Trade policy, retail food prices and access to healthy diets in Africa and worldwide

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Abstract: Recent use of least-cost diets as a measure of global food security revealed that over 3 billion people are unable to afford sufficiently nutritious food for an active and healthy life, driving demand for policy changes to improve access and affordability. This study quantifies the role of imports in consumer prices, matching retail prices in 144 countries to imports by origin of the item or its main ingredient, resulting in a total of 13,912 pairs of a retail price and its import cost in 2017. We also estimate the magnitude of intra-African barriers to be eliminated by the African Continental Free Trade Area (AfCFTA), relative to restrictions on imports to Africa from elsewhere as well as tariff measures used in other regions. We find that 55% of retail items had some active imports supplementing domestic production, and of those around 40% have nonzero tariffs whose average effective rate is around 7% of the imported commodity price. Over all countries for which data are available, the share of consumer prices for least-cost healthy diets that is attributable to tariffs and non-tariff measures averages 0.7% and 1.8% respectively in Africa, and 0.6% and 2.1% globally. The highest restrictions are on nutrient-rich vegetables, fruits and animal-sourced foods. Access to bulk commodities from diverse origins is essential for food and nutrition security, providing a greater diversity of foods and food ingredients at lower and more stable prices than can be grown at any one location. On average over all food products that are imported, 83% of the retail price is domestic value added after arrival. We conclude

that food imports are best understood as inputs to the domestic production and distribution of retail items, with consumer prices and growth of the food sector dependent on the cost levels, infrastructure and institutions underlying each product's entire value chain.

1. Introduction

Trade policies can play a key role in economic development and poverty reduction, with significant impacts on agriculture and food systems and therefore, food security. Access to food with different nutritional values is one of the channels through which trade policy affects nutritional outcomes in a country. This study focuses on two indicators of trade policy – import tariffs and non-tariff measures (NTMs) – tracing their importance for consumer prices of least-cost items in proportions needed for an active and healthy life (FAO, IFAD, UNICEF, WFP and WHO, 2022). We quantify the contribution of import barriers to commodity and retail food prices and the resulting cost of a healthy diet across 144 economies, with a special focus on Africa.

Measuring food access using the cost and affordability of healthy diets was introduced in the flagship annual report on *The State of Food Security and Nutrition in the World* (FAO, IFAD, UNICEF, WFP, and WHO, 2020). Research conducted for that SOFI 2020 report found that about 3 billion people could not afford a healthy diet in 2017, using least-cost items selected from each country's locally available foods in sufficient quantities to meet a globally representative set of national dietary guidelines (Herforth *et al.*, 2020). More recently, SOFI 2022 used an updated set of data and methods to estimate that higher food prices from 2017 to 2020 had raised the number of people who could not afford a healthy diet by 112 million people to almost 3.1 billion people worldwide, with additional harm undoubtedly caused by further price rises in 2021 and early 2022 (FAO, IFAD, UNICEF, WFP and WHO, 2022), with Consoli et al. (2023)

finding that many governments applied trade policy interventions to mitigate the transmission of those prices rises to domestic markets.

This paper measures the effect of import barriers on the affordability of least-cost healthy diets in a large cross-country sample covering 144 economies, with particular emphasis on sub-Saharan Africa and the potential effect of the African Continental Free Trade Area (AfCFTA). In this study, we focus on the magnitude of restrictions in place in 2017, including intra-African trade barriers likely to be reduced or eliminated under the AfCFTA, which could have major impacts on agriculture, food, and nutrition (Bouët, Tadesse and Zaki, 2021). Reducing barriers to trade and investment to facilitate intra-African trade could be especially important in the food sector, to help diversify diets with more differentiated retail products that could take advantage of scale economies in agro-processing, lowering consumer prices to improve welfare and expand access to healthy diets. Our analysis of trade policy effects on least cost healthy diets is also related to recent research by Abay, Ibrahim, and Breisinger (2022), who find that increased tariffs on unhealthy foods are associated with reductions in obesity rates in low- and middle-income countries. More broadly, Traverso and Schiavo (2020) underscore the rapid growth in the role of trade in supplying macronutrients, particularly among low-income countries.

Among the two types of import barriers considered in this paper, non-tariff measures – policy measures other than ordinary customs tariffs that can potentially have an economic effect on international trade in goods, changing quantities traded, or prices or both – are often found to be more costly than import tariffs. In the context of food trade, NTMs include for example Technical Barriers to Trade (such as labelling or packaging requirements) as well as Sanitary and Phytosanitary measures that are in place for the protection of human, animal, or plant life or health (UNCTAD, 2010; FAO, IFAD, UNICEF, WFP and WHO, 2022). Simulations done by the World Bank, International Food Policy Research Institute, and other researchers compare the removal of tariffs on intra-African trade to the removal of both tariffs and ad valorem tariff equivalents (AVEs) of NTMs and find significantly higher welfare gains from the latter scenario (Abrego *et al.*, 2019; Chauvin, Ramos and Porto, 2016; Bouët, Tadesse and Zaki, 2021; World Bank, 2020). Unlike tariffs, however, non-tariff measures such as SPS rules can play important roles in reducing health risks to consumers (as well as animals and plants). The optimal degree of non-tariff trade protection is thus unlikely to be zero, though we model its elimination to illustrate the quantitive effect of non-tariff measures relative to tariffs. Trade facilitation measures such as removing or moderating NTMs (for example by enhancing transparency and harmonization across countries) are possible within regional blocs, such as the eight regional economic communities (RECs) within the African Union. However, increased levels of cooperation and integration across the continent have led to the broader and more ambitious approach of the AfCFTA.

Negotiations towards the AfCFTA began at the AU Summit of 2015, aiming to expand the REC system to allow even more diversity of trading partners between regions within Africa (Abrego *et al.*, 2019). As of May 2022, 54 of the 55 countries in the AU had signed the AfCFTA, aiming to form the largest free trade area in the world. Once fully implemented, the AfCFTA is expected to connect 1.3 billion people and combine country economies to create a $3.4 trillion GDP (World Bank, 2020). To reduce the fragmentation of the continental market, the AfCFTA will implement a nondiscriminatory reduction in tariffs and harmonization and reduction of NTMs, a degree of trade facilitation that is not typically covered in trade agreements (Bouët, Tadesse and Zaki, 2021). The AfCFTA will be implemented in three phases, the first of which focuses on liberalization of trade in goods and services, with free trade officially beginning on January 1, 2021. Over 10 years, the least-developed countries in the bloc are required to remove tariffs on 90% of imported products, leaving 7% of tariff lines designed by each government to be sensitive products to be liberalized over 13 years, and allowing 3% of tariff lines to be excluded from tariff liberalization.

In this paper, we seek to identify the share of retail food prices that can be attributed to border measures, focussing in particular on the least cost healthy diet in each country. Calculating the impacts of import barriers on affordability of a healthy diet differs from traditional research on trade policy in several ways:

First, we estimate the magnitude of trade barriers relative to consumer prices for retail items, in contrast to the traditional focus on wholesale or farmgate prices. Linking trade policy to consumer prices requires matching each traded agricultural commodity to the corresponding differentiated retail food item for which it is the principal ingredient, accounting for all costs along the value chain. We begin with the cost of each traded commodity at the port of entry, such as bulk grain or whole frozen fish in shipping containers, and compare the price of that food to the consumer price of the corresponding retail item such as bread or tinned fish at retail outlets within the country. This linkage is made possible by matching both the traded commodity and the retail product to food composition data, so as to compare cost per calorie of the bulk commodity at a country's port of entry to its cost per calorie after transformation and distribution to retail outlets. Using cost per calorie adjusts for differences in water weight and edible portions from the bulk product to its retail form, extending traditional analysis of price transmission and tariff-equivalent policies that focus on cost per kilogram of farm commodities such as Anderson and Masters (2009) and MAFAP (2015), updated to address the role of product transformation before retail sale as in the analysis of value added in food supplies by Yi *et al.* (2021).

Second, we focus on how trade barriers affect the cost of foods needed for a healthy diet, in contrast to the traditional focus on starchy staples as an indicator of caloric adequacy, or the foods used in observed diets. Measuring the contribution of trade barriers to the retail prices of a least-cost healthy diet requires identifying which are the most affordable items within each food group, first at observed prices and then at the prices that would be paid in the absence of trade restrictions. For international comparisons, we use the global healthy diet basket approach introduced for SOFI 2022, which consists of the least-expensive 11 items across 6 food groups as detailed in Herforth *et al.* (2022). The import barriers considered in this study include both tariffs and NTMs, the implementation of each of which leads to higher domestic prices for commodity ingredients. We trace the magnitude of that added cost to final consumer prices for each retail item, which could affect access to healthy diets to the extent that it affects prices for the least-cost items in a healthy diet.

Third, we add up access to each food group in the proportions needed for health, rather than the proportions actually consumed as in each country's consumer price index. Calculating the cost per day to purchase a healthy diet requires converting all item prices to their cost per calorie of edible matter, then selecting the least-cost items in each food group needed to obtain the nutritional value of that food group, and multiplying cost per unit times the quantity required from that food group for an overall healthy diet. This approach ensures sufficient quantities of the nutritional attributes brought by each food group, allowing for substitution between items within each group while maintaining overall energy balance. Making substitution isocaloric is especially important when items within a food group have different levels of water weight, e.g. comparing dry rice to potatoes. Considering items in terms of their caloric value, rather than weight, ensures that similar quantities of the edible matter needed from items in each food group are included, and to thereby obtain the required balance of macro- and micronutrients as well as phytochemicals, fibre, and other bioactive compounds in each food group.

In summary, this study presents a new approach linking commodity markets to the retail cost of healthy diets, an approach that may be of great value in guiding both trade policies such as the AfCFTA and other investments to improve food access. We focus on the degree to which observed retail prices and healthy diet costs are attributable to import restrictions at the equilibrium level of prices observed in 2017. To the extent that trade barriers continue to play a significant role in the cost and affordability of healthy diets, additional trade facilitation for raw commodities at the border would be needed to bring healthy diets within reach of all people at all times. In contrast, if affordability of healthy diets is driven largely by the domestic costs of product transformation, distribution and retailing from the port of entry to retail outlets, then innovation and investments for market development within each country would be required. Future work could build on these data, adding supply and demand response to trace how policy changes would alter quantities and lead to new equilibrium prices in response to any given counterfactual scenario.

2. Conceptual Framework

The goal of this study is to quantify the contribution of import barriers to the cost of a healthy diet, using data on tariffs and non-tariff measures used by governments worldwide, and with particular focus on intra-African trade and corresponding trade barriers.

Figure 1 shows our conceptual model of a country's market for a food product, expressed in US dollars per calorie of its principal ingredient. For ease of communication, we use the specific example of mackerel, a relatively inexpensive kind of fish in Ghana and other settings. Tinned mackerel appears in least-cost healthy diets as one of the most affordable animal-source foods in Ghana, and the country also imports mackerel in the form of a frozen bulk commodity. Other examples of a traded product transformed into a retail item would include dry and canned beans, wheat and bread, or powdered milk and reconstituted dairy products, some of which might appear as least-cost items for a healthy diet in various settings. Presenting the model with a concrete example like tinned and frozen mackerel allows us to trace findings from actual data to numerical results in terms of their significance for access to healthy diets in Africa. Mackerel in Ghana is a particularly useful example for this study because the bulk product is imported from both within and outside Africa, and some of the imports from within Africa were already duty-free under regional agreements, thereby illustrating a wide range of empirical issues of importance for the analysis of the AfCFTA.

The conceptual model of food value chains shown in Figure 1 is distinctive in that all prices are converted to US dollars per calorie of a specific food. That data transformation, made possible by matching item descriptions to food composition data for retail products and the corresponding traded commodity, allows us to trace the costs of a retail item back to the principal form in which that product might be imported, even when transformation alters the product and adds (or removes) water weight. Items are matched only to their principal ingredient. In practice, almost all least-cost items are actually single-ingredient foods with only water added and inedible portions of the food removed, plus some salt or preservatives and other additives that have little effect on the item's macronutrient content. Taking account of multiple ingredients would require data on the ratio of those ingredients. That kind of data would be helpful for studies of how trade affects prices for packaged foods such as tinned soups or breakfast cereals, but these items do not appear in least-cost healthy diet baskets and are therefore not relevant for this initial study.

For this study, the data we have are observed consumer prices of retail food items for each country, and that country's bilateral import unit values and quantities imported of bulk food commodities from each source country. Prices for retail items are initially quoted in local currency per unit as purchased, while unit values for shipments of internationally traded products are typically quoted in U.S. dollars per metric ton of the raw commodity. Those are then converted into U.S. dollars per calorie of the edible product using food composition data and purchasing power parity exchange rates. Data for each country's tariffs on its imports from each source as well as the average cost of compliance with NTMs for that category of traded commodities are both obtained in ad-valorem terms as a proportion of price paid, so no conversion is needed. The core of our analysis is to transform those data into the cost of trade barriers as a fraction of retail prices paid for a least-cost healthy diet.

The method illustrated in Figure 1 represents the value chain for a single-ingredient product, linking the price paid for imports including cost, insurance and freight of the traded product (P_t), to the domestic cost of buying that traded commodity at its port of entry within the country (P_d) and transforming it through value addition in the food manufacturing and service sector for packaging and transport, storage and distribution to the final price paid by consumers for the corresponding retail item (P_r).

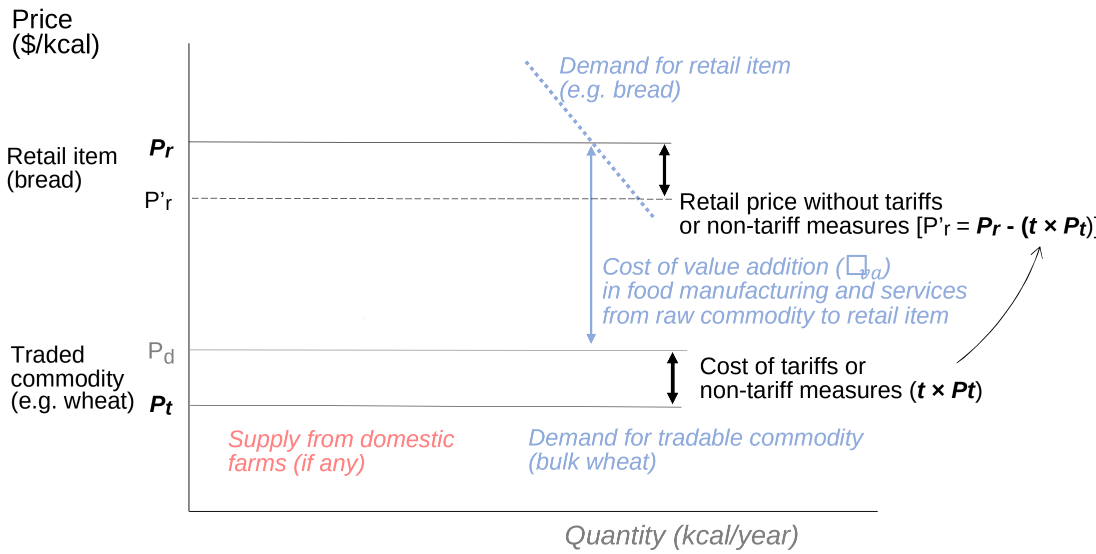


Figure 1. Conceptual model of value added from imports to retail prices

The bulk commodity version of the internationally traded product costs P_t to bring into the port of entry. Costs to clear customs for onward shipment to a distributor involve payment of taxes and compliance with NTMs, both of which are typically reported in ad valorem terms as a proportional tariff-equivalent rate (t) charged on the price paid for the traded commodity (P_t). The resulting price per unit of the bulk commodity for domestic buyers is just one input into food manufacturing and distribution, which involves labor and management as well as rental or ownership of facilities and equipment for product transformation and packaging, storage, transport and handling of the final retail product at its point of sale to consumers. In Figure 1 these costs of value addition (C_{va}) are held constant, because by definition they consist of things that are not the traded product itself. A detailed analysis of this value added along the supply chain to retail sale for 61 countries worldwide is provided by Yi *et al.* (2021).

The variables in this conceptual model for which we have empirically-estimated observations are P_t and P_r (in US dollars per unit), and t (in proportional ad-valorem terms). From those data we can determine what fraction of P_r is accounted for by those tariffs and non-tariff measures paid on imports of the main ingredient, which is $(t \times P_t)/P_r$.

Figure 1 also shows how future work could extend the analysis to changes in quantities, using partial or general equilibrium models of producer and consumer response to estimate the change in local production along the domestic supply curve (shown in dashed red, for the bulk commodity), as well as change in consumption along the demand curve (shown in dashed blue, for either the product in final form at retail prices or as derived demand for the bulk commodity). A simple such model for just one value chain might be based on elasticities of supply and demand along the supply and demand curves shown in Figure 1, but that would fail to account for cross-price effects in domestic markets, as well as elasticities of substitution between the traded form of the product from different origins and locally-produced versions or the effects of income changes generated by a reduction in trade barriers. Many different kinds of equilibrium models could be used to estimate quantity responses to the price incentives measured in this study. The insight provided by the model in Figure 1 is that, by converting quantities into calories of edible matter for each type of food, we can trace products from international trade or farm production through transformation in food value chains to a retail item for potential consumption.

The value chain model shown in Figure 1 can be expressed in algebraic terms to show how observed data are transformed to obtain this study's analytical results, identifying the share of retail costs paid by consumers that is attributable to payment of tariffs and compliance with non-tariff measures. For African countries in this study, we want to distinguish between the cost of tariffs and non-tariff measures paid on imports from within Africa versus other origins, so the trade data underlying the analysis is bilateral in nature. The notation below refers to national average unit values, using the trade-weighted sum of tariffs and non-tariff measures (*t*) on imports from each origin country.

For each imported commodity in each country, the domestic price after paying tariffs and the cost of compliance with NTMs is:

$$P_d = P_t(1 + t)$$

The consumer price paid for the retail form of each product is then:

$$P_r = P_d + C_{va}$$

To obtain the retail cost without tariffs and NTMs, we note that C_{va} is the cost of value addition which consists of labour and returns to management, plus rental or capital cost of ownership for facilities and equipment as well as energy costs and other inputs needed to operate each stage of the value chain from the port of entry through transport and storage, transformation and distribution of the product in retail form. By this definition, C_{va} is all costs of the retail item other than the cost of its primary ingredient which may be subject to import restriction. We, therefore, hold C_{va} constant, which allows us to calculate what retail prices would be with varying degrees of trade barrier reduction (P_r'), by subtracting a given proportion of trade barrier costs from the baseline retail price:

$$P_r{}' = P_r - (t \times P_t)$$

In equation (3), the units of measure for prices are USD per calorie, and all parameters are expressed in proportional form. In other words, we convert ad-valorem tariffs and NTM compliance costs on traded commodities into their specific cost, as US dollars per calorie of food. Equivalently, we can write equation (3) as:

$$(3') \; P_r' - P_r = -(t \times P_t)$$

and in proportional terms, the difference in retail prices depends on the traded commodity's cost share of retail prices:

$$(3'') \; \frac{P_r' - P_r}{P_r} = -t \times \frac{P_t}{P_r}$$

We calculate the magnitude of tariffs separately from NTMs, first because those are distinct policy measures and also because we have different numbers of countries with available data for tariffs and NTMs. We also pay particular attention on countries in the AfCFTA, showing the magnitude of tariffs and NTMs imposed by African countries on imports from elsewhere in Africa, relative to tariffs and NTMs imposed on other trading partners. To compute a trade-weighted reduction in import barriers we eliminate only intra-African tariffs, and subsequently recalculate the weighted average tariff across all sources of each product and per each importing country.

Finally, we use each set of retail prices to identify least-cost healthy diets in each country, adding up prices of the least-cost items within each food group in the proportions needed for health. In each scenario, the resulting cost of a healthy diet

(CoHD) in each country is a weighted sum of least-cost items in the healthy diet basket, as follows:

$$CoHD = \sum_{i=1}^{n} \min\,(P_{ir} q_i)$$

where the quantities required for each item (q_i) is as specified in Table 2 below, and the particular items selected for CoHD are those with the lowest cost per calorie for that category of food. Recalculating CoHD allows for the selection of a different basket when the reduction in trade barrier costs results in new least-cost items, allowing us to calculate the proportion of each country's diet costs that is attributable to payment of import tariffs or compliance with non-tariff measures as $(CoHD - CoHD')/CoHD$.

To illustrate the application of this approach Table 1 shows the actual bilateral data used to calculate the national average cost of tariffs paid on imports of mackerel in Ghana in 2017, and the fraction of that cost that would be removed under the AfCFTA. The bottom line of this calculation is that the 10% rate charged on most but not all origins yields a trade-weighted national average cost of importing that is 9.9% of bilateral trade unit values in 2017, which AfCFTA would reduce to 6.0% by eliminating tariffs on imports from other African countries not already included in regional agreements.

Table 1. Mackerel imports and tariffs in Ghana, at baseline and with AfCFTA

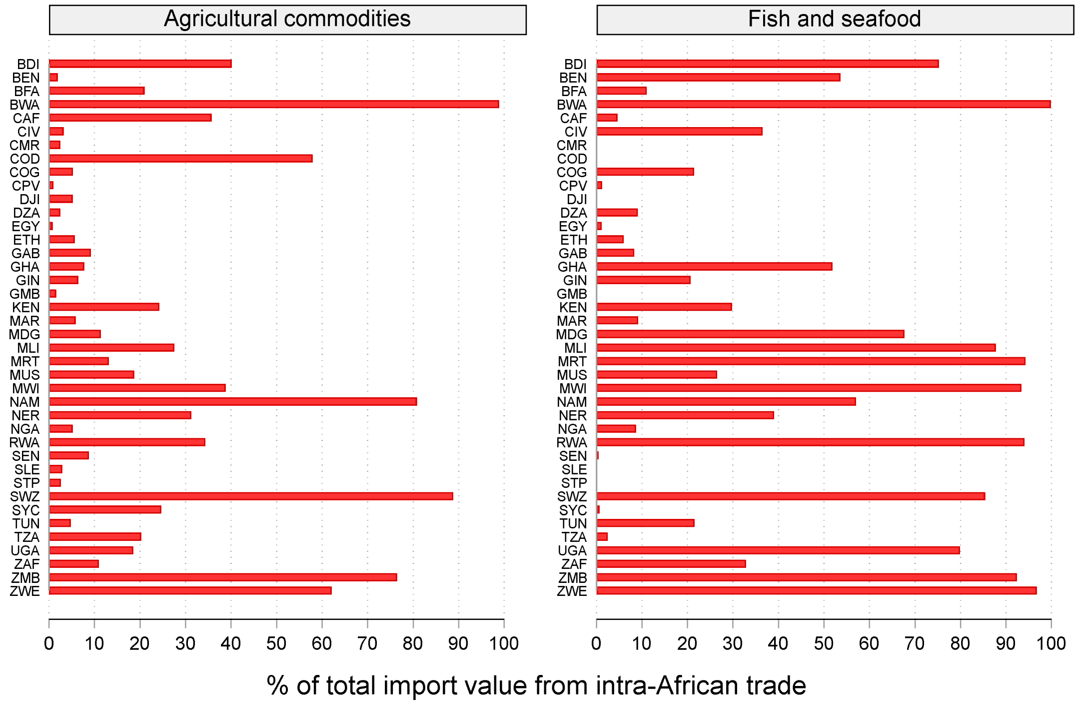
Origin	Value of imports (USD)	Ad valorem tariff rate (%)		Value of duties levied (USD)	
		Baseline (2017)	With AfCFTA	Baseline (2017)	With AfCFTA
Intra-African partners					
Angola	5,426,455	10.0	0.0	542,646	0
Mauritania	16,178,140	10.0	0.0	1,617,814	0
Morocco	12,746,500	10.0	0.0	1,274,650	0
Guinea-Bissau	141,496	0.0	0.0	0	0
Senegal	20,715	0.0	0.0	0	0
Sierra Leone	542,944	0.0	0.0	0	0
Subtotal	**35,056,250**			**3,435,110**	0
Trade-weighted average (within Africa)		*9.8*	*0.0*		
Non-African partners	**52,797,846**	10.0	10.0	**5,279,785**	5,279,785
Total of all tariffs paid	87,854,096			8,714,894	
Trade-weighted average (all origins)		*9.9*	*6.0*		

***Source**:* Authors' calculations from UNCTAD TRAINS bilateral trade flows for fish and seafood products and tariffs.

The example of mackerel imports into Ghana reveals the importance of using bilateral data and trade-weighted values to quantify the cost of tariffs. In 2017, Ghana imported about US$88 million worth of mackerel, of which about US$53 million came from non-African partners and US$35 million came from within Africa. As co-members with Ghana in ECOWAS, three of Ghana's six sources within Africa already had a free-trade agreement with this country in 2017. In practice, the volume of trade from those origins was small so the trade-weighted average tariff on intra-African trade to be removed by AfCFTA was 9.8%, very close to the 10% level paid on imports from elsewhere. The African sources whose tariffs are to be removed by AfCFTA account for about 40% of trade, so the national total cost of tariffs would fall from 9.8% to 6.0% of the national average import unit value for bulk mackerel.

The method used to calculate the contribution of NTMs to retail prices is similar in principle but restricted due to the limited availability of detailed NTM estimates. As described in more detail below, we use data summarizing the extent of NTMs (i.e. whether a country imposes NTMs on a given commodity) as well as global average AVEs by broad commodity sectors. Of the 54 African countries in our larger dataset, only 14 report bilateral NTMs, demonstrating the wide inconsistencies in NTM reporting. Ultimately, we estimate weighted average AVEs of NTMs that rely on qualitative shifts in the extent of global versus intra-African NTMs for our calculation of trade costs in African countries. As a result, our analysis is functionally restricted to those African countries that report NTMs on African trading partners, but do not report any NTMs on trading partners outside of Africa. For these countries, removing intra-African NTMs reduces costs associated with NTMs to zero, while for all other countries some burden from extra-African NTMs will still remain.

The role of intra-African trade barriers in diet costs depends on the relative importance of intra-African trade, which can be represented as the share of imports a given African importer receives from African trading partners. Figure 2 shows the high degree of variation across African countries in the import shares of food and fisheries commodities sourced from intra-African trade. In countries with less intra-African trade, such as Egypt and Nigeria, intra-African trade barriers are likely to have a smaller effect on retail food prices and CoHD. Countries that rely on African trading partners for a large share of imported food commodities, often landlocked countries such as Zambia and Botswana, are likely to be more sensitive to trade barriers. However, higher intra-African trade in these countries may also reflect already reduced intra-African trade barriers.



Notes: Import values for agricultural commodities come from FAOSTAT Detailed Trade Matrix and are from 2017. Import values for fish and seafood come from UNCTAD TRAINS and represent trade years from 2013 to 2017.

Figure 2. Intra-African trade as a percentage of total import value

The method used in this study is designed specifically for calculating the relative importance of tariffs and NTMs within Africa and worldwide in determining access to a least-cost healthy diet. In so doing we hold all else constant, including each partner's share of import trade unit values. Our focus is purely on prices in the base year of 2017, estimating the share of retail item prices that is the cost of bilateral tariff payments or compliance with non-tariff measures that would or would not be removed through the AfCFTA. Future efforts to estimate quantity changes under specific policy scenarios might account not only for supply and demand response, but also substitution among sources of imports. The new equilibrium in such a model would depend on model structure and parameters, including the degree to which resources can be reallocated in response to price changes.

3. Least-cost healthy diets

Least-cost diets are the most affordable combination that meets the criteria for a healthy diet, calculated at each time and place as a measure of food system performance in making healthy diets accessible (Herforth *et al.*, 2020). The Cost of a Healthy Diet (CoHD) is defined as the lowest-cost set of items available at each time and place that meet requirements for each food group specified in food-based dietary guidelines (FBDGs) or according to some other quantitative dietary standard. The calculation of least-cost healthy diets as pioneered in the SOFI 2020 report offers a new way to measure and monitor different populations' physical and economic access to sufficient foods for an active and healthy life. In this study, we use the SOFI 2022 approach to calculating the cost of a healthy diet (CoHD), based on the availability and price of the least expensive locally available items in nutritionally-defined food groups, each consumed in the proportions needed for a balanced diet.

In economic terms, a least-cost healthy diet provides a price index for food ingredients as an input to each person's long-term production function for human health. This stands in contrast to actual consumption, which involves revealed preferences and willingness to pay for different foods based on their taste, culinary habits, time and fuel costs for meal preparation, as well as commercial marketing, culture, and aspirations that influence food choice. Since people cannot directly observe how a food affects their disease risk and longevity, it is the noticeable attributes of food such as appearance or taste and smell as well as brand identity and packaging, price, and convenience that drive food choice and actual consumption.

The definition of a healthy diet used for the CoHD is derived from national governments' food-based dietary guidelines (FBDGs), extracting from those guidelines a target number and quantity of food items in each nutritionally-defined category needed for a balanced intake of nutrients and other bioactive compounds to sustain a healthy population. For the purpose of global comparisons, SOFI 2022 introduced a composite "healthy diet basket" whose diversities meet commonalities among all dietary guidelines whose requirements are reported in terms of food-group quantities. This healthy diet basket consists of 11 food items in 6 food groups, achieving diversity within and between categories by selecting 3 different vegetables and 2 fruits, plus 2 starchy staples and 1 item from the legumes, nuts and seeds category, as well as 2 of any animal-sourced foods and 1 additional source of lipids (oil or fats).

Selecting the least expensive locally available items for such a healthy diet basket allows us to distinguish food access from other factors in food choice. For example, the SOFI 2022 report shows that about 38% of the world's population cannot consume healthy diets because even the least expensive items are unaffordable. The remaining 62% may not consume healthy diets despite being able to afford the required ingredients because they use other items instead for their meal preparation, snacks, and food away from home (FAO, IFAD, UNICEF, WFP and WHO, 2022). This diagnostic provides a powerful guide to policy and program intervention, regarding where policies should focus on affordability via increased production and market access to lower food prices, safety nets, and income growth to raise purchasing power, or the many other factors that influence food selection among affordable items.

While national food-based dietary guidelines have been adopted in over 100 countries, not all countries have quantitative guidelines amenable to costing. The Healthy Diet Basket (HDB) is a set of standard criteria that represents commonalities across most FBDGs globally (Herforth *et al.*, 2022). The HDB was created as a global standard to be used when calculating and comparing the cost and affordability of healthy diets across countries and as such will be the basis for the diet cost calculations for this analysis.

Table 2. Composition of the global Healthy Diet Basket target intake

Food Group	**Number of food items selected**	**Total energy content (kcal)**	**Typical weights of example foods (g)**
Starchy staples	2	1160	322 g dry rice
Vegetables	3	110	270-400 g
Fruits	2	160	230-300 g
Animal-source foods	2	300	210 g egg
Legumes, nuts, seeds	1	300	85 g dry bean
Oils and fats	1	300	34 g oil
Total	**11**	**2330**	

Source: **Herforth, A., Venkat, A., Bai, Y., Costlow, L., Holleman, C. & Masters, W**. 2022. Methods and options to monitor the cost and affordability of a healthy diet globally: Background paper for The State of Food Security and Nutrition in the World 2022. FAO Agricultural Development Economics Working Papers 22. Rome, Italy, FAO. https://doi.org/10.4060/cc1169en

As shown in Table 2, an HDB at each time and place is composed of eleven locally available items, each in sufficient quantities to maintain an energy balance at 2,330 kilocalories across six food groups. The total of 2,330 calories meets energy needs of an active, healthy adult woman and is similar to the average energy requirement for all sex-age-year groups age three years and older (Herforth et al., 2022; Schneider and Herforth, 2020).

Defining a healthy diet basket as in Table 2 is designed to permit substitution between items within food groups, allowing for variation in the volume and water weight of locally available items while maintaining energy balance and diversity of food sources within and between groups.

4. Data sources

The data used for consumer prices of each retail food item are reported by national statistical organizations to the World Bank International Comparison Program (ICP) for 2017. International prices paid for each imported commodity in each country are calculated from FAOSTAT import values and quantities in that year, while tariffs for each commodity imported into each country are from the United Nations Conference on Trade and Development (UNCTAD) Trade Analysis and Information System (TRAINS) database. We also use an estimate of the global average ad valorem cost of compliance with NTMs in each commodity category, and a full set of food composition tables that allow the matching of traded commodities to retail items.

With these data, we identify which retail items in each country are associated with a commodity that was actually imported into that country in the base year and the magnitude of import restrictions imposed on that commodity. We then compute the cost of compliance with NTMs or payment of tariffs as a fraction of the consumer price paid for the corresponding retail item, so as to compare retail prices and diet costs with and without each set of trade restrictions. For access to healthy diets, what matters are the retail prices of the least-cost items, which we add up to compare the overall Cost of a Healthy Diet (CoHD) with and without each set of import barriers: tariffs and NTMs, for intra-African trade and worldwide.

4.1 Food prices: retail items and traded commodities

The starting point for our analysis is the availability and price of retail food items in each country, as reported by national governments to the ICP to compare price levels for computing purchasing power parity exchange rates. Each observation is a single national average price for a standardized item considered widely available in that country.

In 2017, the most recent year for which data are available, the ICP provided retail prices for 680 foods and non-alcoholic beverages across 177 economies. We convert retail prices into 2017 PPP per kilocalorie of edible matter using food composition data from the United States Department of Agriculture (USDA) and the West African Food Composition Table, and the ICP 2017 PPP data (US Department of Agriculture, Agricultural Research Service, 2016; Vicent *et al.*, 2020).

To estimate the cost of the traded commodities that correspond to each retail item, we calculate import unit values from the FAOSTAT Detailed Trade Matrix data as the annual value of imports divided by the annual import quantity for each FAO traded food commodity. Import unit values are calculated for 263 traded food commodity categories (FAO, 2022a). FAOSTAT's trade matrix does not include fish and seafood products, so fish and seafood import unit values are derived from import values and quantities from FAO's Fisheries and Aquaculture database on global fish trade (FAO, 2022c). For agricultural commodities, we estimate a national weighted-average import unit value for each country, using import quantities at the bilateral level as weights to correspond with available tariff data, which use import value weights. As FAO does not publish bilateral trade quantities for fish and seafood, fish and seafood import unit values are unweighted.

Import values are downloaded from FAOSTAT in 2017 USD and must be converted to 2017 PPP for comparability with the ICP retail food prices. To do so, import values are converted to 2017 local currency units using exchange rates from COMTRADE and then converted to 2017 PPP using the ICP 2017 PPP for household consumption expenditure. COMTRADE exchange rates are those used to convert national trade data as reported to the UN into 2017 USD. Import values from countries without a COMTRADE exchange rate are converted from the reported currency to local currency units using exchange rates from the IMF International Financial Statistics or the World Bank before final conversion to 2017 PPP terms. Import unit values are converted into kilocalories of edible matter using food composition data from the United States Department of Agriculture (USDA), the West African Food Composition Table, and the FAO/INFOODS Global food composition database for fish and shellfish (uFiSh1.0) (FAO, 2016).

We match ICP retail food and beverage items to the primary FAO traded food commodity corresponding to the same food product, using detailed metadata provided by the ICP and product category descriptions from FAO for the FAO Commodity List (FCL). For a subset of items for which multiple matches are both possible and plausible, we use trade flow data to match each ICP retail item to the FAO traded food commodity with the largest value of imports.

4.2 Trade barriers: tariffs and non-tariff measures

We draw data from various sources to capture the magnitude and extent of tariffs and NTMs. We use tariff data from the TRAINS database, which represents the most exhaustive and up-to-date database. The bilateral tariff data are published as ad valorem equivalents (AVEs) at the 6-digit Harmonised System (HS) level through the WITS platform hosted by the World Bank. Data are available for 193 reporting countries, with tariff years from 1988 through 2020, covering all traded commodities under the harmonized system (HS) nomenclature. For each tariff line, we use 2017 tariffs and keep the most recent data available for each country in 2015 or 2016 for countries without 2017 tariff data. All trade barriers reported in earlier HS nomenclatures are converted to the HS 2017 nomenclature. After matching to imported FAO foods, this results in 2015 tariffs for 173 HS6 codes, 2016 tariffs for 199 HS6 codes, and 2017 tariffs for 218 HS6 codes.

In our analyses, we use the weighted average of tariffs imposed by the importing country on all trading partners for imported food commodities. This weighted average is calculated as the total duty levied divided by the total value of imports, across all trading partners from which the importing country receives the specified food commodity under consideration. Import values are obtained from TRAINS at the HS6 level and may or may not reflect trade data from the same calendar year as the available tariff data. All tariffs are downloaded as AVEs and converted into specific tariffs as described in equation (3) above, expressed as USD per edible kilocalorie of the product.

Finally, we calculate the retail price contribution of NTMs using AVEs estimated at the global GTAP-sector level by Cadot *et al.* (2018), also expressed in the form of cost per edible kilocalorie of each product. For countries that report imposing NTMs on a given product imported from a given trading partner, we link that product with the corresponding AVE estimate, with reporting data available from UNCTAD TRAINS for 120 countries. W

4.3 Food matching and concordances

In order to apply the appropriate tariff and NTMs to each FAO traded food commodity, we match ICP retail food items-FAO traded food commodity pairs (ICP-FCL pair) to the appropriate 6-digit harmonized system code. We build on an existing one-to-many concordance between the FAO Commodity List (FCL) and the Harmonized System nomenclature developed by the Caliper team at FAO (FAO, 2022b) using ICP and FAOSTAT metadata. Where multiple possible HS6 codes can be matched to a single

ICP-FCL pair, we choose the HS6 code corresponding to the least-processed product group. For example, when matching the ICP-FCL pair “Beef without bones” (ICP) and “Meat, cattle, boneless” (FCL) to an HS code, both HS code 20130 “Meat; of bovine animals, boneless cuts, fresh or chilled” and 20230 “Meat; of bovine animals, boneless cuts, frozen” are reasonable matches. In these scenarios, we matched to the rawest form of the product, in this case “fresh or chilled” rather than frozen.

Non-tariff measures are policy measures other than ordinary customs tariffs that may affect international trade by distorting the quantities or prices of goods traded. This analysis focuses on import measures, including technical measures such as technical barriers to trade (TBT) and sanitary and phytosanitary (SPS) measures (Rial, 2020). Incorporating the trade-impeding effects of NTMs is important in light of estimates that sugges that the AVEs of NTMs are three times larger than tariffs (Cadot, Gourdon and Tongeren, 2018).

To assess the effect of NTM reform on the cost of healthy diets, we combine qualitative data on whether an imported has imposed NTMs on a given product and trading partner with estimates of the ad-valorem equivalent of NTMs for each GTAP product sector. We use data on the number of NTMs imposed at the global and bilateral levels from the UNCTAD TRAINS database. Using a dataset processed by UNCTAD for statistical analysis (Rial, 2020; UNCTAD and World Bank, 2018), we find the total number of NTMs imposed by each importing country before 2017 that was still in effect in that year.

While various publicly available databases estimate AVEs of NTMs at a more disaggregated level, none include data for 2017 or adjacent years or for countries in sub-Saharan Africa (Sanjuán López *et al.*, 2021). We use AVEs of NTMs estimated at the global GTAP-sector level by Cadot *et al.* (2018). These authors estimate the trade effects of NTMs for roughly 5,000 traded goods across 80 countries. We use the price-based estimates averaged across all the countries and grouped by GTAP sector, estimating a total AVE for all SPS, TBT, border control measures (BCM) and quantitative restrictions (QRs) imposed (Cadot, Gourdon and Tongeren, 2018). To apply these estimates to retail food items, their matched FAO traded food commodities were manually matched to the corresponding GTAP sector. There are 16 GTAP product sectors in the final dataset. For any HS6 product group that has a non-zero number of NTMs, we apply the complete AVE estimate from Cadot *et al.* (2018) for the corresponding GTAP sector.

Figure 3 provides a complete description of the dataset, showing sample sizes of the source data for each kind of variable, followed by exclusion criteria and results of matching that leads to the analytical dataset used for our results. Appendix 2 details our process of data cleaning and assessment of measurement error in the trade and retail price data. The combined dataset includes 13,912 country-retail food observations across 144 countries, of which 38% are potentially subject to tariffs (Table 3). In this analysis, retail items with a cost attributable to trade barriers have a primary ingredient that is imported, match to an FCL commodity, match to food composition data, and have a non-missing import (?) unit value as well as a tariff or NTM imposed at the corresponding HS6 level.

Descriptive statistics of the data that drive our results are provided in Table 3, showing the fraction of all retail items with consumer prices that are matched to a traded commodity, the share of the unit value of the imported primary ingredient in the final product's retail price, the fraction of those items that are subject to nonzero import tariffs, and the magnitude of those tariffs. All data are shown in percentage form, along with the total number of retail food price observations in our data, first for all items and then just for the items that appear in baseline least-cost diets.

Table 3 reveals that most retail items could be matched to an imported commodity with a known unit value, especially for starchy staples and legumes, nuts and seeds for which over 70% of items are importable in this sense. The retail items that are least often matched to an importable commodity are animal source foods, whose products are imported for only 37% of all retail items and 27% of the least-cost animal source items. However, the cost (trade unit value) of the primary imported commodity ingredient is relatively small at 17% of retail prices for all items and 21% of retail prices for least-cost items. Additionally, only 38% and 41% of those commodity costs include any tariffs at all, and those tariffs, where imposed, average only around 7.1% for all items and 5.7% for least-cost items. Overall, a relatively small share of diet costs is due to tariffs on the traded product, with some interesting differences between food groups and for least-cost items. Vegetables are the food group for which least-cost items face the highest tariffs,

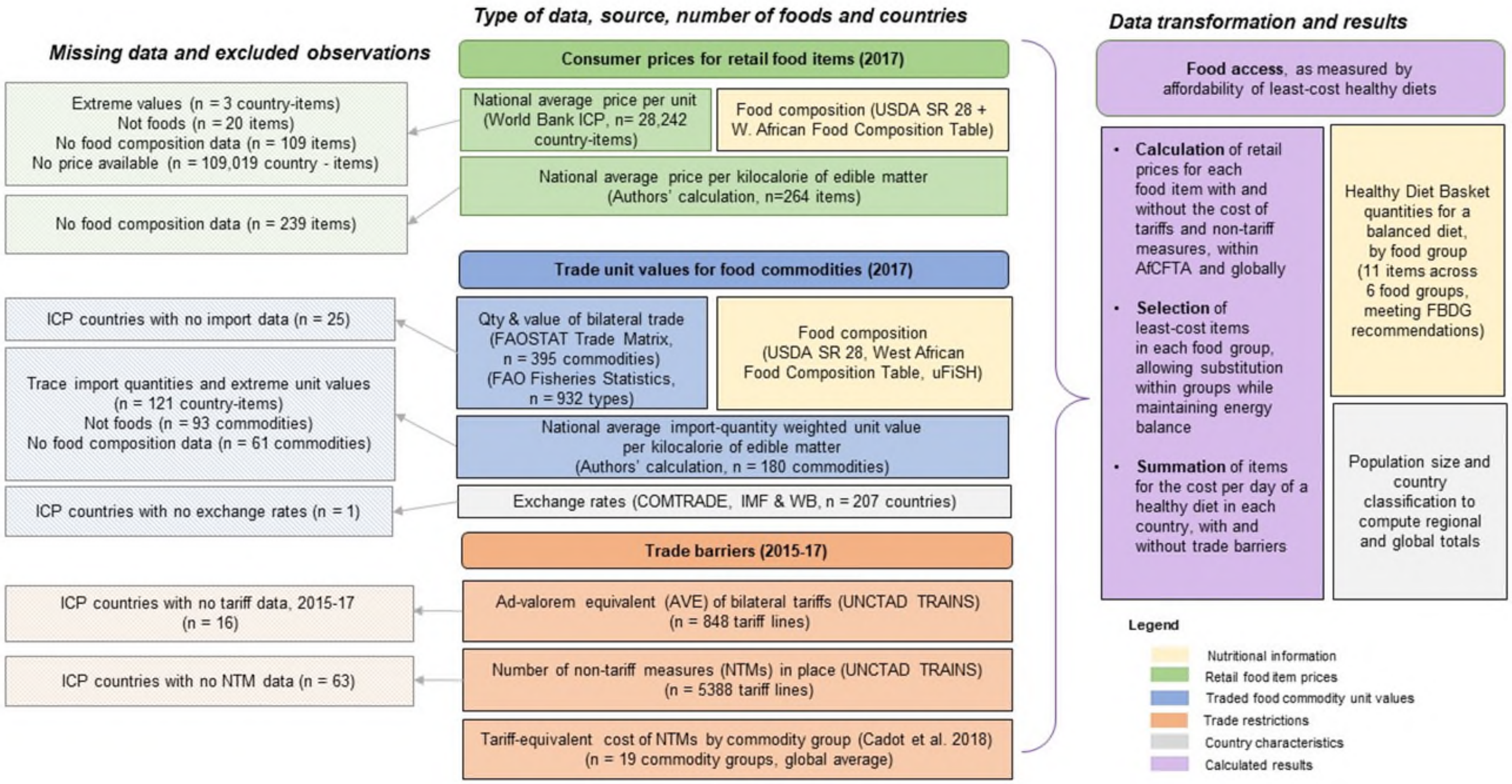


Figure 3. Sources and number of observations, data transformation, and results of the study

Table 3. Extent to which retail foods and least-cost foods are traded and tariff-laden

	All items					Least-cost items				
	Pct of items matched to an imported commodity unit value (a)	Unit value of imported commodity as % of retail price (b)	Pct of imported commodities with tariffs (c)	Ave. tariff, where present (d)	N (e)	Pct of items matched to an imported commodity unit value (a)	Unit value of imported commodity as % of retail price (b)	Pct of imported commodities with tariffs (c)	Ave. tariff, where present (d)	N (e)
Starchy staples	72	10	36	7.10	3,473	70	18	33	5.77	288
Vegetables	56	20	50	6.65	1,420	59	24	55	7.81	432
Fruits	63	16	50	6.53	1,477	53	19	28	4.55	288
ASF	37	26	26	7.59	5,726	27	32	22	4.15	288
LNS	75	14	57	6.11	826	78	19	65	3.44	144
Oils and fats	72	17	62	7.87	990	57	22	51	4.65	144
Total: all foods	55	17	38	7.10	13,912	56	21	41	5.74	1,584

Notes: Data shown are for all retail items on the left, and only items selected in least-cost diets on the right. Column details are (a) Percentage of all country-retail food combinations for which the retail item was successfully matched to a primary ingredient from the FAO Commodity List, where that country is a net importer of the commodity and the commodity has a non-missing unit value; (b) percentage of the final product's retail price that is accounted for by the trade unit value of the corresponding imported commodity; (c) percentage of those imported commodities that have any tariffs; (d) average tariff for all items in column c; (e) total country-retail food item observations. Food group abbreviations are ASF = animal-source foods; LNS = Legumes, nuts, seeds.

averaging 7.8% compared to 6.7% for all least-cost foods. Protection of high-value crops is consistent with explanations of trade policy based on the relative power of interest groups, as described for example in Anderson, Rausser and Swinnen (2013).

5. Results

Our results demonstrate that trade barriers on imported commodities make only a small contribution to the retail prices of least-cost healthy diets globally. As shown in Table 4, we estimate that tariff payments account for only 0.59% of healthy diet costs in the 144 countries for which we have data, and 0.66% of diet costs in the 40 African countries for which we have data. One-fifth of the latter is due to intra-African trade barriers to be lifted by the AfCFTA, which account for 0.13% of healthy diet costs. Compliance with NTMs accounts for a larger portion of diet costs at 2.14% worldwide and 1.54% of diet costs in Africa, of which NTMs applied against imports from within Africa are estimated to account for 0.66% of diet costs. Appendix 1 illustrates detailed results for three illustrative countries. We also find that commodity substitution within food groups plays essentially no role in driving the changes in CoHD associated with trade reform. This finding stands in contrast to Law (2019), who finds large effects of trade reform on diet diversity in rural India.

Table 4. Percentage of the cost of a healthy diet attributable to trade barriers

	Barriers to imports from all origins in all countries	**Barriers to imports from all origins in African countries**	**Barriers to imports from AfCFTA partners in Africa**
Cost of tariffs (percent of import price)			
By food group			
Starchy staples	0.06	0.08	0.00
Vegetables	0.23	0.22	0.05
Fruits	0.08	0.17	0.07
Animal-source foods	0.14	0.13	0.00
Legumes, nut, seeds	0.05	0.03	0.00
Oils and fats	0.02	0.02	0.00
Total over all items in a healthy diet	**0.59**	**0.66**	**0.13**
Number of countries	*144*	*40*	*40*
Cost of non-tariff measures (pct of import price)			
Total over all items in a healthy diet	**2.14**	**1.54**	**0.66**
Number of countries	*105*	*14*	*14*

Note: Data shown are average percentages of each country's total cost per day for a healthy diet basket.

The magnitude of tariff and NTM costs as a share of retail diet costs shown in Table 4 is driven by the descriptive statistics shown in Table 3: focusing on the set of all least-cost items in our dataset, more than half (56%) are matched to imports but less than half of those imports (40%) are affected by tariffs. Where tariffs are in place, the average applied rate is relatively small (5.8%), and those tariffs are applied to imported commodities whose value is a small share of retail product prices (21%). For most foods in least-cost diets, most of the retail cost is accounted for by labour, facilities and other value added in transforming, distributing and selling the final product. The workers and companies that generate this value added rely on having reliable access to imported commodities, but the value added itself reflects domestic investments and labour costs that are not traded internationally.

Among African countries, the tariff burden on retail items included in the CoHD is slightly higher than the global average, suggesting that African countries' least-cost items are more tariff-burdened than those of other countries. Furthermore, due to the widespread existence of RECs on the continent, the tariff burdens imposed on African countries' least-cost items are higher for imports from non-African trading partners than from their intra-African partners. The tariff burden attributable to intra-African tariffs in our sample of 40 countries is only 0.13%, as compared to the 0.66% when global trading partners are included. This pattern is even more pronounced for the cost associated with NTMs imposed by African importers – more than half of the burden comes from extra-African trade for the 14 countries for which we have bilateral NTM data.

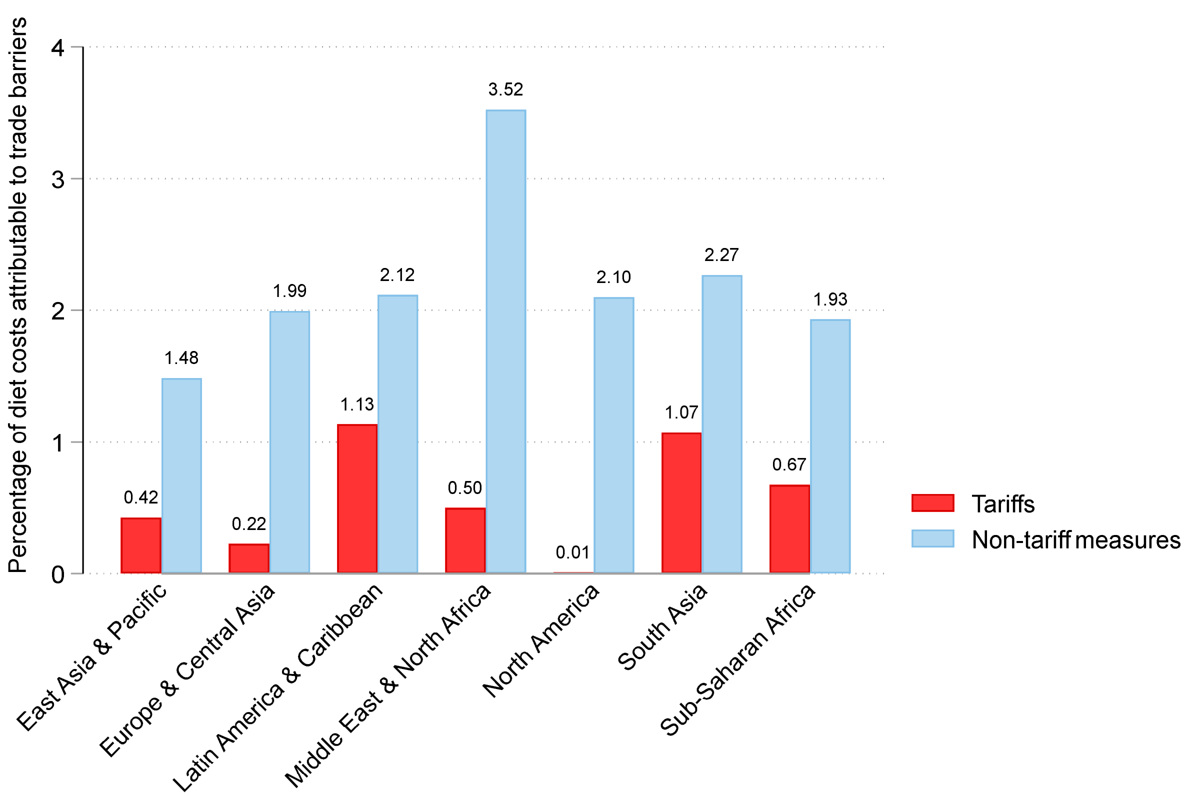
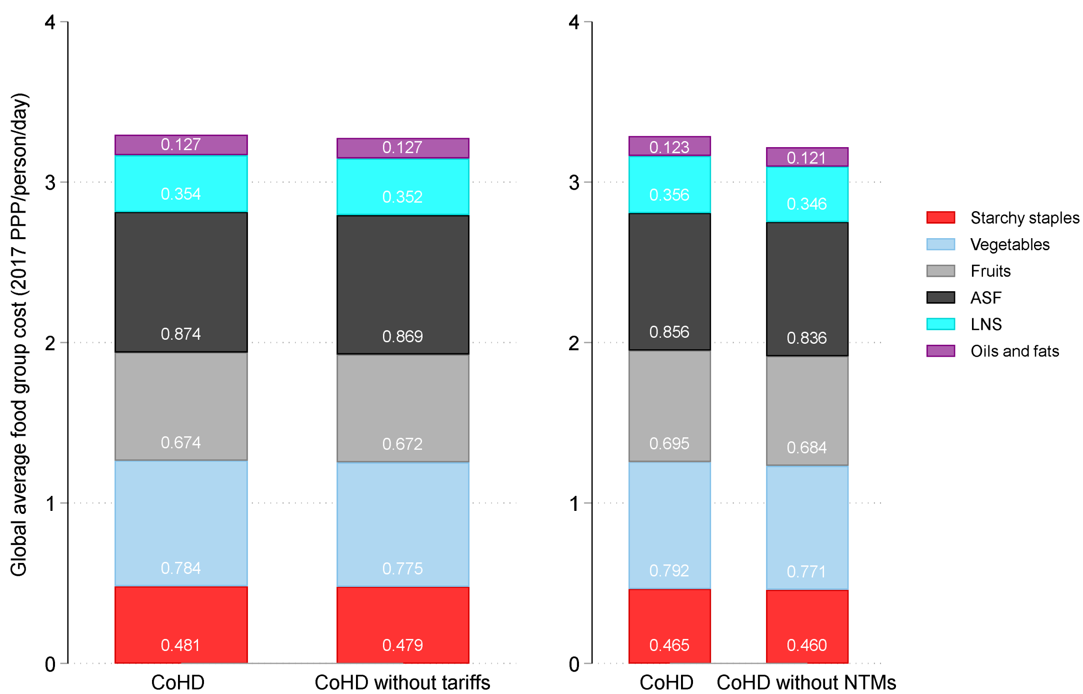


Figure 4. Percentage of diet costs attributable to trade barriers by region

Figure 4 demonstrates substantial variation in the contribution of tariffs to least-cost diets across regions. At the regional level, tariff costs contribute the most to CoHD in Latin America and the Caribbean and South Asia. Figure 5 aggregates regions while disaggregating these results by food group, illustrating the cost per day of each HDB food group, both with and without tariffs and NTMs. The cost of consuming enough of the least-cost animal-source foods is the most affected by tariff measures. Globally, the average least-cost way to meet animal-source foods (ASF) needs per person per day is USD 0.874 when trade barriers are in place, compared to 0.869 without tariffs. Amongst the 105 countries for which NTM data are available, NTMs on ASFs contribute most to the cost of healthy diets, along with those on vegetables.



Notes: Data shown are the global mean cost per day. Data on NTMs are only available for N=105 countries.

Figure 5. Global average food group cost, with and without trade barriers

Disaggregating both regions and food groups, Table 6 demonstrates the substantial heterogeneity underlying the previous aggregates. At the global level, the largest trade barrier costs derive from import measures applied to vegetables and animal-source foods. Barriers on animal-source foods are highest in the South Asia and MENA regions. In LAC and SSA, the vegetable food group is subject to the greatest trade barrier costs.

Table 5. Share of diet costs attributable to import barriers, by region and food group

	EAP	ECA	LAC	MENA	NA	SA	SSA	Global
	%	%	%	%	%	%	%	%
Tariffs								
By food group								
Starchy staples	0.11	0.00	0.16	0.00	0.00	0.03	0.09	0.06
Vegetables	0.13	0.13	0.52	0.04	0.00	0.30	0.26	0.23
Fruits	0.11	0.05	0.04	0.00	0.01	0.07	0.20	0.09
Animal-source foods	0.05	0.02	0.27	0.39	0.00	0.37	0.08	0.14
Legumes, nut, seeds	0.01	0.02	0.12	0.04	0.00	0.21	0.03	0.05
Oils and fats	0.02	0.01	0.02	0.03	0.00	0.08	0.02	0.02
Total over all items in a healthy diet	0.42	0.22	1.13	0.50	0.01	1.07	0.67	0.59
Number of countries	*16*	*43*	*26*	*15*	*2*	*7*	*35*	*144*
Non-tariff measures								
Total over all items in a healthy diet	1.48	1.99	2.12	3.52	2.10	2.27	1.93	2.14
Number of countries	*13*	*34*	*22*	*12*	*2*	*5*	*17*	*105*

It is also interesting to observe both the pattern of CoHD across the spectrum of countries' per capita incomes and the relative impacts across that distribution of the effects of eliminating tariffs and NTMs. Figure 6 shows the level of CoHD for all individual countries in our sample with and without tariffs (left panel) and non-tariff measures (right panel). A non-parametric line shows the mean and 95% confidence interval for diet costs at each income level, at observed prices (the red line) and without trade barriers (the blue line). Notably, the highest CoHDs are concentrated among middle-income countries, and those costs then decline with income such that the wealthiest countries exhibit the least costly CoHDs. Bai *et al*. (2021) explain a similar cross-country pattern in diet costs, in part, as a result of greater electrification and denser marketing chains disproportionately reducing the costs of perishable foods in wealthier countries.

These results show how small differences in diet costs due to trade barriers arise in only a few countries where the X (for diet costs without trade barriers) is below the square (for diet costs at observed retail prices), with no clear difference other than the larger role of non-tariff measures outside of Africa (purple) compared to the African countries (green). Our analysis demonstrates that the contribution of intra-African trade barriers is quite small across income levels. Among African countries, tariffs and NTMs appear to make similarly small contributions to CoHD.

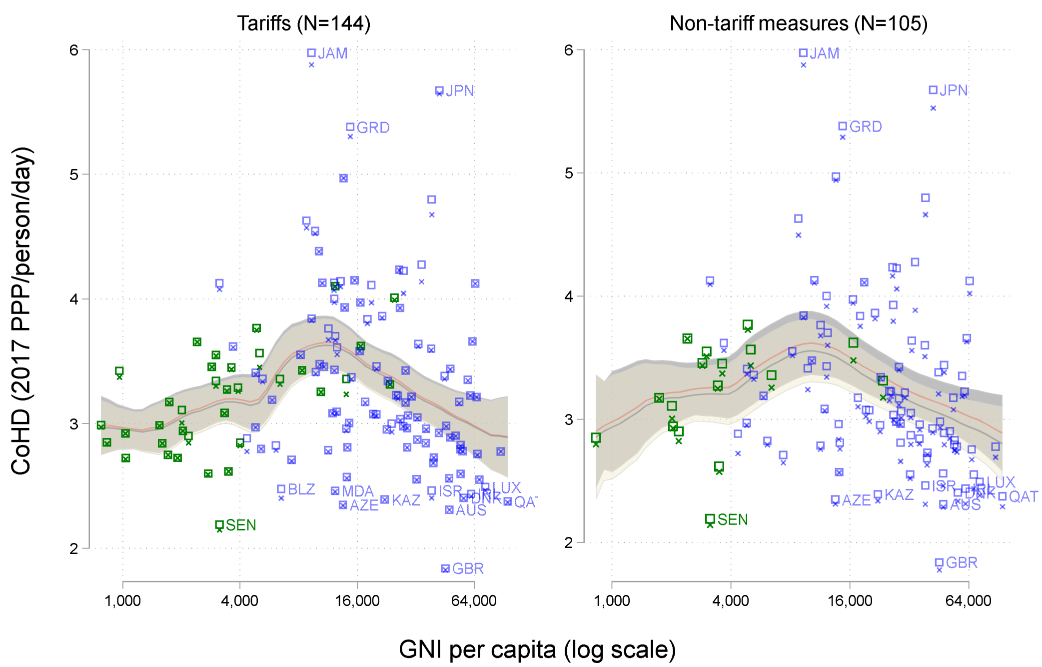


Figure 6. Cost of a Healthy Diet with and without trade barriers (global)

Figure 7 extracts just the non-parametric line to show differences in the percentage contributions of trade barriers to least-cost healthy diets by food group at each level of national income per capita. Here we find wide variation across food groups. Tariffs on least-cost vegetables and ASFs make the largest contribution to diet costs, especially in middle-income countries. With the exception of fruits, the contributions of tariffs to diet costs declines in percentage terms as national per capita income increases.

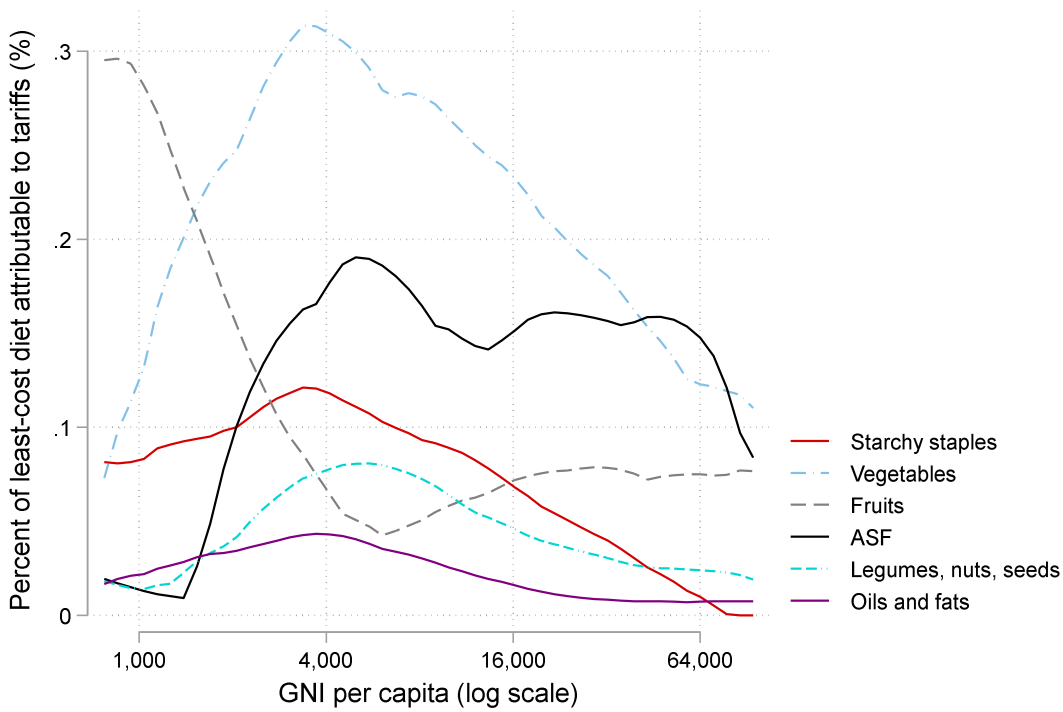


Figure 7. Percent of least-cost diet attributable to tariffs, by food group

6. Conclusions

The analyses presented in this study suggest several novel findings. Most importantly, matching retail items to importable commodities reveals that trade unit values account for only about one-fifth of consumer prices. Four-fifths of consumer prices are the cost of value added services and other inputs needed for retail food provision, attenuating the impact of trade barriers on retail diet costs even for the minority of items that use imported commodities whose prices are raised by tariffs and non-tariff barriers. Almost half of least-cost items are not made of an imported product, and those that are have relatively low tariff burdens. Trade barriers impose more meaningful costs in the case of least-cost vegetables and animal-source foods, particularly in South Asia and in Latin America and the Caribbean. The fact that South Asia would benefit more than other regions from tariff reduction is consistent with some of the recent results of simulations from computable equilibrium (CGE) models. The impact of repurposing of border measures (which include tariffs and NTMs) on the cost of healthy diets is most pronounced in South Asia in the analysis based on MIRAGRODEP CGE model (FAO, IFAD, UNICEF, WFP and WHO, 2022).

Second, although the contribution of NTMs is larger, the nature and extent of NTMs as implemented by individual importers and as applied to distinct imported commodities remains poorly understood. Calculating country- and commodity-level AVEs of NTMs is an important area for future research, which will allow for more nuanced estimates of the contribution of NTMs to the retail prices of least-cost items. Third, based on currently available data, tariff and NTM burdens on least-cost foods in African countries are largely imposed on trading partners outside of Africa. This implies that intra-African free trade under AfCFTA could be important for many purposes, but will not result in substantial reductions in retail costs of least-cost healthy diets.

Our results can be seen as the trade-policy counterpart to recent findings that farmgate prices constitute a relatively small fraction of retail food spending even in low- and middle-income countries (Yi *et al.*, 2021). That study used input-output data to explicitly account for the cost of labor, facilities and other resources used at each stage of food value chains in 61 countries, finding that farmgate prices received by growers averaged only 27% of retail costs paid by consumers. Our corresponding observation is that the trade unit value for imported bulk commodities that could be subject to import tariffs cost averaged 17% of retail item prices, and 21% amongst least-cost foods needed for healthy diets. Taken together, these two studies demonstrate the important difference between farmgate and wholesale markets for food commodities that drive agricultural income and employment, versus consumer markets for retail items that drive access to a healthy diet.

This study is subject to important limitations. Our method focuses on accounting for the trade unit value of food commodities used in each retail item, as observed in the data. This is a necessary first step to future counterfactual modelling of substitutions that might occur in response to policy change, and it reveals severe limits on the scope and quality of available data. One central challenge relates to the need to match traded commodities to retail items, aligning trade unit values for the traded ingredients in each food product. Focusing on diet costs requires costs to be expressed per calorie for each type of food, and the underlying data from which we constructed our bilateral trade unit values were quite noisy with numerous implausible outliers. This necessitated truncating those unit values at the 25th and 75th percentiles. Next, our finding that imported items are not found in least-cost diets is somewhat limited by our analytical approach, which does not capture the likelihood that eliminating high tariffs could lead to substitution of domestically-produced goods with cheaper imported equivalents. In such cases, our estimates of the role of tariffs in CoHD are biased toward the null. In addition, our analysis on the effects of removing NTMs is hampered by lack of granular data at the item level in sub-Saharan Africa, and the work presented in this paper thus relies on GTAP sector level estimates for global trade. Producing AVE estimates for individual products and for countries in Africa would not only enrich the analysis presented in this paper but also facilitate further research on trade and regional integration in Africa. Finally, trade data employed in this paper is only reflective of formal trade. While informal trade exists in every region, its particular prevalence across the lengthy and porous borders common in sub-Saharan Africa suggest that focusing on formal trade data may exclude a substantial share of actual intra-African trade. Such under-reporting has been estimated to range from 11 to 40 percent (Mold and Chowdhury, 2021; Harding, 2019).

In summary, availability of low-cost, healthy food products at the farmgate or port of entry is just one step towards physical and economic access to healthy diets for an entire population. Next steps involve lowering prices along the entire value chain to the final consumer, especially for least-cost healthy options, as well as providing safety nets,nutrition assistance and nutrition education for those most at risk of malnutrition. Managing trade policy to ensure access to a diversity of products and origins is important for functioning of food markets and to promote livelihoods in agriculture and the agribusiness sector , while research and policy on access to healthy diets can focus primarily on drivers of retail market conditions and other determinants of consumer choices.

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Appendix 1

Table A1 Least-cost diet baskets in three countries, with and without tariffs or NTMs

	Least-cost diet with trade barriers		Least-cost diet without tariffs		Least-cost diet without non-tariff measures	
	ICP item name	**Cost**	**ICP item name**	**Cost**	**ICP item name**	**Cost**
Nigeria	Maize grains, white	0.34	Maize grains, white	0.34	Maize grains, white	0.33
	Broken rice, 25%	0.41	Broken rice, 25%	0.41	Broken rice, 25%	0.41
	Fresh carrots	0.23	Fresh carrots	0.21	Fresh carrots	0.21
	Fresh onions	0.24	Fresh onions	0.24	Fresh onions	0.22
	Fresh cucumber	0.47	Fresh cucumber	0.47	Fresh cucumber	0.47
	Banana, short finger length	0.24	Banana, short finger length	0.24	Banana, short finger length	0.24
	Large mango (grafted)	0.28	Large mango (grafted)	0.28	Large mango (grafted)	0.28
	Milk, fresh, unskimmed	0.42	Milk, fresh, unskimmed	0.37	Milk, fresh, unskimmed	0.35
	Beef, minced	0.57	*Beef, with bones*	*0.53*	Beef, minced	0.57
	Spotted beans	0.23	Spotted beans	0.23	Spotted beans	0.23
	Palm oil, unrefined	0.13	Palm oil, unrefined	0.13	*Peanut oil*	*0.12*
		3.56		**3.45**		**3.44**
	ICP item name	**Cost**	**ICP item name**	**Cost**	**ICP item name**	**Cost**
Bangladesh	Maize	0.16	Maize	0.16	Maize	0.14
	Wholemeal flour	0.20	*Broken rice, 25%*	*0.20*	Wholemeal flour	0.20
	Fresh cabbage, green	0.16	Fresh carrots	0.14	Fresh carrots	0.14
	Water spinach	0.16	Fresh cabbage, green	0.16	Fresh cabbage, green	0.16
	Fresh carrots	0.16	Water spinach	0.16	Water spinach	0.16
	Coconut, young green	0.19	Coconut, young green	0.19	Coconut, young green	0.19
	Fresh bananas, standard	0.37	Fresh bananas, standard	0.37	Fresh bananas, standard	0.37
	Whole duck, fresh	0.56	Milk, UHT, unskimmed	0.51	Milk, UHT, unskimmed	0.50
	Milk, UHT, unskimmed	0.58	Whole duck, fresh	0.56	Whole duck, fresh	0.56
	Dhal, Khesari	0.23	Dhal, Khesari	0.23	Dhal, Khesari	0.20
	Palm oil	0.12	Palm oil	0.11	Palm oil	0.11
		2.88		**2.78**		**2.72**
	ICP item name	**Cost**	**ICP item name**	**Cost**	**ICP item name**	**Cost**
Honduras	Wheat flour, not self-rising	0.29	Wheat flour, not self-rising	0.29	Wheat flour, not self-rising	0.29
	Long-grain rice, not parboiled	0.35	Long-grain rice, not parboiled	0.34	Long-grain rice, not parboiled	0.35
	Fresh carrots	0.17	Fresh carrots	0.17	Fresh carrots	0.17
	Fresh cabbage, green	0.24	Fresh cabbage, green	0.24	Fresh cabbage, green	0.23
	Fresh onions	0.26	Fresh onions	0.26	Fresh onions	0.26
	Fresh bananas, standard	0.16	Fresh bananas, standard	0.16	Fresh bananas, standard	0.16
	Fresh oranges	0.32	Fresh oranges	0.32	Fresh oranges	0.32
	Milk, fresh, unskimmed	0.48	Milk, fresh, unskimmed	0.48	Milk, fresh, unskimmed	0.48
	Chicken, whole, fresh	0.60	Chicken, whole, fresh	0.60	Chicken, whole, fresh	0.60
	Red Kidney beans, dried	0.23	Red Kidney beans, dried	0.23	Red Kidney beans, dried	0.21
	Vegetable oil	0.25	Vegetable oil	0.25	Vegetable oil	0.25
		3.36		**3.34**		**3.32**

Appendix 2

Measurement error, data cleaning, and summary of the analytical dataset

We identified outliers in the TRAINS tariff data by identifying those tariffs that lie more than 150% of the IQR above the 75^{th} percentile for each traded commodity, flagging 360 tariffs at the HS6 level imposed by 79 importing countries. We reviewed each tariff and cross-checked with tariff data published in the Market Access Map (MACMAP) to confirm whether the tariff appeared to be correct as published in TRAINS. This process was limited by the inherently complex nature of tariff implementation. Tariffs downloaded from TRAINS reflect most favoured nation status and schedules, preferential trade agreements, tariff rate quotas, and other types of trade policies, which are exceedingly difficult to track even in their raw form. We therefore took a cautious approach and only revised tariffs in cases where an error was clearly present in the TRAINS database. We only replaced the TRAINS data with MACMAP data if the TRAINS weighted average AVE tariff was larger than the MACMAP most favoured nation rate, as the complexity of trade agreements could result in a smaller but almost never a larger average weighted average rate. We also replaced TRAINS data when MACMAP included tariff data from a more recent year. For 341 of the flagged tariffs, the MACMAP database closely corresponded to the value downloaded from TRAINS, and therefore we retained these tariffs in our analysis. For the remaining 19 flagged tariffs, we recalculated the global weighted average AVE tariff using the bilateral tariff data available through MACMAP. For 3 of these tariff lines, the data available through MACMAP were more recent than those available through TRAINS. In the case of two extraordinarily large Indonesian tariffs, we replaced the TRAINS data with MACMAP data from 2013.

The ICP dataset on retail prices in 2017 is provided by the World Bank in its near-final form, after extensive averaging for use in purchasing power parity calculations. After matching to food composition data, of the 28,242 item prices we found only three instances where the reported price per calorie was implausibly low, perhaps due to reporting errors in the reported unit of measure of item description. In contrast, the bilateral import unit values we derived from the FAOSTAT trade matrix had very wide variance, perhaps due to misreporting of quantities or prices. Of the 37,260 potential national average trade unit values (180 commodities imported into 207 countries), the trade matrix reports import quantities and values for a total of 8,403 product-country flows. Of those, we exclude 885 observations that we thereby reclassify as non-traded commodities for that country, because the trade unit values were outliers for their commodity using the 1.5*IQR criterion, and also imported in trace quantities under 5,000 mt/year by that country. We then winsorised the remaining trade unit values at the 25^{th} and 75^{th} percentile of observations for each commodity, to allow variance around the median without the full range of extreme values in the raw data. Even so, 121 of the resulting trade unit values exceeded the retail price and were excluded, reclassifying the retail item as nontraded due to lack of suitable match to a traded commodity.