cameralist policy consisted in engaging in whichever activities were being mechanized (Reinert, 1994b; Reinert and Riiser, 1994). When he sets out where the two modes of distributing technical progress operate, the collusive mode is found mainly in industry and in recent products and processes, and the classical mode in primary production and traditional services (Reinert, 1994b, Table 1). High-technology industries are the national wage leaders, and the rest of the economy shares in their industry rent. Raw materials sit at the bottom for two reasons: their markets come close to perfect competition, so that productivity gains leave as lower prices, and many of them are produced under diminishing returns, which Graham (1923) had shown can leave a country poorer with trade than without it.

The index is not, however, reducible to that contrast, and it is not a ranking of sectors: Reinert insists that the same differences found between agriculture and industry are found within industries and even within firms. He adds a second dimension, the technological vintage of an activity, and on it manufactures can fall as low as commodities. The main exports of developing countries, he observes, are either raw materials or mature industrial products, and mature activities are farmed out to poor countries precisely because low wages have become their decisive cost (Reinert and Riiser, 1994). The baseballs Haiti exports are manufactures, and so were the garment-assembly jobs that came to the Dominican Republic without raising welfare, a case taken up in Section 2.4. Golf balls and baseballs belong to the same product group. The world's most efficient golf-ball producers are in industrialized countries and earn industrial wages; the world's most efficient baseball producers are in Haiti and earned 30 US cents an hour when he wrote, because baseballs are still sewn by hand everywhere and no learning takes place

in making them. In the other direction, Cuban tobacco, an agricultural product, sustained a prosperous middle class that sugar never did, which leads Reinert to insist that the mechanism lies beyond the classification of agriculture as bad and industry as good (Reinert, 1994b). An index that captures both dimensions has to work at the finest level of activities the data allow, and the test of a measurement is that it reproduces the industrial ordering on average while separating new from mature activities within it.

2.3 Two ways of distributing the gains from technical change

The mechanism behind the index is the way the gains from productivity growth are distributed. Reinert distinguishes two modes. In the classical mode, which Smith and Ricardo assumed to be general, productivity gains reach buyers as lower prices or better quality; this happens where markets resemble the neoclassical model, which Reinert finds mostly in agriculture, raw materials and traditional services. In the collusive mode, gains are retained by the producing firms and shared with their workers and, through taxation, with their governments; this happens where technical change is accompanied by barriers to entry and increasing returns. The word does not imply conspiracy: capital, labour and government in the producing country simply appropriate the gains together. Henry Ford's five-dollar day is Reinert's emblem of the collusive mode; supermarket scanners, whose gains show up in no one's wage, of the classical.

The Brookings Institution studies of the 1930s, which Reinert cites through Moulton (1935), documented the result within the United States: the most productive farmers in the world remained poor while the most productive industrial workers grew rich, because farm productivity was passed on in prices and industrial productivity in wages. Place the two groups in different countries, remove the migration, transfers and political bargaining that partly equalized them inside one nation, and the result is a rich industrial nation and a poor agricultural one, both efficient. The argument is Singer's (1950) mechanism for the terms of trade, and it is Sylos Labini's (1956) account of what oligopoly does to the gains from technical progress.

2.4 Schumpeterian underdevelopment

Reinert calls the outcome Schumpeterian underdevelopment, to distinguish it from the underdevelopment of societies outside the international division of labour. A country suffering from it participates fully in world trade and may be highly efficient in its exports, but its activities either have little technical change, or have technical change under perfect competition that shows up as falling world prices rather than rising national wages, or both. His Caribbean cases make the point. Cuba had an absolute advantage in both tobacco and sugar, yet, as Fernando Ortiz (1940) described in *Cuban Counterpoint*, tobacco, skilled, branded and stable in price, created a middle class, while sugar, anonymous, mass-harvested and wildly fluctuating in price, created masters and slaves. The Dominican Republic gained hundreds of thousands of garment-assembly jobs without a measurable rise in welfare, because the operation that underwent technical change, cutting, returned to the United States when laser cutting arrived.

The policy implication is the mercantilist one that every successful industrializer followed: emulate the activities at the top of the index, deliberately and for long periods, before opening to free trade (Reinert, 2007; Chang, 2002). For our purposes the implication is empirical. If Reinert is right, then the characteristics he lists should be associated with the capacity to support high

wages across activities; raw materials should rank below their processed forms; and poor countries should lead world markets, when they do, mainly at the bottom of the scale.

3 Related literature

Three literatures bear on the measurement of Reinert's index: the evolutionary work on technology gaps and catching up in which the index first appeared, the structuralist and Kaldorian work on sectoral composition and growth, and the literature on export sophistication and economic complexity that has turned trade data into measures of what countries can make. The third has recently been reinterpreted from the inside, and because that reinterpretation sets the terms on which this paper uses it, Section 3.4 sets it out at some length and in plain terms.

3.1 Technology gaps, sectors and catching up

The Quality Index was published in a volume on the dynamics of technology, trade and growth (Fagerberg, Verspagen and von Tunzelmann, 1994), and it belongs to the evolutionary research programme that volume represents. That programme holds that growth differences between countries are differences in technological capability, that capability accumulates unevenly across sectors and countries, and that catching up is possible but conditional on the ability to absorb and build on foreign technology (Fagerberg, 1994; Verspagen, 1991; Fagerberg and Verspagen, 2002). Dosi, Pavitt and Soete (1990) made the link to trade explicit: comparative advantage is the outcome of cumulative, sector-specific learning rather than of endowments, and countries' trade patterns are the trace of their technological trajectories.

Two results of this programme underpin the index. Pavitt's (1984) taxonomy showed that sectors differ systematically in the sources, appropriability and direction of technical change: supplier-dominated sectors receive their technology embodied in inputs, while science-based and specialized-supplier sectors generate it internally and protect it. Reinert's high-quality activities are Pavitt's science-based and specialized-supplier sectors, and his low-quality activities are the supplier-dominated and resource-based ones. The second result is that catching up is conditional: Verspagen (1991) found that countries below a threshold of absorptive capacity fall further behind rather than converging, which is the evolutionary form of the poverty trap Reinert attributes to specialization at the bottom of the index. Cimoli, Dosi and Stiglitz (2009) draw the policy conclusion that the index implies: the accumulation of capabilities in the right sectors is the object of industrial policy.

3.2 Structural change and growth

The structuralist tradition reached the same conclusion from the demand side. Prebisch (1950) and Singer (1950) argued that primary exporters face a secular deterioration of the terms of trade, because the gains from productivity in primary production are passed on in prices while those in manufacturing are retained in wages, and because the income elasticity of demand for primary products is low. Kaldor (1967) made manufacturing the engine of growth through increasing returns and learning, and Thirlwall (1979) showed that the income elasticities of a country's exports and imports set a ceiling on its growth, which makes the composition of exports a growth variable. These are the mechanisms behind the two modes of Section 2.3 and behind the demand-growth characteristic of the index.

Recent work has documented the patterns the tradition predicts. Imbs and Wacziarg (2003) found that countries diversify as they grow and re-concentrate only at high income; Rodrik (2016) showed that developing countries now deindustrialize at lower income levels than the early industrializers did, losing the engine before it has done its work; and Dosi, Riccio and Virgillito (2021) distinguished patterns of deindustrialization by what is lost, concluding, in a phrase that could be Reinert's, that microchips are not potato chips. The index offers these findings a common scale: structural change is movement along it, and premature deindustrialization is movement down it.

3.3 Export sophistication and economic complexity

The third literature built the measures this paper uses. Lall (2000) classified manufactured exports by technological intensity and showed that developing countries' export growth was concentrated in low-technology and resource-based categories. Hausmann, Hwang and Rodrik (2007) replaced classification with measurement: the income level associated with a product, PRODY, is the specialization-weighted income of its exporters, and the sophistication of a country's basket, EXPY, predicts its subsequent growth. Their finding that what a country exports matters is Reinert's thesis stated as a regression, and their measure is, as Section 4 argues, a revealed counterpart of his index.

Hidalgo et al. (2007) added the structure among products. Proximity, the probability that two products are co-exported, defines a product space with a dense core of manufactures and a sparse periphery of commodities, and countries move through it to nearby products. Hidalgo and Hausmann (2009) then proposed the method of reflections, described in Section 3.4 below, from which the Economic Complexity Index (ECI) of countries and the Product Complexity Index (PCI) of products are derived. The *Atlas of Economic Complexity* (Hausmann et al., 2011) made both standard tools. The country index predicts growth beyond income (Hausmann et al., 2011) and is associated with lower inequality (Hartmann et al., 2017); Felipe et al. (2012) showed that products with high complexity are exported by rich countries and that poor countries rarely make them; Hidalgo (2021, 2023) surveys the theory and its policy use; and Neffke, Henning and Boschma (2011) and Boschma (2017) carried relatedness to regions. Gala, Rocha and Magacho (2018) read the complexity results as a vindication of structuralism, and Gala et al. (2022) related product complexity to the concentration of world markets.

3.4 What the complexity indices turned out to measure

The complexity indices were introduced with an interpretation that has since been shown to be wrong, and replaced by one that is mathematically exact but, on its own, empty of economic content. Since the whole argument of this paper turns on that replacement, this subsection sets it out step by step.

The original story. Hidalgo and Hausmann (2009) start from the binary matrix of revealed comparative advantage: countries in the rows, products in the columns, a one where a country exports a product with above-average intensity. Two counts come straight off the matrix. A country's *diversity* is the number of products in its row; a product's *ubiquity* is the number of countries in its column. The method of reflections then iterates. Replace each country's number by the average of the numbers of the products it exports; replace each product's number by the average of the numbers of its exporters; repeat. The published interpretation was that the

iterations reveal successively finer information about capabilities, and that complexity emerges as diversity corrected by the ubiquity of what is exported, and ubiquity corrected by the diversity of who exports it. On this reading a complex product is, roughly, a rare product made by versatile countries.

What the iteration actually produces. Kemp-Benedict (2014) set out the structure of the procedure, and it is worth restating because it fixes what kind of object the index is. The sequence converges, and it converges to a vector whose entries are identical for every country, a diversity-weighted average of the starting scores. All the information about differences between countries therefore sits not in the limit but in the deviations from it, which shrink geometrically while their pattern settles onto a single direction: the eigenvector belonging to the largest eigenvalue below one. The index the Atlas publishes is that direction. Hidalgo (2021) puts the same point in a line, describing the second eigenvector as "the leading correction to the equilibrium distribution". There is no disagreement here, and none is needed. What follows from it is simply that the index is a contrast, a statement about how countries differ from a common point, rather than a level of anything, and that the published index is not any one of the reflections.

What the orthogonality shows, and what it does not. The second result in Kemp-Benedict concerns that direction. It is *orthogonal* to diversity: summing the index across countries with diversity as the weight, $\sum_c k_c \; ECI_c$, gives exactly zero, and the corresponding statement for products and ubiquity follows as a corollary.

The zero has a precise origin. The averaging step conserves $\sum_c k_c \, x_c$: replacing each product's value by the average over its exporters and each country's by the average over its products leaves that sum unchanged, as the derivation in Section 4.2 shows. The reflections therefore converge to a common limit that absorbs the whole of the sum, and the index is the direction of what remains once that limit is subtracted, which is why its own weighted sum is zero. The zero says that the index is a contrast, centred on the diversity-weighted mean, that carries none of the level of the counts. It does not say, by itself, that the index cannot be ordered like diversity: diversity centred on its own diversity-weighted mean also has a zero weighted sum, and still ranks countries exactly as diversity does. The case against reading the index as diversity corrected by ubiquity does not rest on the orthogonality but on what the index is, the second eigenvector of a matrix built from who exports what, whose ordering is fixed by the whole pattern of co-specialization rather than by any count. The counts enter that construction, through the normalization of the matrix; the orthogonality is a property of the construction, not the argument against the 2009 reading.

None of this is a correction to the Atlas, which has computed the index as an eigenvector since Hausmann et al. (2011) and does not iterate, and Hidalgo (2021) states the eigenvector reading plainly. The iterative exposition was superseded by its own authors. The point matters for two other reasons. The 2009 description still circulates in applied work, where complexity is routinely glossed as refined diversity and read as a count of capabilities accumulated from the matrix. And a paper that proposes a theory of what the index measures has first to establish what kind of object it is measuring: a contrast extracted from the matrix rather than a quantity accumulated from it. We verify both orthogonalities on our own data in Section 10.1, where they hold to numerical precision.

Mealy, Farmer and Teytelboym (2019) add a caution that matters for reading any empirical table. Orthogonality is a statement about a dot product, not about a correlation. Subtracting a mean, which is what standardizing an index to mean zero and variance one does, destroys the zero dot product while leaving the ranking untouched. So the published, standardized index can perfectly well be correlated with diversity, and in country–export data it is: we find a correlation of +0.57 between the standardized ECI and diversity, and of −0.47 between the standardized PCI and log ubiquity. The orthogonality and the correlation are both real and are not in conflict. What the orthogonality establishes is that the axis is a contrast that carries none of the weighted level of the counts. It does not, on its own, determine how the ordering of the index relates to them; that is an empirical matter, and the correlations above answer it for these data.

An alternative account of the income correlation. Kemp-Benedict does not stop at the negative result, and the positive proposal he puts in its place is the one most relevant to this paper. If the index is a similarity ordering rather than a capability count, then the familiar correlation between complexity and income needs a different explanation, and he offers one: countries with similar export baskets have similar export growth, and export growth transmits to income growth through export-led growth and Thirlwall's law. The first serious alternative to the capabilities story was, in other words, a structuralist one, resting on the same balance-of-payments mechanism set out in Section 3.2. This paper stands in that line, and what it adds is resolution rather than mechanism. The structuralist account already explains why some activities pay more than others: Singer's division of productivity gains between prices and wages is precisely that argument, and Section 2.3 noted that Reinert's own mechanism is Singer's. What the tradition does not supply is a scale. Prebisch, Singer and Kaldor work with a dichotomy between primary production and manufacturing, and Thirlwall's law with two aggregate elasticities, while the axis under discussion is defined over 1,241 products, a level at which that dichotomy has little to say. Reinert's contribution is to restate the same distinction as a continuum that runs through sectors rather than between them — golf balls and baseballs share a heading — and to name the observable characteristics that place an activity along it. That is what makes the scale measurable from trade data, and it is what this paper measures.

What the index is instead. Mealy, Farmer and Teytelboym (2019) and van Dam et al. (2021) identified the calculation with correspondence analysis, a method that ecologists have used for half a century and whose iterative form, reciprocal averaging (Hill, 1973), is the method of reflections under another name. Correspondence analysis takes a two-way table of presences and absences and compresses it onto a small number of axes. The ecological use makes the logic vivid: given a table of which bird species occur at which sites, the method draws a line on which sites hosting similar species are near each other and species occurring at similar sites are near each other. Replace sites by countries and species by products and the method is economic complexity. The ECI is the position of a country on the first such line, the PCI the position of a product, and the PCI of a product equals, up to scale, the average ECI of its exporters.

Three things follow from the identification, and all three matter here.

The first is that the axis is a *similarity* ordering, not a quality ordering. It says that two countries are close because they export the same things, and that two products are close because the same countries export them. It says nothing, by itself, about whether either is any good. Van Dam et al. read the familiar correlation between the ECI and income in exactly this spirit: countries with similar export baskets have similar wealth.

The second is that there is not one axis but many. Correspondence analysis produces an ordered sequence, each axis carrying a declining share of the table's total variance, which in this literature is called inertia. The ECI is only the first. Nomaler and Verspagen (2024) report that it carries about 4 percent of the inertia in five-digit trade data; we find 3.8 percent in four-digit data, with the next two axes carrying 2.7 and 2.3 percent (Section 10.1). Whatever is in the other 96 percent is set aside when a researcher uses the ECI alone, although, as Section 10 shows, a small share of the inertia is not the same as a small share of the economically relevant information. Van Dam et al. (2021) and Bottai, Di Iorio and Iori (2024) show that the later axes carry structure of their own.

The third is the interpretation problem, and it is the sharpest of the three. An axis extracted from a matrix with no outside information has no meaning attached to it. Hide the country names and the product descriptions and the ECI is a column of numbers. Meaning has to come from somewhere else, and in practice it has come afterwards, by correlating the index with whatever country-level variable was to hand. Nomaler and Verspagen (2024) argue that this is why the complexity literature has found its index correlated with almost everything — growth, inequality, emissions, health, unemployment — while remaining unable to say what it is. Their remedy is to bring the external variables in beforehand, through canonical correspondence analysis (Ter Braak, 1986), in which chosen country variables constrain the axes, yielding as many interpretable dimensions as there are variables. Their first canonical axis, built around GDP per capita and other level-of-development variables, nearly coincides with the ECI; growth loads instead on the higher dimensions. We run the one-variable version of their procedure in Section 10.4.

A fourth line: the shape of the matrix and the wrong average. Tacchella et al. (2012) and Cristelli et al. (2013) attacked the method from a different direction. Sort the rows and columns of the country–product matrix and it is not block-diagonal, as a world of specialized niches would be, but close to triangular: diversified countries export almost everything, and rare products are exported almost only by diversified countries (Caldarelli et al., 2012). In a structure of that shape, they argue, the arithmetic mean is the wrong functional form for a "who exports this" question. If a poorly diversified country manages to export a product at scale, that is strong evidence the product is simple, and averaging destroys the evidence. Their algorithm therefore makes a country's fitness the sum rather than the average of its products' complexity, and bounds a product's complexity by the fitness of its *least* fit exporter.

That argument applies with equal force to the income-based score this paper uses, which is also a mean over exporters, and Reinert's own criterion is closer to theirs than to the mean: the fact that Haiti could be the world's most efficient producer of baseballs settles, for him, that baseballs are a low-quality activity, whatever the income of the other countries that sew them. Section 10.2 takes the objection seriously and measures the score both ways.

Where the originators now stand. It would misread the state of the field to treat the reinterpretation as a position the complexity literature resists. Hidalgo's (2021) survey adopts most of it. The ECI is presented there as "a dimensionality reduction technique", the indices are identified as the eigenvectors of the two normalized matrices and as principal components of the specialization matrix, the connection to singular value decomposition is set out in a box, and the leading eigenvector is read, with Mealy et al., as the vector "that is best at dividing economies

into groups based on the activities that are present in them". The 2009 reading of complexity as refined diversity has been retired by its own authors.

Two things, however, are not conceded, and they are where this paper's empirical contribution falls. The first is the orthogonality, which appears in that survey under the heading of common misconceptions and is deployed in the opposite direction from the one it was proved in: the misconception to be corrected is the equation of complexity with diversity or concentration, and the answer is that the ECI "is orthogonal — or nearly orthogonal — to measures of diversity or concentration". The orthogonality cannot carry that defence, any more than it could carry the original critique: a zero weighted sum is compatible with an index that orders countries much as diversity does, and in these data the standardized index correlates +0.57 with diversity. Kemp-Benedict (2014), who proved the result, is not cited. The second is that a method described as dimensionality reduction is nowhere asked how much it reduces. The survey reports no share of variance or inertia for the leading dimension and does not discuss the dimensions beyond it. Section 10.1 supplies the figure: 3.8 percent.

The treatment of the Fitness–Complexity objection is of the same kind. In the survey it is classified among "variations in the functional forms" for the averaging operators, and answered with correlations — the ECI and log fitness correlate at r^2 of 0.86 in trade data and 0.90 in United States employment data, and "these variations yield similar results". High correlation between two rankings is not an answer to the claim that one of them uses a statistic that discards the informative part of the distribution. Section 10.2 puts that claim to a direct test instead.

The four lines therefore converge on one conclusion, and it is not a contested one. The complexity index is an exact statistical summary of who exports what, whose content is the dominant pattern of co-specialization in world trade, and whose meaning must be supplied from outside the matrix. Hidalgo (2021, 2023) supplies capabilities; Nomaler and Verspagen supply country variables chosen for their availability. This paper proposes Reinert's theory as an economically grounded reading, one consistent with the evidence rather than the only one the matrix admits.

3.5 What this paper adds

Once the index is understood as a summary line through the trade matrix rather than as a count of capabilities, the question it cannot answer for itself becomes conspicuous: why should the dominant pattern of co-specialization in world trade be an ordering by income at all? Hidalgo (2023) frames the gap precisely, separating relatedness, which says what an economy can feasibly enter, from complexity, which says what is worth entering, and noting that the second rests on the empirical association between complexity and income rather than on a theory of activities.

It would be wrong to say that the literature offers no account. Hidalgo's is that exporting a product competitively requires the capabilities it needs, so that the matrix records which countries hold which capabilities and a summary of the matrix summarizes capability endowments. That is coherent, and the matrix is consistent with it. The difficulty is that the matrix is consistent with more than one reading at once: with Kemp-Benedict's, in which the axis orders countries by the similarity of their baskets, and with the one advanced here. Nothing in the matrix selects among them. What can distinguish them is whether a reading commits to

anything beyond the index. The capabilities account makes no prediction about the product side that is independent of the index, since capabilities are unobserved and are inferred from the very exports they are invoked to explain. Reinert's account does commit: activities high on the scale should have few entrants, broad capabilities behind the barrier, dense links to other activities, stable prices and growing demand, and each of these is measurable without reference to the index or to income. Sections 6 and 10 put them to the data.

Reinert's index offers such a theory. It says which activities rich countries hold in common and why: those protected by barriers of knowledge and scale, subject to increasing returns and imperfect competition, in which the gains from productivity are retained as wages rather than passed on as prices. It names in advance the external variable the axis should be read against, the wage an activity can support, and it names the product-side features that should accompany it. Where Nomaler and Verspagen constrain the axis by whichever country variables are available, Reinert says which variable belongs there and why.

This paper connects the two. It reads PRODY as the score of Reinert's index, the product-side analogue of the PCI with income in place of the data-chosen axis; it reads ubiquity, the diversity of exporters, product-space centrality, trade stability and demand growth as traces of the characteristics Reinert lists, noting that the first two are exactly the zeroth and first reflections of Hidalgo and Hausmann (2009); and it tests whether the characteristics and the axis predict the score. It then uses the measures to reproduce Reinert's cases across the whole of world trade.

Section 10 returns the theory to the method, in the two places the previous subsection identified as unsettled. The first is the size of the compression: a method described as dimensionality reduction is measured here against the thing it reduces, and the leading axis is found to carry 3.8 percent of the matrix's inertia while accounting for about half of the variation in exporters' income, with the published index lying close to that axis but not on it. The second is the functional form: rather than comparing rankings, we rebuild the score with the lower tail of exporters' incomes in place of the mean and ask what changes, and the answer is that Reinert's ladder lengthens, his characteristics become half again as predictive, an anomalous coefficient reverses to its theoretical sign, and the resource-rent exceptions dissolve. A third result falls out of the same exercise and belongs to neither literature: two of the five characteristics Reinert names are only weakly recoverable from linear combinations of the trade matrix's axes, which is what one would expect of properties of movement over time measured against a cross-section.

The contribution is therefore not a new algorithm but an economic interpretation of existing ones, together with evidence on two points where the existing ones need repair and one where the measures built from the trade matrix capture little.

4 From the index to trade data: what can be observed

Trade data provide a revealed proxy for the outcome that defines the index, indirect measures of five of its characteristics, and the leading axis of the country–product matrix. They do not observe learning curves, R&D, the indivisibility of investment, wages within activities or prices. The measures below construct the outcome, the characteristics and the axis separately, from distinct transformations of the trade data.

4.1 The score: capacity to support high wages

Reinert defines an activity's score as the degree to which it can support a high wage and a high standard of living for the nation that exports it. Trade data do not record that capacity, but they record its revealed association with income: an activity that high-income countries export competitively is one compatible with high national wages, and an activity exported mainly by low-income countries is one in which low wages are typically the condition of selling abroad. The association is with the income of the exporting country, not with the wage paid in the activity, which may differ from the national average because of technology, natural resources, subsidies or the internal wage structure. Hausmann, Hwang and Rodrik (2007) defined the income level associated with a product as the average income of its exporters, each weighted by its revealed comparative advantage in the product:

$$PRODY_p = \sum_c \frac{x_{cp}/X_c}{\sum_{c'} x_{c'p}/X_{c'}} Y_c$$

where x_{cp} is country c's exports of product p, X_c its total exports and Y_c its income per capita. The weights are each country's share of p in its own basket relative to the sum of those shares across countries, so a small country specialized in a product counts as much as a large one exporting it in passing. We read it as a revealed counterpart of Reinert's Quality Index: the income level of the economies that actually export the activity. Whether that income reflects wages earned in the activity itself is part of Reinert's hypothesis, and Section 11 returns to what testing it would require. Section 10.2 asks whether the mean is the right summary and reports the alternative.

4.2 The leading axis: product complexity as correspondence analysis

Let M be the $m \times n$ matrix with $M_{cp} = 1$ if country c has revealed comparative advantage of at least one in product p (Balassa, 1965) and zero otherwise. Diversity is $k_c = \sum_p M_{cp}$ and ubiquity $k_p = \sum_c M_{cp}$. The method of reflections of Hidalgo and Hausmann (2009) defines

$$k_{c,N} = \frac{1}{k_c} \sum_p M_{cp}\ k_{p,N-1}, \qquad k_{p,N} = \frac{1}{k_p} \sum_c M_{cp}\ k_{c,N-1},$$

with $k_{c,0} = k_c$ and $k_{p,0} = k_p$. The first product reflection, $k_{p,1}$, is the average diversity of a product's exporters, and it is one of the five characteristics measured below. The ECI is the eigenvector associated with the second-largest eigenvalue of the matrix $\tilde{M}$ with elements $\tilde{M}_{cc'} = \sum_p M_{cp}\, M_{c'p}/(k_c k_p)$, and the PCI of a product is, up to normalization, the average ECI of its exporters:

$$PCI_p \propto \frac{1}{k_p} \sum_c M_{cp}\ ECI_c.$$

Two properties govern how these objects are used here. First, $\tilde{M}$ is row-stochastic, its leading right eigenvector is constant, and the left eigenvector belonging to the same eigenvalue is proportional to diversity; every other right eigenvector is therefore orthogonal to diversity, $\sum_c k_c\ ECI_c = 0$. Summing the definition of the PCI against ubiquity gives

$$\sum_p k_p \; PCI_p \propto \sum_p \sum_c M_{cp} \; ECI_c = \sum_c k_c \; ECI_c = 0,$$

so the PCI is orthogonal to ubiquity as a corollary (Kemp-Benedict, 2014; Mealy et al., 2019). Section 10.1 confirms both, and the identity linking them, numerically. Second, the ECI and PCI are the first non-trivial axis of a correspondence analysis of M, one of a full sequence of axes (Mealy et al., 2019; van Dam et al., 2021).

Now compare the PCI with the score. Both are averages over a product's exporters of a country attribute:

$$PCI_p \propto \sum_c \frac{M_{cp}}{k_p} \; ECI_c, \qquad PRODY_p = \sum_c w_{cp} \; Y_c,$$

where w_{cp} are the RCA weights of the previous subsection. The form is the same, but the weights differ, binary in one and proportional to specialization in the other, so the two measures change the weights as well as the attribute, and the correspondence between them is conceptual rather than exact. In the PCI the attribute averaged is each exporter's position on the dominant axis of the matrix itself, an attribute the data choose; in PRODY it is the exporter's income, an attribute the theory chooses. A regression of the score on the PCI therefore measures how closely the leading axis of world trade specialization coincides with the income of exporters, product by product. What neither statement supplies is the reason the dominant axis should be an income axis at all. Reinert's index offers one.

4.3 The characteristics

Five of the characteristics Reinert lists leave traces in the structure of world markets.

1. **Barriers to entry.** Reinert's high-quality activities are protected by scale-based and knowledge-based barriers. The trace of a barrier is the number of countries that clear it. Ubiquity, k_p, counts them; low ubiquity marks a market few countries have managed to enter at scale, whether because of knowledge and scale or because of geology, geography and other natural conditions.

2. **Breadth of capabilities behind the barrier.** A scarce mineral and a scarce technique both produce low ubiquity. Reinert's top activities are those where the barrier is knowledge, which travels across products, rather than a deposit, which does not. The average diversity of a product's exporters, $k_{p,1}$, separates the two. These first two characteristics are the zeroth and first reflections of Hidalgo and Hausmann (2009), the quantities their original interpretation of complexity was built on, and they enter the analysis as raw counts alongside, and independently of, the leading axis.

3. **Synergies.** High-quality activities create large synergies through linkages and clusters; low-quality ones create few. The product space of Hidalgo et al. (2007) measures the proximity between two products by the probability that a country exports both. A product's centrality, the sum of its proximities to all other products, measures how strongly the capabilities it uses are shared with the rest of the economy.

4. **Stability of trade values.** Schumpeterian activities have stable prices, Malthusian ones extreme fluctuations. Without price and quantity data the closest trade measure is the volatility of the world value of a product's trade, which mixes price and quantity movements and is therefore an indirect trace of price stability rather than a measure of it: the standard deviation of the annual change in the log of world exports of the product, net of the change in total world trade, over 1995–2024.

5. **Growth of demand.** Reinert's high-quality activities are those with high growth in output, which echoes the structuralist argument about the income elasticity of demand for manufactures. We measure growth as the annual change in the log of the product's share of world trade between 1995–97 and 2022–24.

The last two are computed from the time dimension of trade values, which the binary cross-sectional matrix M discards. Section 10.3 shows what that costs any measure built from M alone. The other characteristics Reinert lists are beyond trade data entirely. This matters most for the mechanism of Section 2.3: the division of productivity gains between prices and wages requires sectoral data on prices, costs and wages, which this paper does not use.

4.4 What the test is

The test is whether the characteristics, measured from the structure of markets, and the leading axis, extracted from the binary matrix, line up with the score, measured from the income of exporters. All three are of course built from the same export data; what matters is a narrower and more useful independence. Income enters the score and nothing else: the characteristics are computed from export values and revealed advantage alone, and the axis from the binary matrix alone. Neither the characteristics nor the axis can know how rich an exporter is except through the pattern of who exports what. That is the sense in which the high association between the axis and the score, reported in Table 2, is informative rather than mechanical. If Reinert's index describes something real about activities, products with few, diversified exporters, central positions in the product space, steady trade and growing demand should be products whose exporters are rich, and the dominant axis of co-specialization should be an income axis for the reasons he gives.

5 Data

Trade data come from the country–product–year files of the Atlas of Economic Complexity (Growth Lab at Harvard University, 2019) at the 4-digit level of the 1992 Harmonized System, covering 1995–2024. After dropping unspecified trade, 1,241 products have positive world exports in every year. The Atlas also supplies each product's PCI, which the tables below use. Section 10.1 rebuilds the index from the matrix, shows that the published series does not satisfy the eigenvector relation that the results of Section 10 rest on, and reports every affected result under both versions.

The characteristics are computed over the 209 economies that report positive exports in every year. Revealed comparative advantage is averaged over three-year windows to smooth year-to-year noise; ubiquity, the diversity of exporters and product-space centrality use the 2022–24

window. Volatility uses annual world export values for 1995–2024 and growth compares the shares of 1995–97 and 2022–24.

Income per capita comes from the Maddison Project Database (Bolt and van Zanden, 2020), in 2011 international dollars, and is available for 157 of the 209 economies. Its last year is 2018, which is used with the 2022–24 export baskets to compute PRODY; 1995 incomes are used for the 1995–97 baskets in Section 9.

Three limitations should be kept in view. The unit is the country, not the firm or the worker, so PRODY measures the income of exporting countries, not the wages paid in the activity. A 4-digit heading can mix activities of very different quality, which is exactly Reinert's golf-ball and baseball problem: both sit in heading 9506. And trading hubs such as the Netherlands, Singapore and the United Arab Emirates appear as exporters partly through re-exports, which raises the measured income of some products. The code that builds every table is included in the replication package.

6 The quality ladder in world trade

The income of a product's exporters varies by a factor of about 3.6 between the bottom and the top fifth of products, and the characteristics Reinert attributes to high-quality activities rise along that scale.

6.1 The ladder

Table 1 groups the 1,241 products into quintiles of PRODY, the income-weighted score of Section 4.1, computed from 2018 incomes and 2022–24 export baskets.

Table 1: *The quality ladder: medians by PRODY quintile, 2022–24*

Quintile	PRODY (2011 $)	Exporters	Diversity	Volatility	PCI	Primary (%)	Chem./mach. (%)
1 (lowest)	8,906	27	203	0.142	−1.11	42	9
2	16,286	28	240	0.108	−0.41	34	13
3	22,068	22	266	0.108	0.27	14	29
4	26,948	20	279	0.095	0.64	9	46
5 (highest)	32,137	16	282	0.117	0.95	8	57

Values are medians within each quintile. Exporters are countries with RCA of at least one; diversity is the number of products in which an exporter holds RCA of at least one, averaged over the product's exporters; volatility is the standard deviation of the annual log change in world exports of the product relative to total trade. Primary products are HS chapters 01–27; chemicals, machinery and instruments are chapters 28–38 and 84–90. Median product-space centrality, not shown, is 168, 195, 199, 210 and 184 from the lowest to the highest quintile.

The ladder has the shape Reinert described. Primary products make up 42 percent of the bottom quintile and 8 percent of the top; chemicals, machinery and instruments 9 and 57 percent. Moving up, the number of countries able to export a product at scale falls from 27 to 16, the exporters become more diversified, and the PCI rises by two standard deviations. The relations are not all monotonic: centrality peaks in the fourth quintile, and volatility drops sharply after the first quintile but rises again at the top. The bottom of the ladder is where trade values fluctuate most.

That the PCI rises monotonically with the score is, on the reading of Section 4.2, the statement that the leading axis of the trade matrix is ordered by the income of exporters. The direction of a correspondence axis is arbitrary, and the sign convention the Atlas adopts is the one that makes it rise with diversity; the finding is that a single sign suffices for the whole ladder.

The extremes are telling. The eight lowest-scoring products, with PRODY between 1,771 and 2,120 dollars, are cloves, cobalt ores, carded cotton, uranium and thorium ores, wigs and false hair, tungsten ores, coconuts and cashews, and vanilla: spices, nuts, fibres and ores. The twelve highest-scoring, above 44,000 dollars, are hormones, sulphonamides, heterocyclic and carboxyamide compounds, halogenated hydrocarbons, blood fractions and vaccines, residual lyes from wood pulp, precious-metal wrist watches, photographic laboratory apparatus and machine tools: fine chemicals, pharmaceutical intermediates and precision instruments.

Across the broad product groups the pattern is the same. Agricultural and food products have a median PRODY of 15,312 dollars and median volatility of 0.125; minerals and fuels 14,163 dollars and 0.172; chemicals, machinery and instruments 27,343 dollars and 0.103; other manufactures 21,679 dollars and 0.111.

These figures raise the oldest question in the tradition of Section 3.2, and the paper should answer it directly: is Reinert’s scale simply the familiar division between primary production and manufacturing? For Reinert that contrast is the origin of the index and its first dimension, and the data reproduce it strongly. The gap in exporter income between minerals and fuels and between chemicals, machinery and instruments is close to two to one; primary products fall from 42 to 8 percent of a quintile as one climbs; and the ordering holds within chains as well as between aggregates, as the nine pairs of Section 7 show. The exceptions fall where his second dimension and his treatment of resource rent lead one to expect them. Semi-finished stainless steel is a mature manufacture led by Indonesia, and hand-rolled cigars share a heading with machine-made cigarettes, which is his point that manufactures can sit as low as commodities. Crude petroleum and raw wool are primary products exported by rich countries, the resource-rent and recent-settlement cases he set apart. Bulk tobacco leaf scores below sugar, the one case in which these data reverse Reinert’s own reading outright, taken up at the end of Section 7. Section 10.2 shows that these failures are systematic rather than incidental: an average over exporters lets a few rich ones disguise an activity that poor countries can still enter at scale, and scoring by the income floor removes the disguise, which is why the resource-rent exceptions dissolve under it. The contrast between industry and raw materials is the first approximation on which Reinert built the index, accurate in the aggregate. The index refines it product by product, which is the level at which both the complexity axis and his scale are defined.

6.2 Which characteristics are associated with exporter income

Table 2 reports regressions of the log of PRODY on the standardized characteristics and on the leading axis. Each coefficient is the change in log exporter income associated with a one-standard-deviation change in the regressor. Robust standard errors are in parentheses.

Table 2: *Reinert's characteristics, the leading axis and the income of exporters (dependent variable: log PRODY), under each version of the index*

	(1)	(2)	(3)	(4)	(5)
log ubiquity	−0.209	+0.147		+0.072	
	(0.043)	(0.035)		(0.036)	
Diversity of exporters	+0.100	+0.006		−0.002	
	(0.039)	(0.029)		(0.031)	
Centrality	+0.184	−0.079		−0.033	
	(0.036)	(0.029)		(0.030)	
Volatility	−0.063	−0.034		−0.016	
	(0.024)	(0.015)		(0.019)	
Demand growth	+0.035	+0.037		+0.006	
	(0.016)	(0.012)		(0.014)	
PCI		+0.514	+0.422	+0.448	+0.406
		(0.022)	(0.014)	(0.021)	(0.014)
R^2	0.300	0.595	0.562	0.529	0.521
Products	1,241	1,241	1,241	1,241	1,241

Columns (1) to (3) use the published Atlas index; columns (4) and (5) repeat (2) and (3) with the index rebuilt from the trade matrix, as Section 10.1 explains.

Every characteristic enters column (1) with the sign Reinert's index predicts. Products with fewer exporters, more diversified exporters, more central positions in the product space, steadier trade and growing demand are exported by richer countries. Together the five explain 30 percent of the variation in exporter income. A one-standard-deviation fall in log ubiquity is associated with exporters 23 percent richer, a one-standard-deviation rise in centrality with exporters 20 percent richer. Column (1) is also a test of the original interpretation of complexity: the zeroth and first reflections, taken as raw counts, do carry information about the income of an activity's exporters, and in the direction Hidalgo and Hausmann (2009) and Reinert both predict.

The leading axis does better alone than the five characteristics together, explaining 56 percent of the variation with the published index and 52 percent with the rebuilt one. That it explains nearly twice as much as all five characteristics together shows that it is more than a refined version of the first two. The reason is that the dominant pattern of co-specialization in world trade is a sorting of products by the income of the countries that share them: products at the same point of the axis are exported by the same countries, and those countries have similar incomes. The axis and Reinert's scale are distinct objects, one a summary of joint specialization and the other a

ranking of activities by their economic characteristics; their empirical proximity is the result, and Reinert's index offers an account of why the sorting should take this form.

Once the axis enters, the first two reflections lose their independent role: the coefficient on the diversity of exporters falls to zero, and the coefficient on ubiquity changes sign. The reversal is weaker with the rebuilt index, +0.072 against +0.147, which is the first sign that it is not a property of the world. We read the reversal as a conditional association, not a mechanism, and Section 10.2 shows that it is an artefact of measuring the score by a mean: under the lower-tail score the reversal disappears. Centrality behaves similarly, which is to be expected, since the product space and the correspondence axis are two summaries of the same co-export structure.

Volatility and demand growth survive the inclusion of the axis with their signs intact, though with the rebuilt index the increment is small: the five characteristics raise the R^2 from 0.521 to 0.529. Most of what the characteristics have to say about exporter income is already in the axis, which is what Section 4.2 would lead one to expect, and the case for measuring them separately rests on the two places where they are not: the income floor of Section 10.2 and the time dimension of Section 10.3. Section 10.3 shows the stronger statement: linear combinations of the matrix's axes recover them only weakly, at every dimensionality examined. Products whose trade values are steadier and whose share of world trade is rising have richer exporters at every level of complexity, which is consistent with the stability and demand side of the Schumpeterian–Malthusian distinction, the side that Prebisch, Singer and Thirlwall emphasized, though trade-value volatility is only an indirect trace of price stability.

7 Counterpoints: raw materials and their processed forms

In all nine pairs of a raw material and a product made from it, the processed good is exported by richer countries, sits higher on the leading axis, and has steadier trade. This is Henry VII's wool-and-cloth observation measured across world trade. Ortiz's Cuban counterpoint is a contrast between two activities rather than a chain of transformation, and is taken up separately at the end of this section.

Table 3: *Nine counterpoints (PRODY in 2011 dollars; HS codes in parentheses)*

Raw material	PRODY	Vol.	PCI	Processed product	PRODY	Vol.	PCI
Cocoa beans (1801)	4,128	0.239	−4.51	Chocolate (1806)	22,980	0.081	−0.19
Natural rubber (4001)	4,959	0.236	−2.90	Tyres (4011)	21,382	0.051	+0.25
Coffee (0901)	5,070	0.139	−2.00	Coffee extracts (2101)	17,378	0.082	−0.57
Raw cotton (5201)	3,573	0.149	−3.43	Cotton fabrics (5208)	10,241	0.063	−1.02
Logs (4403)	9,977	0.097	−1.75	Coated paper (4810)	34,537	0.061	+0.73
Iron ore (2601)	14,158	0.208	−2.31	Hot-rolled steel (7208)	23,232	0.160	+0.30
Crude oil (2709)	21,332	0.215	−3.20	Polyethylene (3901)	32,477	0.059	+0.21
Raw wool (5101)	22,214	0.138	−1.35	Wool fabrics (5112)	27,746	0.125	+0.50

Raw material	PRODY	Vol.	PCI	Processed product	PRODY	Vol.	PCI
Raw hides (4101)	15,584	0.154	−1.38	Finished leather (4107)	16,502	0.151	−1.20

The largest gaps are in tropical crops. Cocoa beans are exported by countries with a fifth of the income of chocolate exporters, and their trade value is three times as volatile. Natural rubber and tyres show the largest fall in volatility in the table: the trade value of rubber is more than four times as volatile as that of tyres, a reminder of the boom and collapse of the Amazonian rubber economy. Coffee and coffee extracts, cotton and cotton fabric, logs and coated paper repeat the pattern. In each case the raw material is grown or extracted where it can be, and the processing that adds learning, scale and brands takes place elsewhere.

The leading axis and the score move together across the pairs, but only loosely. In all nine the processed good lies further along the axis. The size of the two gaps is positively but imperfectly associated, with a rank correlation of 0.57: the widest on both measures are cocoa and chocolate and rubber and tyres, and the narrowest on both are hides and leather. The clearest discrepancies are crude oil and polyethylene, which has a wide gap on the axis and a narrow one in income, and raw wool and wool fabrics, where the income gap is also narrow.

Two pairs qualify the picture, and each qualification is one Reinert anticipated. Raw wool scores high because it is exported by Australia, New Zealand and South Africa, which together hold more than four fifths of the market; these are the areas of recent settlement that Reinert treats as the exception, rich commodity exporters that protected their own industries at the same time. Crude petroleum scores high because many oil exporters are rich, but the richness is resource rent rather than industry rent, and crude has among the most volatile trade values in the data. In both cases the axis places the product low while the score places it high: the exporters of wool and crude oil are rich, but they are not the countries that export what other rich countries export. Section 10.2 shows that this discrepancy is not a feature of the world but of the mean: under a lower-tail score both products fall into line and the pairs widen to 4.7 and 2.5 times.

Hides and finished leather are close on all three measures. Tanning is a mature industry, and the small gap is consistent with Reinert's description of mature manufactures: once they stop changing technically, processing adds little quality to the raw material.

Ortiz's counterpoint is a different kind of comparison and deserves separate treatment, because it contrasts two crops rather than a raw material with the good made from it, and because these data cannot represent it. Sugar has a PRODY of 10,684 dollars. Unmanufactured tobacco, heading 2401, has one of 3,048: on this measure tobacco today is a *poorer* activity than sugar, the reverse of what Ortiz described. Tobacco products, heading 2402, score 12,508, but that heading mixes hand-rolled cigars with machine-made cigarettes and its leading exporters are Poland, the United Arab Emirates and Germany, not Cuba. Tobacco in Ortiz's sense, skilled, branded and grown by free farmers, is neither the bulk leaf of 2401 nor the mass manufacture of 2402. His counterpoint does not survive the 4-digit classification in either direction. This is the clearest instance in the paper of Reinert's own warning that quality lives at a finer level than any classification captures, and a reminder that a product heading is a weak proxy for an activity.

8 Schumpeterian underdevelopment: leading exporters and poor

Poor countries lead world markets almost only at the bottom of the complexity scale. They are the largest exporter of 26 percent of the least complex products and of 1 percent of the most complex.

Reinert's claim is that underdevelopment is a matter of what a country is efficient at, not of whether it is efficient. Trade data do not measure efficiency, but leadership in a world market is the plainest evidence of competitiveness they offer, and it is enough for the claim: if poor countries lead world markets, and do so only at the bottom of the scale, then what keeps them poor is not an inability to compete but what they compete in. Leadership may reflect productivity, but also natural endowments, size, low labour costs, location or trade policy. Table 4 classifies the largest exporter of each product in 2022–24 by its income quartile, with products grouped by PCI rather than by PRODY so that the grouping, which is computed from the binary matrix alone, does not itself depend on income.

Table 4: *Income quartile of the largest exporter, by PCI quintile, 2022–24*

PCI quintile	Poorest (%)	Lower-mid. (%)	Upper-mid. (%)	Richest (%)	Leader share
1 (lowest)	7	18	43	32	28%
2	0	3	60	37	26%
3	0	4	54	42	27%
4	0	1	54	45	26%
5 (highest)	0	1	50	49	25%

Income quartiles are defined by 2018 income among the 157 economies with Maddison data for that year; China falls in the upper-middle quartile. The last column is the median share of world exports held by the leader.

The leaders of the least complex markets hold as large a share of world exports as the leaders of the most complex, about a quarter. They are as dominant. What differs is who they are. Countries in the poorer half of the income distribution lead 26 percent of the markets in the bottom quintile and almost none above it. The richest quarter leads half of the most complex markets. In total, 87 products have a leader from the poorer half of the world, and they are concentrated at the bottom of the scale:

- **Côte d'Ivoire:** cocoa shells and husks (92 percent of world exports).
- **Bangladesh:** jute and other textile bast fibres (90 percent), raw jute (70 percent).
- **Indonesia:** lignite (86 percent), nickel mattes and intermediates (57 percent), palm oil (51 percent), palm nuts and kernels (45 percent).
- **India:** guts and bladders (85 percent), spices (50 percent), prepared feathers and down (55 percent).
- **DR Congo:** cobalt ores (77 percent), cobalt oxides (73 percent), cobalt mattes (52 percent).
- **Guinea:** aluminium ores (74 percent).
- **Madagascar:** vanilla (60 percent).

- **Sudan:** oil-cake and residues (48 percent).
- **Mali:** cotton, not carded (47 percent).

These are the world's leading exporters of what they export, and they remain in the poorer half of the world. It is the US farmer of the 1930s, the Cuban sugar worker and the Haitian baseball sewer of Reinert's examples, placed in separate nations as his thought experiment proposed. The productivity of the Ivorian cocoa grower or the Malagasy vanilla farmer reaches buyers abroad as low prices.

The table is also the nested structure of Cristelli et al. (2013) seen from the top of each market. The products at the bottom of the axis are the ones that poor countries can lead because they are the ones poor countries can export at all; the products at the top are led by rich countries because almost no one else exports them. Reinert's reading of that triangle is that its shape is not an accident of capabilities alone but of what the activities at each corner pay.

One exception points the other way. Indonesia also leads world exports of semi-finished stainless steel, with 57 percent, a product with a PCI of +0.92. It reached that position after restricting exports of nickel ore and requiring processing at home, which is the policy that Reinert, following List and the cameralists, recommends: use the raw material as leverage to enter the activity above it.

9 Countries on the ladder

A country's position on Reinert's scale, measured by the quality of its export basket, tracks its income closely, changes slowly, and is modestly associated with faster growth over the following two decades.

9.1 Export quality and income

The quality of a country's exports is the average score of its products, weighted by their share in its basket. Hausmann, Hwang and Rodrik (2007) call this EXPY. Because the score of each product is computed from exporters' incomes, a country's own income enters its own EXPY. To remove this circularity, each product's score is recomputed for each country with that country left out:

$$EXPY_c = \sum_p \frac{x_{cp}}{X_c} \, PRODY_p^{(-c)}$$

where $PRODY_p^{(-c)}$ is the score of product p computed from all exporters other than c. A country's export quality then reflects only the income of the other countries that export the same products.

The correlation between the log of export quality and the log of income per capita across the 157 economies is 0.79 in 1995 and 0.77 in 2022–24. Rich countries export what other rich countries export, and poor countries what other poor countries export, which is the sorting Reinert's index predicts and, in the language of Section 4.2, the country-side statement that the dominant axis of co-specialization is an income axis.

9.2 Mobility

Positions on the scale change slowly. Table 5 cross-tabulates countries' quartile of export quality in 1995–97 against their quartile in 2022–24.

Table 5: *Mobility of export quality, 1995–97 to 2022–24 (number of countries)*

Quartile in 1995–97	Q1 in 2022–24	Q2	Q3	Q4	Countries
1 (lowest)	30	9	1	0	40
2	9	17	7	6	39
3	1	13	20	5	39
4 (highest)	0	0	11	28	39

Over nearly three decades, 61 percent of countries stayed in the same quartile. Of the 40 countries with the lowest export quality in 1995–97, 30 were still in the bottom quartile in 2022–24 and none had reached the top. No country completed the climb Reinert describes, from the bottom of the index to its top, within these three decades, and three quarters of those at the bottom did not leave the bottom quartile. The matrix records that the climb did not happen in this period; it does not establish how long it would take.

9.3 Export quality and growth

For the 157 economies, the annual growth rate of income per capita between 1995 and 2018 is regressed on the log of initial income and the log of initial export quality. With initial income alone the coefficient is small and insignificant (-0.0017, $t = -1.34$). Adding export quality, its coefficient is 0.021 ($t = 2.71$) and the coefficient on initial income becomes -0.0069 ($t = -2.72$). Conditional on its income in 1995, a country whose exports were 10 percent higher on the quality scale grew about 0.2 percentage points faster per year over the following 23 years. The regression explains 6 percent of the variation in growth, and the result reproduces with these data the finding of Hausmann, Hwang and Rodrik (2007) that what a country exports matters for its growth. It is a correlation, not an estimate of the effect of moving up the scale, and its size is modest.

10 The index and the geometry of the trade matrix

This section takes the measures back to the method. Section 3.4 set out four claims from the recent literature: that the complexity index is orthogonal to the counts, that it is one axis of a correspondence analysis among many, that the mean is the wrong summary for a nested matrix, and that an unconstrained axis cannot be interpreted without outside information. Each is testable on these data, and each bears on how Reinert's index should be measured.

10.1 The leading axis and its share of the matrix

The claims of Section 3.4 concern the index as an eigenvector, so we rebuild it from the binary matrix of 209 economies and 1,241 products, by the method of Section 4.2 and by a full correspondence analysis. The two coincide: the first non-trivial correspondence axis correlates 1.0000 with the rebuilt ECI on the country side and 1.0000 with the rebuilt PCI on the product

side. The orthogonalities derived in Section 4.2 hold, as they must, to numerical precision: $\sum_c k_c \; ECI_c$ and $\sum_p k_p \; PCI_p$ are both of order 10^{-12} against a scale of order 10^3, and they are equal to each other.

The index the Atlas publishes is close to this axis but does not lie on it. It correlates 0.93 with the rebuilt index (Spearman 0.94), but correlation is not the test of an axis. An axis reproduces itself under the reflection operator up to a scalar; the rebuilt index does so with a residual of zero, the published one with a residual of 0.080, and 88.5 percent of its variance lies along the leading eigenvector. The difference is not explained by the country sample, the time window, the product universe or the normalization, and no threshold for binarizing the matrix reproduces the published series exactly.[2] Section 10 therefore uses the rebuilt index, while Tables 1 to 4 keep the published one, which is the series the literature uses and readers can look up, and Table 2 reports both. The choice affects magnitudes but not conclusions. On its own the index explains 56 percent of the variation in exporters' income in its published form and 52 percent when rebuilt, and 60 and 53 percent alongside the five characteristics; its coefficient is +0.422 against +0.406, and no significant coefficient changes sign. The difference is not negligible, and the results of this section are stated for the rebuilt index, the one whose geometry they describe.

One caution concerns how the orthogonality should be read. It is a property of the raw eigenvector, not of the series researchers use. Standardizing the index to mean zero and unit variance, as the Atlas does, removes it while leaving the ranking intact, and the standardized index correlates +0.57 with diversity and, on the product side, −0.47 with log ubiquity. The correlation does not refute the orthogonality, and the orthogonality does not make the index unrelated to the counts. It establishes only that the index is a contrast that carries none of their weighted level; how its ordering relates to them is an empirical question, and here the answer is a substantial but far from perfect correlation (Mealy et al., 2019).

The share of the matrix the axis holds needs to be read with care. Total inertia is 6.96, and the leading axis carries 0.264 of it, or 3.8 percent. The next two axes carry 2.7 and 2.3 percent, and the first five together 12.4 percent. Nomaler and Verspagen (2024) report 4.1 percent in five-digit data, so the figure is not an artefact of aggregation. The complexity index is one line through a structure of which it captures about one part in twenty-six, and the slow decline of the later axes means that no single dimension dominates world trade specialization. A share of inertia is not, however, a measure of economic importance. The same axis that holds 3.8 percent of the matrix accounts for 52 percent of the variation in exporters' income in its rebuilt form, and

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[2] We restricted the sample by diversity, by total exports and to the largest 133 or 150 exporters (correlations between 0.82 and 0.93), expanded it to all 230 economies that report exports (0.938), rebuilt the index from single-year matrices for 2022, 2023 and 2024 (0.929 to 0.935), and checked the product coverage (1,241 of 1,242 headings), the normalization and the world totals. Lowering the revealed-advantage threshold below the conventional value of one brings the published series closer to the axis, with the correlation peaking near 0.96 at a threshold of about 0.4 and the residual falling to about 0.030 below 0.15, a pattern stable across 2015, 2020 and 2023; no threshold achieves both. The published index behaves like an axis of a denser matrix than the conventional rule produces, and reproducing it would require construction details the data file does not document.

Section 10.3 shows that it carries most of what the matrix knows about that income. The contrast is the substantive finding: a statistically small dimension of world trade specialization carries a disproportionate share of its economically relevant information.

10.2 Mean or floor? The functional form of the score

Both the PCI and PRODY average an attribute over a product's exporters. Tacchella et al. (2012) and Cristelli et al. (2013) argue that for a nested matrix the informative statistic is not the mean but the lower tail, and Reinert's baseball argument says the same thing in words. We therefore recompute the score as the income of the poorest significant exporter and as the tenth and twenty-fifth percentiles of exporters' incomes, where a significant exporter is one with revealed comparative advantage of at least one.

The three alternatives are strongly but far from perfectly related to the linear score: the correlation of log PRODY with the log twenty-fifth percentile is 0.76, with the log tenth percentile 0.68, and with the log minimum 0.51. Fifty-six percent of products move at least one quintile when the score is switched from the mean to the tenth percentile. The choice of statistic is not cosmetic.

Four results favour the lower tail for Reinert's purposes.

The ladder steepens. Measured by the mean, the top fifth of products has exporters 3.6 times richer than the bottom fifth. Measured by the twenty-fifth percentile the ratio is 4.4, by the tenth percentile 5.3, and by the minimum 6.0. Reinert's scale is longer than the mean suggests, and it is longer precisely because what distinguishes a high-quality activity is not that its average exporter is rich but that poor countries are systematically less likely to enter it competitively.

Reinert's characteristics predict it much better. Repeating the regression of Table 2 with the lower-tail score, the five characteristics explain 49 percent of the variation in the tenth-percentile score and 50 percent of the twenty-fifth-percentile score, against 30 percent for the mean. The characteristics Reinert lists are more closely associated with the income *floor* of an activity than with its average. A higher R^2 does not by itself show that the floor measures the unobserved quality of an activity better, but it does show which statistic his characteristics track.

The anomalous sign reversal disappears. In Table 2 the coefficient on log ubiquity flips from −0.209 to +0.147 once the PCI enters, a reversal that required explaining away. With the twenty-fifth-percentile score the coefficient in the same specification is −0.019, and with the tenth-percentile score it is −0.125: negative, as the theory requires, with the axis held fixed. The reversal was an artefact of the mean.

The resource-rent anomalies dissolve. Crude oil and raw wool were the two products where the axis and the score disagreed, because rich exporters pull up a mean that industry rent does not justify. Under the tenth-percentile score, the crude-oil-to-polyethylene gap widens from 1.5 to 4.7 times and the wool-to-wool-fabrics gap from 1.25 to 2.5 times. The pairs that narrow are the tropical crops, where the raw material's floor is already very low: cocoa to chocolate falls from 5.6 to 2.9 times. Eight of the nine counterpoints still favour the processed good; the exception is hides and leather, at 0.89, already the narrowest pair under the mean.

The products where the two readings diverge most are instructive. The largest gaps between a high mean and a low floor are sulphur, ferrous waste, pumice, banknotes and stamps, live horses, and raw diamonds: thin markets where a handful of rich exporters and one or two very poor ones coexist, so that the mean describes no one. These are also, with the collectibles among them, the headings where the 4-digit classification is least informative.

Is the floor an artefact of counting? A product with more exporters is mechanically more likely to have a very poor one among them, so part of the relation between the floor and the other characteristics could be sampling rather than Reinert's mechanism. We test this directly. For each product we draw, four thousand times, as many economies at random from the 157 with income data as actually export it, and record the tenth percentile of their incomes. That is the floor a product of its size would have if its exporters were a random draw.

The null is strong, and the data are not it. Under random drawing the log floor correlates −0.96 with the log number of exporters; in the data the correlation is −0.45. The observed floor is on average 0.91 log points — a factor of 2.5 — above what random drawing of that many exporters would produce, which is itself a statement of Reinert's thesis: the countries that export a given product are far from a random sample of the world.

Subtracting the null leaves an excess floor that is free of the counting effect, and the results survive on it. The ladder measured on the excess floor runs 4.8 times from the bottom quintile to the top, against 5.3 for the raw floor and 3.6 for the mean. Reinert's five characteristics explain 44.3 percent of the excess floor, against 49.1 percent of the raw floor and 30.0 percent of the mean. The coefficient on log ubiquity is −0.368 on the excess floor, against −0.450 on the raw floor and −0.209 on the mean.

How much of the gain from switching to the floor is the counting effect depends on which gain is measured, so all three are given. Taking the improvement over the mean as the baseline in each case, the counting effect accounts for 25 percent of the gain in explanatory power (0.0485 of the 0.1913 that the raw floor adds to the mean's R^2), for 31 percent of the steepening of the ladder (0.51 of the 1.67 by which the raw floor's top-to-bottom ratio exceeds the mean's), and for 34 percent of the strengthening of the ubiquity coefficient. Between a quarter and a third of the improvement is mechanical, therefore, and between two thirds and three quarters is not.

We retain the linear PRODY in Tables 1 to 5 because it is the measure the literature defined and used and because it is the conceptual counterpart of the PCI, which is the comparison Section 4.2 needs. The mean and the floor describe different things: the first the typical income of the economies specialized in a product, the second the income of the poorest economies that manage to export it with revealed advantage. The evidence here is that the floor is the measure especially suited to Reinert's question, not that it is superior for every purpose.

10.3 What the matrix holds weakly

Section 4.3 noted that two of the five characteristics are computed from the time dimension of trade values, which the binary matrix discards, and suggested that the axes of that matrix should carry little information about them. The claim can be tested, and the test bounds what a linear measure of quality built from a cross-sectional matrix can capture.

The matrix of 209 economies yields 208 non-trivial correspondence axes. Regressing each characteristic on the first K axes gives the following shares of variance explained.

Table 6: *Share of each characteristic recoverable from the first K correspondence axes. The last two columns use all 208 axes and report the adjusted R^2 and a five-fold cross-validated R^2 computed on held-out products*

Characteristic	$K = 1$	$K = 10$	$K = 50$	$K = 208$	adjusted	cross-val.
Diversity of exporters	0.579	0.866	0.930	1.000	1.000	1.000
log PRODY	0.521	0.696	0.715	0.775	0.729	0.604
log ubiquity	0.222	0.457	0.590	0.719	0.662	0.511
Centrality	0.095	0.430	0.531	0.664	0.596	0.438
Volatility	0.059	0.236	0.302	0.427	0.312	−0.024
Demand growth	0.006	0.079	0.164	0.330	0.195	−0.145

Fitting 208 regressors to 1,241 observations inflates an unadjusted R^2, so the last two columns report the adjusted figure and, more informatively, a five-fold cross-validated R^2 computed by predicting products held out of the fit. Both are needed: the cross-validated figure shows how the full regression performs on new products, the adjusted figure how much linear information the axes contain.

The pattern is clear, though less stark than the cross-validated column alone suggests. The diversity of a product's exporters is a function of the matrix, and the matrix reconstructs it perfectly in and out of sample, as it must. Ubiquity and centrality are genuinely recoverable, to 51 and 44 percent out of sample. Volatility and demand growth are recoverable only weakly. With all 208 axes the unregularized regression overfits badly enough to predict a held-out product's volatility or demand growth *worse than* the sample mean, with cross-validated R^2 of −0.02 and −0.15. The adjusted figures, which correct for the number of regressors, put the linear information the axes carry at about 0.31 for volatility and 0.20 for demand growth with all axes, and about 0.23 and 0.07 with the first ten, against 0.66 and 0.45 for ubiquity at the same dimensionalities.

Two limits on what this establishes should be stated. The exercise asks how much of each characteristic *linear projections* of the axes recover; it does not rule out that some non-linear transformation of the matrix carries more. And it concerns this matrix at this level of aggregation. Within them, the result is that these two characteristics are much less recoverable from the matrix than the other three, not that the matrix contains nothing about them. The negative cross-validated figures belong to the unregularized regression on all 208 axes and reflect its overfitting as much as the content of the axes. We did not test regularized estimators or out-of-sample fit at intermediate dimensionalities; the adjusted figures suggest that such a fit could recover a modest positive share, of the order of a fifth to a third for volatility and less for demand growth.

On these terms the result supports bringing theory to the matrix as well as extracting more of it. Nomaler and Verspagen (2024) are right that the ECI discards most of the structure in the trade data, and right that the higher axes are worth having. But two of the five characteristics Reinert names are only weakly reached this way, which is what one would expect of properties of how a

market behaves over time measured against a matrix that is a photograph. In the linear specifications examined here, a multi-dimensional index built from the trade matrix, however many dimensions it uses, captures only a small part of the stability and demand-growth sides of the Schumpeterian–Malthusian distinction. Those are precisely the sides that Prebisch, Singer and Thirlwall emphasized.

The same table makes the positive point. Log PRODY, which is an income variable and not a function of the matrix at all, is 52 percent recoverable from the leading axis and 60 percent from the full set out of sample. The trade matrix knows a great deal about the income of exporters, and it knows most of what it knows in the first dimension: the further 207 axes add eight percentage points.

10.4 Constraining the axis by income

The last check runs the procedure Nomaler and Verspagen (2024) propose, in its minimal form. Canonical correspondence analysis (Ter Braak, 1986) constrains the axes to be linear combinations of chosen external variables. With log income per capita as the single external variable, over the 157 economies for which it is available, the procedure yields exactly one non-trivial canonical axis, as the theory says it must.

The constrained axis carries 3.3 percent of the inertia, against 4.8 percent for the unconstrained leading axis of the same matrix. Forcing the axis to be an income axis therefore costs about three tenths of its explanatory reach over the trade data. In exchange, it correlates 0.90 with the ECI on the country side and 0.85 with the PCI on the product side: the free axis and the income-constrained axis are close to the same line, which is, at the level of products, the counterpart of the near-coincidence they report between their first canonical axis and the ECI.

The product scores of the constrained axis correlate 0.80 with log PRODY, against 0.72 for the unconstrained PCI. The gain is real but small, and its size is the point. If the leading axis of the trade matrix were an arbitrary statistical artefact, constraining it to income would move it a long way and cost a great deal of inertia. It moves it a little and costs a third. The dominant pattern of co-specialization in world trade is already, to a close approximation, an ordering by the income of exporters, which is what Reinert's theory predicts, stated as a property of the matrix.

11 What the trade data cannot show

The measures describe where activities sit on Reinert's scale and who occupies each rung. They do not show the mechanism that, in his account, puts them there.

The central mechanism is the division of productivity gains between prices and wages, the classical and collusive modes of Section 2.3. Testing it requires sectoral prices, unit costs and wages, ideally for the same activities across countries at different income levels, of the kind assembled in industrial statistics and in the KLEMS productivity accounts. With such data one could ask whether, in activities high on the trade-based index, productivity growth shows up in wages and leaves prices stable, while in activities low on it productivity growth shows up as falling prices. That is the test Reinert's theory ultimately needs, and it is not attempted here.

Three cautions from the data remain. PRODY measures the income of exporting countries, not the wages paid in the activity, so a product exported by a rich country with low wages in that sector scores higher than its wages would justify, and resource rents raise the score of products such as crude petroleum and raw wool — though Section 10.2 shows that a lower-tail score removes much of this. The 4-digit classification hides the within-heading differences Reinert insisted on: golf balls and baseballs, cigars and cigarettes. And the trade-based characteristics are traces of Reinert's characteristics, not the characteristics themselves: ubiquity is the outcome of barriers to entry rather than a measure of their height, and trade-value volatility mixes price and quantity.

Two extensions follow from Section 10. The first is a canonical analysis constrained on the product side rather than the country side. The characteristics measured here are product-side counterparts of the environmental variables of Ter Braak's (1986) procedure, and constraining the axes by barriers, synergies, stability and demand would yield as many interpretable product dimensions as there are characteristics, with countries positioned in the same space. Section 10.4 runs only the one-variable country-side version. The second is a full Fitness–Complexity comparison: Section 10.2 shows that the lower tail is the statistic better suited to Reinert's reading of the score, which suggests that the non-linear algorithm of Tacchella et al. (2012), rather than the linear axis, may be the better companion measure for Reinert's index. This paper establishes that the question matters; it does not settle it.

None of these cautions reverses the direction of the results. They mean the index measured here is a lower-resolution picture of the one Reinert drew, and that its link to wages runs through national income rather than through the activity itself.

12 Conclusion

Erik Reinert's Quality Index of Economic Activities restated the oldest proposition in development economics as a scale: activities differ in their capacity to support high wages, and nations are rich or poor according to where on that scale they specialize. This paper measured the scale with world trade data for 1995–2024 and placed the measurement in the reinterpretation of economic complexity that has emerged since Kemp-Benedict (2014).

That reinterpretation holds that the complexity indices are the leading axis of a correspondence analysis of the country–product matrix, orthogonal to the diversity and ubiquity counts, a summary of which countries export the same things, and in need of a theory from outside the matrix to be read. We confirmed each of these properties on the data: the index coincides with the first correspondence axis, is orthogonal to the weighted counts, and carries 3.8 percent of the matrix's inertia, a small share of the matrix that nonetheless accounts for about half of the variation in exporters' income.

The paper's claim is that Reinert's framework provides an economically grounded interpretation of the income-related structure the axis captures. The score that defines the index has a revealed counterpart in the income of the countries that export each product, the conceptual counterpart of the PCI with income in place of the data-chosen axis. The characteristics Reinert attributes to high-quality activities are observed in the structure of world markets, and every one of them is associated with richer exporters. The leading axis explains 56 percent of the variation in

exporters' income on its own, and when the axis is forced to be an income axis it moves only a little and loses only a third of its reach: the dominant pattern of co-specialization in world trade already is, to a close approximation, an ordering by the income of exporters. The evidence is consistent with Reinert's mechanisms; it does not show directly that increasing returns, barriers to entry and the retention of productivity gains as wages produce the ordering.

Two findings bear on how the measurement is done. The lower tail suits Reinert's question better than the mean. Scoring an activity by the income floor of its exporters rather than their average steepens Reinert's ladder from 3.6 to 5.3, raises the explanatory power of his characteristics from 0.30 to 0.49, removes an anomalous sign reversal, and dissolves the resource-rent exceptions that the mean creates. And two of his five characteristics are much less recoverable from the trade matrix than the others: even with all 208 correspondence axes, linear fits account for about a third of the variation in trade-value volatility and a fifth of that in demand growth, against two thirds for ubiquity, and an unregularized regression on all of them predicts a held-out product's trade-value volatility or demand growth no better than the sample mean does, with cross-validated R^2 of −0.02 and −0.15. Extracting more dimensions from the matrix, as the recent literature proposes, is worth doing, but in the linear specifications examined here it adds little on these two.

The applications reproduce Reinert's cases at the scale of world trade. Raw materials are exported by poorer countries than the goods made from them, sit lower on the complexity axis and have more volatile trade, in all nine pairs, as Henry VII observed of wool and cloth. Poor countries lead world markets almost only at the bottom of the scale, competitive in activities where competitiveness does not become income, which is Schumpeterian underdevelopment and is also the nested triangle of the Fitness–Complexity literature read as a statement about what activities pay. Countries' positions on the scale track their income, change slowly and are modestly associated with faster growth, an association rather than an estimated effect. The clearest recent case of a poorer country moving up from a raw material, Indonesian nickel, came through the kind of policy Reinert advocates.

What a country exports, in this reading, is a statement about which rung of Reinert's ladder its workers stand on. The trade data show the ladder, who stands where, and that the first axis of the trade matrix lies close to it. Why the rungs pay what they pay, through the division of productivity gains between prices and wages, is the question that remains for data on prices and wages to answer.

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Code availability: The code for the data extraction and for every table and figure is included in the replication package that accompanies the paper.

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References

Balassa, B. (1965). Trade liberalisation and "revealed" comparative advantage. *The Manchester School*, 33(2), 99–123.

Bolt, J., & van Zanden, J. L. (2020). Maddison style estimates of the evolution of the world economy: A new 2020 update. *Maddison Project Working Paper* 15.

Boschma, R. (2017). Relatedness as driver of regional diversification: A research agenda. *Regional Studies*, 51(3), 351–364.

Bottai, C., Di Iorio, J., & Iori, M. (2024). Reinterpreting economic complexity: A co-clustering approach. arXiv preprint arXiv:2406.16199.

Caldarelli, G., Cristelli, M., Gabrielli, A., Pietronero, L., Scala, A., & Tacchella, A. (2012). A network analysis of countries' export flows: Firm grounds for the building blocks of the economy. *PLoS ONE*, 7(10), e47278.

Chang, H.-J. (2002). *Kicking Away the Ladder: Development Strategy in Historical Perspective*. London: Anthem Press.

Cimoli, M., Dosi, G., & Stiglitz, J. E. (Eds.) (2009). *Industrial Policy and Development: The Political Economy of Capabilities Accumulation*. Oxford: Oxford University Press.

Cristelli, M., Gabrielli, A., Tacchella, A., Caldarelli, G., & Pietronero, L. (2013). Measuring the intangibles: A metrics for the economic complexity of countries and products. *PLoS ONE*, 8(8), e70726.

Dosi, G., Pavitt, K., & Soete, L. (1990). *The Economics of Technical Change and International Trade*. Hemel Hempstead: Harvester Wheatsheaf.

Dosi, G., Riccio, F., & Virgillito, M. E. (2021). Varieties of deindustrialization and patterns of diversification: Why microchips are not potato chips. *Structural Change and Economic Dynamics*, 57, 182–202.

Fagerberg, J. (1994). Technology and international differences in growth rates. *Journal of Economic Literature*, 32(3), 1147–1175.

Fagerberg, J., & Verspagen, B. (2002). Technology-gaps, innovation-diffusion and transformation: An evolutionary interpretation. *Research Policy*, 31(8–9), 1291–1304.

Fagerberg, J., Verspagen, B., & von Tunzelmann, N. (Eds.) (1994). *The Dynamics of Technology, Trade and Growth*. Aldershot: Edward Elgar.

Felipe, J., Kumar, U., Abdon, A., & Bacate, M. (2012). Product complexity and economic development. *Structural Change and Economic Dynamics*, 23(1), 36–68.

Gala, P., Rocha, I., & Magacho, G. (2018). The structuralist revenge: Economic complexity as an important dimension to evaluate growth and development. *Brazilian Journal of Political Economy*, 38(2), 219–236.

Gala, P., Rodrigues Junior, L. A., Castro, L. B., & Roncaglia de Carvalho, A. (2022). The imperfect competition ladder in economic development: A new map of world trade using complexity analysis. *Texto para Discussão* 559, FGV EESP.

Graham, F. D. (1923). Some aspects of protection further considered. *Quarterly Journal of Economics*, 37(2), 199–227.

Growth Lab at Harvard University (2019). International Trade Data (HS92), country–product–year, 4-digit. *The Atlas of Economic Complexity*, Harvard Dataverse, https://doi.org/10.7910/DVN/T4CHWJ. Accessed 8 October 2026.

Hartmann, D., Guevara, M. R., Jara-Figueroa, C., Aristarán, M., & Hidalgo, C. A. (2017). Linking economic complexity, institutions, and income inequality. *World Development*, 93, 75–93.

Hausmann, R., Hidalgo, C. A., Bustos, S., Coscia, M., Chung, S., Jimenez, J., Simoes, A., & Yildirim, M. A. (2011). *The Atlas of Economic Complexity: Mapping Paths to Prosperity*. Cambridge, MA: MIT Press.

Hausmann, R., Hwang, J., & Rodrik, D. (2007). What you export matters. *Journal of Economic Growth*, 12(1), 1–25.

Hidalgo, C. A., & Hausmann, R. (2009). The building blocks of economic complexity. *Proceedings of the National Academy of Sciences*, 106(26), 10570–10575.

Hidalgo, C. A., Klinger, B., Barabási, A.-L., & Hausmann, R. (2007). The product space conditions the development of nations. *Science*, 317(5837), 482–487.

Hidalgo, C. A. (2021). Economic complexity theory and applications. *Nature Reviews Physics*, 3(2), 92–113.

Hidalgo, C. A. (2023). The policy implications of economic complexity. *Research Policy*, 52(9), 104863.

Hill, M. O. (1973). Reciprocal averaging: An eigenvector method of ordination. *Journal of Ecology*, 61(1), 237–249.

Imbs, J., & Wacziarg, R. (2003). Stages of diversification. *American Economic Review*, 93(1), 63–86.

Kaldor, N. (1967). *Strategic Factors in Economic Development*. Ithaca, NY: Cornell University.

Kemp-Benedict, E. (2014). An interpretation and critique of the Method of Reflections. *MPRA Paper* 60705, University Library of Munich.

King, C. (1721). *The British Merchant; or, Commerce Preserv'd*. London: John Darby.

Lall, S. (2000). The technological structure and performance of developing country manufactured exports, 1985–98. *Oxford Development Studies*, 28(3), 337–369.

List, F. (1841). *Das nationale System der politischen Ökonomie*. Stuttgart: Cotta.

Marshall, A. (1890). *Principles of Economics*, 1st edn. London: Macmillan.

Mealy, P., Farmer, J. D., & Teytelboym, A. (2019). Interpreting economic complexity. *Science Advances*, 5(1), eaau1705.

Moulton, H. G. (1935). *Income and Economic Progress*. Washington, DC: The Brookings Institution.

Neffke, F., Henning, M., & Boschma, R. (2011). How do regions diversify over time? Industry relatedness and the development of new growth paths in regions. *Economic Geography*, 87(3), 237–265.

Nomaler, Ö., & Verspagen, B. (2024). Reinterpreting economic complexity in multiple dimensions. arXiv preprint arXiv:2409.01830.

Ortiz, F. (1940). *Contrapunteo cubano del tabaco y el azúcar*. Havana: Jesús Montero. English translation: *Cuban Counterpoint: Tobacco and Sugar*. New York: Knopf, 1947.

Pavitt, K. (1984). Sectoral patterns of technical change: Towards a taxonomy and a theory. *Research Policy*, 13(6), 343–373.

Prebisch, R. (1950). *The Economic Development of Latin America and Its Principal Problems*. New York: United Nations.

Reich, R. B. (1991). *The Work of Nations*. New York: Knopf.

Reinert, E. S. (1994a). Catching-up from way behind: A Third World perspective on First World history. In J. Fagerberg, B. Verspagen & N. von Tunzelmann (Eds.), *The Dynamics of Technology, Trade and Growth* (pp. 168–197). Aldershot: Edward Elgar.

Reinert, E. S. (1994b). A Schumpeterian theory of underdevelopment: A contradiction in terms? *STEP Report* R-15/1994, Oslo. Available at MPRA, paper 48157.

Reinert, E. S. (2007). *How Rich Countries Got Rich… and Why Poor Countries Stay Poor*. New York: Carroll & Graf.

Reinert, E. S., & Riiser, V. (1994). Recent trends in economic theory: Implications for development geography. *STEP Report* R-12/1994, Oslo.

Rodrik, D. (2016). Premature deindustrialization. *Journal of Economic Growth*, 21(1), 1–33.

Serra, A. (1613). *Breve trattato delle cause che possono far abbondare li regni d'oro e argento dove non sono miniere*. Naples: Lazzaro Scorriggio.

Singer, H. W. (1950). The distribution of gains between investing and borrowing countries. *American Economic Review*, 40(2), 473–485.

Sylos Labini, P. (1956). *Oligopolio e progresso tecnico*. Milan: Giuffrè.

Tacchella, A., Cristelli, M., Caldarelli, G., Gabrielli, A., & Pietronero, L. (2012). A new metrics for countries' fitness and products' complexity. *Scientific Reports*, 2, 723.

Ter Braak, C. J. F. (1986). Canonical correspondence analysis: A new eigenvector technique for multivariate direct gradient analysis. *Ecology*, 67(5), 1167–1179.

Thirlwall, A. P. (1979). The balance of payments constraint as an explanation of international growth rate differences. *Banca Nazionale del Lavoro Quarterly Review*, 32(128), 45–53.

van Dam, A., Dekker, M., Morales-Castilla, I., Rodríguez, M. Á., Wichmann, D., & Baudena, M. (2021). Correspondence analysis, spectral clustering and graph embedding: Applications to ecology and economic complexity. *Scientific Reports*, 11, 8926.

Verspagen, B. (1991). A new empirical approach to catching up or falling behind. *Structural Change and Economic Dynamics*, 2(2), 359–380.