BATModel

better agri-food trade modelling for policy analysis

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Deliverable D1.1

Broaden welfare implications of trade policy

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EXECUTIVE SUMMARY

This deliverable is D1.1 “Broaden welfare implications of trade policy”. It aims at developing a conceptual framework to assess the welfare and other trade related impacts pertinent to societal concerns and expectationsof trade policies with a focus on the agricultural and food sector.

The deliverable starts with the introduction (first section) which recalls the objective of the deliverable, the overall organisation and the structuration of BATModel.

Section 2 deals with the main contributions in the economic literature on the standard measures of welfare in models of agri-food trade, their limits and extensions still to be done. It also highlights the importance of tradecosts in the agri-food sector and the main determinants of these trade costs at firm level.

Recent developments in economic research show in sub-section 2.1 that the sources of welfare associated withagri-food trade are twofold. First, based on comparative advantage models, specialisation and input/output relationships are important components to account for in analyses of gains from trade. Second, based on imperfect competition models analysing firm-level decisions, we know that the nature of the gains from tradediffers from its nature in comparative advantage models. It relies on the entry of foreign varieties and the selection effect, with the expansion of productive producers detrimental to the less productive firms. The quality of products is also an important characteristic of competition. Even if theoretical and empirical developments account for quality in trade models, the applications focusing on efficiency gains neglect this dimension.

Among the extensions needed and presented in sub-section 2.2, to account for uncertainty is an important one.The agricultural sector is characterised by high volatility (in production and price). The trade of agricultural products affects this volatility. This characteristic is not often accounted for in standard welfare analysis. Needed extensions will also have to deal with the distributive impact of trade. Consumers will not face the same challenge according to their income as the share of expenditure in food products vary with income. In the same line, the taste of consumers is considered as given in current trade models. In reality, tastes evolve with time and their evolution is partly linked to the past prices of food products. The analysis of these links are crucial to better qualify the gains from trade in food products. Last, but not least, the structure of the food industry may not fit the theoretical assumptions in trade models. Trade models assume a continuum of firms whereas, some food industries involve a few big firms, some of them being multinational firms, and a large number of small firms. These various extensions are important but may not be easily implementable in standardwelfare analyses. Standard analyses focus mainly on real income changes, but several other issues are not easily summarized as real

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income changes or when they can be, it is thanks to strong assumptions that threatentheir generality. Among those issues that are difficult to integrate with standard welfare measures, we can mention food security issues, non-economic adjustment costs (or hidden costs in the next section), and environmental damages. BATModel will work on some of these to go beyond welfare measures.

Section 3 highlights the importance of some adjustments costs following trade shocks, and especially the costslinked to the labour market dynamics. Despite the major divide between neoclassical models and models incorporating frictions, or that between models with intersectoral allocation and intra-sectoral allocation, recent years have seen tremendous developments in how trade economists understand the dynamics of labor responseto trade shocks. The issue, from policy makers' point of view, is to determine whether workers are harmed byjob reallocation, by how much, and whether there are costs involved in moving to another sector or location of the job. Whereas the previous section focused on economic research in the agri-food trade area, this sectionstarts with a larger scope and ends with a focus on agri-food markets.

Sub-section 3.1 examines the relationship between trade and inequality. Whereas the inequality in wage structure between countries seems to decrease over time, the literature review shows that it increased within countries.

Sub-section 3.2 discusses the new techniques that have been implemented for estimating structural models oflabor market dynamics, and how these are crucial for analyzing welfare and distributional effects of trade. Global economic integration has shifted relatively low-skilled jobs from the rich world to labor-abundant low-wage countries, thus decreasing between-country inequality but increasing within-country inequality. The evidence so far shows that the distributional effects of globalization are centered mostly around job displacement, and stagnant and falling living standards in advanced economies, thus further increasing the gap between the rich and poor in industrialized countries. Besides, it appears that evidence mostly points to large costs of switching industries and occupations in response to a trade shock. The availability of employer- employee matched data in several countries helps to better understand the mechanism at play in these adjustment dynamics.

Furthermore, with a shrinking manufacturing sector due to competitive pressures from abroad, trade-induced structural changes in the economy of industrialized countries most likely underlie not only the distributional effects of trade but also some hidden costs. As presented in sub-section 3.3, these hidden costs concern increased mental and physical health risks, obesity and morbidity, lower fertility, greater job insecurity, decreased working conditions and impaired social functioning. The link between the wave of globalisation and political polarization in different countries received also great attention in recent publications. Hence, the distributional

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consequences of trade(or globalization)-induced changes within countries, partly through labour market adjustments and other hidden costs, are important components that should be better understood and if possible accounted for in agri-food trade models.

Analyses specific to the agricultural sector are summarised in sub-section 3.4. First, the application in developed and developing countries are distinguished, as the importance of the agricultural sector is not the same for these type of countries. To date, there are only a few studies investigating the impact of trade shocks on agricultural labor market dynamics in developed countries, and no one focused on EU countries. From thisperspective, it is necessary to start to fill this research gap. In addition, given the persistency of the agriculturalproductivity gap also in developed countries, future analyses should better figure out to what extent these productivity gaps are the result of an effective resource misallocation, versus other potential explanations stressed by the recent literature, such as labor market frictions and the selection or the high trade costs of agricultural and food products

Section 4 shifts focus from emprical evidence to ex-ante indicators, moving from (standard) welfare to well- being indicators. As seen in section two, traditional welfare indicators focus on real income changes. As it wasshown in the overview of recent developments in agri-trade models (sections 2 and 3), it is neither easy nor tractable to translate all trade-induced changes into real income changes. To broaden the assessment of trade liberalisation in forthcoming trade agreements, BATModel aims at proposing an ex-ante framework to select relevant indicators.

In a sub-section 4.1, the need to build a relevant framework implies thinking about three important questions:the “What-Where-When” approach is a useful tool to identify i) what we need to measure (definition of well-being, in line with stakeholders’ priorities), ii) where do we measure impacts (here vs there- spatial or distributive impacts) and iii) when do we measure these impacts (now vs then). Then we address the issue of the aggregation of the well-being indicators we are looking for. The move from a single indicator like GDP tomultiple dimensions of well-being requires treating this issue. The choice of a dashboard limited to 7 to 10 top-level indicators is preferred to other alternatives when aiming for policy guidance.

Sub-section 4.2 presents the outline of the procedure to select relevant indicators for ex-ante assessments. Constructing a measurement of well-being implications that can be used in ex-ante assessments of trade policyadds additional requirements on top of more general concerns with measuring well-being outlined in section

4.1. We first discuss the challenges in quantifying changes in trade policies presenting three categories of trade policy indexes used in the literature based on incidence, outcome or equivalence measures. Because quantification of changes in well-being induced by trade policy is needed to allow incorporation in the quantitative assessments by ex-ante simulation models,

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we define operational requirements on well-being indicators. Aiming for a limited set of well-being indicators which is multi-dimensional by nature requires anindicator framework that is context specific. We thus do not propose a fixed set of indicators but outline a process to move from scenario definition to a presentation of synergies and trade-offs using dahsboards, incorporating insights from simulation and econometric studies at each step.

Sub-section 4.3 lists the potential sources of indicators to measure social, economic and environmental dimensions of well-being. We focus on indicators of potential relevance for BATModel, i.e. linked to assessing agri-food trade policies, drawing on existing analyses, stakeholders expectations and the availability of indicators from the models included in BATModel.

Section 5 deals with the way BATModel will contribute to the measurement of well-being implications of trade policies. First, we screen SDG indicators presented in Section 4 in relation to foreseen work in BATModel. As trade policies affect well-being through different channels, it is important to pay attention to the type of policy indicators that can be provided through simulation models, especially those involved in BATModel. Then, we present the main directions of the work foreseen in the different components of BATModel, focusing on the potential contributions of each work package and look ahead towards extensions for a better understanding and measurement of well-being implication of trade policies. By construction, WP1will contribute more to the use of new indicators especially regarding hidden costs of trade shocks (such as unemployment, health and nutrition, environmental damages). The other work packages (WP2 to WP6), besides working on their specific issues, will also contribute through the understanding of new mechanisms orlinks between key variables and relevant indicators.

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1. Introduction

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This deliverable is a step to reach the overall objective of the BATModel project. The aim of this project is toimprove the assessment of trade policies with a focus on the agriculture and food sectors to better inform andimprove policy design. To achieve this aim, the innovation-driven structure of BATModel will particularly stimulate collaboration among the community of European teams working on established simulation models and that of teams working econometrically on micro evidence concerning agent and firm heterogeneity trade models, hand in hand with end-users. Some econometrics developments based on deep data analyses and the most recent approaches in econometrics will contribute to some improvements in existing trade models

In BATModel, we work with applied equilibrium models that capture bi-lateral trade flows at the global scaleand are currently used by the EC: CAPRI (as a partial equilibrium model that has more details for agri-food sectors drawing mostly on EUROSTAT and FAOSTAT data), CGEBox, MAGNET, and MIRAGE (all three Computable General Equilibrium (CGE) models based on the Global Trade Analysis Project (GTAP)). Thesemodels will allow BATModel to cover spatial scales (ranging from NUTS2 and EU Member State level to theglobal scale) to assess the spatial distribution of impacts such as gains and losses in agri-food trade. Jointly a more detailed sectoral view of the CAPRI partial equilibrium model can be complemented with the economy-wide perspective of general equilibrium models.[1]

BATModel aims to improve these models and to surmount their current limits. These improvements are foreseen in several workpackages organised in three components and aim to (i) assess impacts on labour markets, health or environment and have distributional impacts across sub-national regions or household types,

(ii) capture relevant aspects of trade such as quality differentiation, emerging trade flows and global value chains, (iii) cover policy instruments such as GIs and NTMs, which are particularly important in agri-food markets. This deliverable will provide a conceptual framework common to all BATModel work packages. It will help increase the interactions between teams working on established simulation models, teams working econometrically on micro evidence concerning agent and firm heterogeneity trade model and stakeholders.[2]

The deliverable is organised into 4 parts. The first two parts aim to review the literature in economic researchthrough a focus on 20 years of work on models of agricultural and food trade and on new developments in howtrade economists understand the dynamics of labor response to trade shocks. The third part deals with ex-anteindicators, which will permit us to move from

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standard welfare to a broader well-being approach. The fourth one comes back on BATModel and the way the work foreseen will contribute to the measurement of well- being implications of trade policies.

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2. Standard welfare in models of agri-food trade

This section presents the standard measures of welfare in models of agri-food trade and their limits. It builds extensively on the recent survey by Gaigné and Gouel (2022). Please refer to this chapter for more details. Thelast 20 years have seen a renewal of analyses of gains from trade thanks to the three key contributions of Eaton and Kortum (2002), Anderson and Wincoop (2003), and Melitz (2003). This recent literature builds around the gravity model which will be at the center of our exposition. While most policy analyses are rather based on CGE models, the insights about welfare mechanisms provided by the recent literature apply to CGE modelsas well, because their theoretical structure is usually very close to the gravity models used in modern trade models.

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[1] The models involved in BATModels already provide important starting points for the improvements envisaged in BATModel. CGEBox allows heterogeneous firms (Melitz model), computes the value-added components of gross tradeflows and a module working at the tariff line level and allows for the analysis of impacts from NUTS2 to global scale. CAPRI and MAGNET include detailed modelling for Common Agricultural Policy instruments. MAGNET includes a SDG module. MIRAGE provides a detailed model for trade policy analysis (Krugman model). CAPRI covers the NUTS2scale and explicit modelling of bi-lateral and global tariff-rate quotas (TRQs).
[2] In line with this objective, we also organised a training session for beginners in CGE models. We had a presentation(including demonstration) of the CGEBox model by Wolfgang Britz (UBO). See Annex 1.

2.1 Modern welfare measures

We organize the exposition by distinguishing models based on their supply-side and market structureassumptions: first presenting insights from perfect competition models focused on comparative advantage, second discussing results from imperfect competition models analyzing firm-level decisions. Although trade models differ in terms of their supply-side assumptions, they share similar demand structures, trade frictions, and trade equations. Preferences are mostly represented by a constant elasticity of substitution (CES) utility function (Dixit and Stiglitz 1977), or variations of it, because of its high tractability. For trade costs, the icebergtechnology is the second main ingredient of trade models: only a fraction of a good shipped between two places reaches the destination, the missing share having melted on the way. These demand-side assumptionscombined with the supply-side assumptions from either Eaton and Kortum (2002) or Melitz (2003) lead to a gravity equation for trade, around which most of the following literature is built.
In these models, as well as in previous generations of models, welfare is measured through the change in realincome. The welfare effects of trade depend mainly on the change in income (wages, land incomes, and profitsif any) and in price, quality (or variety-appeal), and the number of products. Tastes, heterogeneities of producers and production factors, input-output relationships, and market structures play a key role in welfare analysis. The new gravity-based models allow a new approach of welfare measures compared to what was done before. With conventional trade models and with CGE models, it was standard to do the first-order decomposition of welfare changes into its various components (e.g., terms of trade, tariff revenue, firm- relocation effect). The analytical structure of gravity models has allowed obtaining new sufficient-statistic formulas for the welfare consequences of foreign shocks or changes in trade policy (Arkolakis, Costinot, and Rodríguez-Clare 2012; Costinot and Rodríguez-Clare 2014) that are functions of (i) observable shares (the share of expenditures on domestic products, the share of intermediates in production, the share of expenditureson a product, the

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share of total revenue generated from a sector, the share of factor income in total income, etc.), and (ii) key elasticities in particular the elasticity of bilateral imports with respect to variable trade costs(trade elasticity). This new approach is valid for all shocks, not just marginal ones, so allows comparing gains from trade across trade model generations and making clear the mechanisms underlying the welfare changes.It is central to the literature presented below.

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2.1.1 Comparative advantage

- *Specialization*

The gains from trade tend to be studied in settings that include several countries and trade between countries but this poses important empirical challenges due to limited information on the changes to international tradecosts and the fact that these costs can change for political reasons. Working with domestic trade costs removessome of these problems. In addition, analyzing a situation where domestic trade costs decrease from very highlevels provide the rare opportunity to observe a textbook-like evolution from autarky to integrated market. There is a strand of work that studies the outcome of domestic trade cost reductions. It tends to focus on agriculture because the periods of strong reductions in domestic trade costs are often periods when economieswere still mostly agrarian.

A groundbreaking paper in this literature is Donaldson (2018) ``Railroads of the Raj''. He studies the benefitsderived from the development of railroads in colonial India using a simple Ricardian, Eaton-Kortum, gravity model. In this model, the trade share is a sufficient statistic for welfare in the sense that the effect of access tothe railroad network should be captured by this variable. This equation allows for a linking between the annualdata and the Ricardian model. Donaldson shows that a district real income, corrected for rainfall, is increasedby access to a railroad. However, this positive effect is halved if the predicted trade share is included as a control. This result demonstrates that the gains from domestic trade in agricultural products are in large part consistent with the mechanisms of the Ricardian model.

Another approach to analyze the gains from economic integration and to compare them to the benefits from productivity gains is the backcasting exercise proposed by Costinot and Donaldson (2016). They use a linear programming model of US agriculture to recover historical prices (and thus trade costs) and productivity shifters from 1880 to 1997. This exercise rests on the key insight that with a few assumptions the production possibility frontier is observable in agriculture at one point in time thanks to the crop potential yields simulatedby agronomists. Provided that the pattern of comparative advantage does not change between the pixels withina county, it is possible to use the model optimality conditions combined with observations of the value of agricultural output, the quantity produced, and the corresponding acreages to recover the prices and productivity shifters. From this, Costinot and Donaldson provide counterfactual simulations to show that the reduction in domestic transport costs between counties led to a 1.5% annual growth rate in real output between 1880 and 1920 and a 1% growth rate between 1954 and 1997, in the first period slightly higher than productivity increases and in the second period slightly lower than the productivity increases. This result showsthat in agriculture the historical gains from specialization allowed by better trade integration are commensuratewith the gains from improved productivity.

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Historical evidence on episodes of trade costs reductions shows that trade costs are crucial determinants of thegains from trade in agriculture, crop specialization, and the value of the land. Given these results, it is naturalto wonder how much gain could be expected in countries where trade costs are still sizable. For example, Porteous (2019) documents that trade costs between Sub-Saharan African markets are five times higher than international benchmarks. To address this question requires trade models representing the current market situation in order to conduct counterfactual simulations. Several papers develop such models and confirm the importance of the overall gains from agricultural trade from lowering the trade costs but show also that such ashock could have distributional effects: winners and losers across regions and groups (farmers and non- farmers). Porteous (2019, 2020) and Sotelo (2020) highlight two key mechanisms determining the distributional effects: first, the baseline specialization pattern, whether the region is a net seller or a net buyerof crops, and second, the price effect of the shock on these crops, i.e., the terms of trade effect. Porteous (2019,2020) shows that in Sub-Saharan Africa, where most markets are net-importers, the dominant effect of lower trade costs is a reduction in the output price, so farmers tend to lose from lower trade costs but overall the gains from lower food prices and higher consumption of the outside good dominate the welfare effects and only a small number of regions experience welfare losses. In the case of Peru, Sotelo (2020) shows that the welfare losses from a policy to pave all roads affect more than 20% of farmers concentrated in already well connectednet-exporting regions where lower trade costs would lead to increased competition.

The papers discussed so far in this section are all concerned with gains from domestic trade in settings with large domestic trade costs. Few papers analyze gains from international trade focusing on agricultural products.Reimer and Li (2010) adapt Eaton and Kortum (2002) approach to the crop sector and find modest gains fromtrade (0.6% of GDP for the median country). These small gains could be explained by trade costs which tend to be higher for agricultural than for manufacturing products, explaining also the relatively low trade intensityof agricultural products (Xu 2014). Another explanation for these low gains is the combination of the low share of agricultural and food products in consumers' budgets combined with the modelling framework (Costinot and Rodríguez-Clare 2014).

Considering multiple crops instead of one aggregate agricultural sector is a first step to obtain higher gains (Farrokhi and Pellegrina 2021). This acknowledges that the agricultural sector is heterogeneous which opens important opportunities for specialization. A second step could be acknowledging the specificities of this sector. Although Fally and Sayre (2018) do not provide numbers on the gains from trade associated with trade in agricultural products, their work provides insights into why they could be much higher than predicted by a simple neo-Ricardian model which does not account for this sector characteristics. Agricultural goods and

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commodities are special: their production requires a fixed factor, land in the case of agriculture, with very heterogeneous spatial endowments whose quality also differs. Their demand is also quite inelastic because oftheir role in human nutrition. Hence, for many agricultural products, production is concentrated in a few countries but consumption is global (e.g., cocoa, coffee, soybeans). According to Fally and Sayre, this combination of limited demand and supply reactions implies much larger gains from trade attributable to commodities than in a standard setup.

- Inputs use

Another source of gains from trade in agriculture is the interaction with the non-agricultural sector through the use of inputs and their productivity-enhancing effects. Costinot and Rodríguez-Clare (2014) show that in modern trade models, based on comparative advantage or imperfect competition, accounting for (compared to neglecting) input/output relationships magnifies the gains from trade. Modern agriculture relies hugely on inputs (modern seeds, machinery, fertilizer, pesticides, fuel, livestock feed, etc.), and many of them are involved in significant domestic and international trade.
Following the literature referred to previously, most papers studying the role of trade costs in inputs use are based on a developing country context where high transport costs are an impediment to their wider use. For example, Adamopoulos (2020), Aggarwal et al. (2018), Porteous (2020), and Sotelo (2020) build quantitativetrade models featuring traded inputs to analyze the counterfactual effects of lower domestic trade costs (mixing the domestic and international trade costs in the case of Porteous (2020)). However, they do not distinguish the effects of these lower costs on specialization and inputs use. To our knowledge, the only paper to decompose the gains from trade between specialization and inputs use, and to study the question in a global context is Farrokhi and Pellegrina (2021). They use a quantitative trade model to study the effects of the 1980—2017 globalization (i.e., lower international trade costs) on input availability and agricultural productivity and distinguish between the effects of lower trade costs on input choice and on crop choice. Their results show thatincreasing trade costs in agriculture to their 1980 values would decrease welfare by 2.4%, and increasing tradecosts just for agricultural inputs would decrease welfare by 1%. Farrokhi and Pellegrina's results show that thegains from trade in agricultural inputs is comparable with the gains from trade associated to standard comparative advantage related to crop specialization.

2.1.2 Firm-level analysis

The literature discussed so far emphasizes trade at the country or region level as an aggregate phenomenon. However, the developments in trade theory from the 2000s emphasize that it is

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individual firms not countries that are involved in exporting and importing. Melitz (2003) provided the first convincing theoretical explanation for the observations that only a fraction of the firms in developed and developing economies are involved in international trade (Bernard et al. 2007) by positing that the productive capacities of firms are heterogeneous and that only firms that are productive enough can overcome fixed export costs.

- *Firm rationalization*

Modern approaches of international trade based on sunk costs, product differentiation, and firm heterogeneityprompted the emergence of a new research agenda which is particularly relevant to the food industry (Gaigné, Laroche-Dupraz and Matthews 2015; Gopinath, Sheldon and Echeverria 2007; Sexton 2013). In this new generation of models, the nature of the gains from trade differs from its nature in comparative advantage models. First, there is an entry (variety) effect. Trade liberalization implying more import competition (or lower input prices) forces low productive domestic firms to exit. Globalization allowing the introduction of new foreign varieties in domestic countries destroys some domestic varieties by making them unprofitable. This is a spatial version of the process of creative destruction described by Joseph Schumpeter. This entry effect is due to demand-side changes of substitutability among varieties, and the existence of fixed costs: consumers exploit the fall in the price of imports by expanding the number of imported varieties and consumingthe same set of domestic varieties but in lower amounts. For some low-productivity domestic firms, their operating profits become lower than their fixed costs forcing them to exit.

The gains from trade arise mainly from a selection effect. Indeed, trade liberalization induces the expansion ofmore efficient incumbents at the expense of less productive producers within each sector. It follows that aggregate productivity increases through either market share shifts to more efficient firms or the exit of low productivity producers. Hence, a greater spread of productivities leads to higher proportional gains from tradeliberalization. Ruan and Gopinath (2008) find food industry average productivity increases with liberalized international trade. Olper, Pacca, and Curzi (2014) confirm this finding for a sample of 25 European countriesand 9 food industries over the period 1995—2008.

In a one-sector model, the gains from trade are the same with or without selection effect (Arkolakis et al. 2012).However, in a multi-sector economy with firm-level scale economies, the selection effect due to foreign shockscan be magnified or weakened due to changes in the allocation of resources and income across sectors withina country with consequences for the number of varieties that can be produced due to a reallocation of primaryfactors across sectors.

- *Quality*

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In the trade of food products, a crucial issue is that of quality. It matters for firm strategy, the effects of trade costs, and ultimately for welfare because the price index used to determine real income changes has to be adjusted for changes in product quality and because producing higher quality goods involve higher variable and fixed costs. Building on Melitz's framework, several papers consider vertical differentiation to explain thequality sorting found in the international trade (Gaigné and Larue 2016; Hallak and Sivadasan 2013; Kugler and Verhoogen 2012). Concerning the choice of product quality, the trade literature considers that the characteristics of the different varieties are customized for each foreign market, and therefore the quality of the varieties is adjusted by the firms as often as prices are adjusted. Under these circumstances, product qualitydepends on the characteristics of the destination country (market size, trade cost) and firm features (productivity, ability to produce quality). Firms have an incentive to improve the quality of their varieties if demand increases with a better quality of products perceived by consumers. However, a higher product qualityinduces additional variable and fixed costs of production in line with the industrial organization literature. Theimpact of quality on firm profits depends on the foreign consumers' attitude to quality relative to the cost elasticities of quality.

Quantification of the role of quality in explaining trade outcomes has received much attention. However, quality is unobservable and measuring it is not straightforward. By focusing on the Champagne industry, Crozet, Head, and Mayer (2012) obtained direct quality measures from wine guides. Unfortunately, there are numerous products for which no direct measures of product quality exist. This is why much of the literature uses prices or unit values computed from trade statistics to proxy for quality. However, higher unit values mayalso reflect lower efficiency. As a result, several researchers use alternative approaches. In Curzi and Olper (2012), product quality is proxied by investment intensity, R&D expenditure, product and process innovations, and quality standard certifications (ISO 9000). Applying this methodology to a sample of 750 Italian food exporting firms, they find that more efficient firms sell higher-quality goods at higher prices and serve more distant markets, confirming the positive relationship between productivity, product quality, and export performance. Other works compute an index of food product quality at the firm-destination-product level using the methodology developed in Khandelwal (2010) and Khandelwal, Schott, and Wei (2013). For a given price in a firm-destination-product triplet, a variety with a higher quantity is attributed higher quality. Conditional on price, avariety with a higher quantity is assigned higher quality. Using this methodology, Curzi, Raimondi, and Olper(2015) find that in Europe lower prices of imported food products can be accompanied by higher quality. In addition, Curzi and Pacca (2015) report that lower variable trade costs encourage quality upgrading in the foodindustry.

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This literature shows that tools have been developed to account theoretically and empirically for quality in trade models. However, measurement issues make this accounting sufficiently challenging that most applications focused on welfare effects neglect this dimension.

2.2 Extensions na limits

The standard framework presented previously has various limits. The analysis of trade effects on welfare focuses mainly on price, quality, and the number of varieties. More trade is expected to provide welfare gainsto consumers from access to new import varieties and lower quality-adjusted prices. Many important dimensions of agri-food trade cannot be summarized as real income change and so cannot be well accounted for in standard welfare measures. In addition, empirical studies document that rising trade exposure is also associated with hidden costs for consumers, whose assessment is crucial for a correct evaluation of the net welfare gains from trade. In this section, we discuss various extensions of the standard framework accountingfor other welfare dimensions.

2.2.1 Trade costs vs market failures

Consumers show increasing concern for some food characteristics which go beyond quantity, price, and tasteand are linked to additional arguments in their utility function, such as health, safety, pollution, and moral aspects (moral concerns are related to situations where consumers feel guilt about their responsibility for the externalities imposed on citizens or living beings located in the trading partners). However, the vast majority of the trade literature assumes that the perceived and true quality of products do not deviate while not all attributes are perfectly observed by all consumers. If consumers can learn about the quality level prior to the purchase (*search good*) or after repeated purchases (*experience good*), uncertainty about product quality mayprevail. In some cases, consumers lack the technical expertise to obtain information and cannot perfectly judgethe quality even after consumption (*credence goods*). There is demand for attributes in food products which cannot be verified by consumers either ex-ante and ex-post, such as: (i) attributes that have health/safety consequences (e.g., pesticide residues) and (ii) attributes that are related to production processes such as the environmental costs of production, the living and working conditions of farmers, use of child labor, use of genetically modified organisms, animal welfare standards, and use of traditional production process in specificplaces. Many food products exhibit credence characteristics. As information asymmetry exists between buyerand seller with respect to the quality of food products, the introduction of quality standards can be justified asthey can partially solve a real-world information problem.

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They can be viewed as correctives for market failures due to mainly asymmetric information and externalities

Quality standards, such that Technical barriers to trade (TBT) and sanitary and phytosanitary (SPS) measuresas well as "Geographical Indications'' (GI) labels are contentious issues in trade negotiations. The quality- related non-tariff measures (TBT and SPS) affect most traded agricultural and food products and are playing an increasing role in global food chains and can be viewed as protectionist if governments use these measuresas a trade policy. There has been much concern about the misuse or mischaracterization of public standards asnon-tariff barriers. Yet, regulatory measures such as TBT and SPS measures are not per se trade obstacles. Indeed, quality standards are not a priori discriminatory measures since they must be respected by both foreignand domestic firms. The incidence of those quality standards on trade and welfare has received growing interestin agricultural economics.

The effects of quality standard on welfare is ambiguous (Gaigné and Larue 2016). On the one hand, quality standard can facilitate trade and improve welfare. The demand for foreign products may increase due to a better quality of products or due to a reduction in informational asymmetries between domestic consumers andforeign producers. In addition, a stricter quality standard yields a better reallocation of resources from low- productivity low-quality firms to high-productivity high-quality firms (Disdier, Gaigné and Herghelegiu 2021). On the other hand, there are two distortions associated with the introduction of a minimum quality whenimperfect competition prevails: (i) a distortion on the distribution of the quality-adjusted prices (some firms have to adopt the minimum standard while the optimal quality for those firms without quality standard differs); and (ii) an entry distortion implying less varieties available in the country. Even if the public mandatory standards imposed by national governments are applied in a non-discriminatory way (between domestic and foreign firms), standards can be ``post-discriminatory'' agreements and eliminate trade because of additional variable and fixed costs of production (compliance costs and the lack of transparency). This effect is exacerbated when standards differ among countries, which significantly increases the cost of doing business internationally. Such measures may remove product varieties that consumers demand but which do not satisfy the standard. Hence, the relationships between standard-like measures and welfare are complex. Although standard-like non-tariff may alleviate market failures (negative externalities and information asymmetry), theycan also create distortions.

Furthermore, firms may decide to invest in quality signaling and choose strategically to disclose information to uninformed consumers about the quality of their product. Credible quality disclosure can take different forms. Sellers may make the quality of their products known to the purchaser through a guarantee issued by an independent third party (certification). However, quality-signaling activities imply a sunk cost for the firm(e.g., the cost of obtaining certification

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of product quality from an independent third party). While small firmsmay be unable individually to invest in quality signaling, there is scope for producers to act cooperatively. Asin (Moschini, Menapace and Pick 2008), GIs can be interpreted as a common brand allowing sharing of the marketing, promotion, and certification costs required for a credible GI.
While much attention has been devoted to the impact of quality standards on trade, little attention has been paid to their impacts on welfare.

2.2.2 Gains from under uncertainty

A specificity of agricultural commodities (common also to other commodities) is that their production and their price are much more volatile than those in other tradable sectors. This high volatility implies that trade may also play a role in smoothing idiosyncratic shocks. Neglecting the gains from trade under certainty as discussed previously, identical countries could benefit from trade because of the stability in consumption it provides. World cereal production is indeed less volatile than that of most individual countries, so there is a potential role for international trade in smoothing idiosyncratic shocks. However, this says little about how much a market with trade costs can enable or hinder risk sharing. Some works have addressed this crucial issueby comparing periods with different levels of trade costs or analyzing how shocks are transmitted in the market.
At the world level, one problem related to addressing this question is that periods of increased price volatilityare often periods of increased barriers to trade in reaction to this price volatility. Thus, it is important to find episodes of trade barriers unrelated to commodity market events. To do this, Jacks, O'Rourke, and Williamson (2011) draw on three-century-long time series of commodity prices and show that during periods of war or autarkic regimes, i.e. when there are impediments to the smoothing of idiosyncratic shocks by international trade, commodity prices are significantly more volatile than during peace time.
Because of the difficulties related to identifying episodes with higher trade costs unrelated to commodity eventsat the world level, one solution is to exploit the national level as do several papers on the gains from trade under certainty. Burgess and Donaldson (2010) show that the relation between famine severity and rainfall shortage is reduced by the connection of the affected district to the railroad network.
These papers show that although trade may not achieve a perfect smoothing of idiosyncratic shocks, it reducesagricultural price volatility and the food security risk associated with localized harvest failures. However, price volatility is not related directly to welfare (famine is more likely to be). Since the above-mentioned literature on trade and uncertainty is econometric based and does not involve full-fledged trade models where uncertaintymatters, it is silent about the interactions between trade openness, volatility, and welfare. However, these interactions can

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matter. As shown theoretically by Newbery and Stiglitz (1984), the price stabilization broughtby trade could be detrimental to welfare. If markets for risk are missing, the variation in the domestic price incontrast to domestic production provides insurance for risk-averse producers. So, by loosening the connection between prices and yield, trade may remove an implicit insurance mechanism.

Sorting out these various effects credibly, beyond the simple theoretical model of Newbery and Stiglitz, is a difficult endeavour. The difficulties include that risk-averse agents will base their allocations on the distribution (or at least the mean and variance) of returns which are themselves a function of the chosen allocations. In a standard trade model setup, this would involve costly numerical methods to solve for the rational expectations equilibrium of the problem. A workaround was proposed by Allen and Atkin (2016). Based on new theoretical foundations, they develop a general equilibrium Ricardian trade model with an analytical solution and approximate the risk-averse farmer problem as a mean-variance problem. Using this framework, they analyze 40 years of reduced intranational trade costs in India. They confirm that lower tradecosts decrease the sensitivity of local prices to local production shocks but that lower trade costs increase farmers' revenue volatility if the farmer maintains a constant crop choice, which reduced the welfare gains from lower trade costs. If the farmer adjusts the crop choice to the new distribution of returns, this can mitigatealmost completely the increase in the variance of the farmer's returns and he/she will benefit from even higherwelfare gains.

This stream of work shows that changing market uncertainty is an important consequence of trade in agricultural products and there exist methods to account for its welfare effect. However, those are far from standard and this dimension is usually neglected in most work.

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2.2.3 Distributive effects

Up to now, we have mostly discussed aggregate welfare effects, but trade has also distributional impacts. We address here those operating through an expenditure channel. As expenditure shares in food products vary with income, the impact of a trade-induced change in the prices of food products varies according to consumers' income. Because low-income consumers have larger food expenditure shares than richer consumers, more imports implying lower quality-adjusted prices of food may have a stronger positive effect on low-income consumers. Fajgelbaum and Khandelwal (2016) and Nigai (2016), study the gains from trade across households by allowing for income heterogeneity within countries. The approach developed in Fajgelbaum and Khandelwal (2016) embeds Deaton and Muellbauer (1980) almost ideal demand system (AIDS) preference structure in the upper stage (food, manufacturing and services) into a standard model of international trade. Using aggregate trade data from many countries, they find that falling costs of importing in the food sector exhibits a pro-poor bias. In addition, a pro-poor bias arises from the fact that poor households spend relatively more in sectors that are more traded (food and manufacturing sectors), while high-income individuals consume relatively more in the least traded sectors (services).
However, the choice of the demand system can have a significant impact on the quantification of distributional effects of trade. Using the data from Fajgelbaum and Khandelwal (2016) and Borusyak and Jaravel (2021) find that (i) the import shares on food expenditure for poorest (resp., richest) households imputed by AIDS imply too high (resp., low) values and (ii) the pro-poor expenditure channel of trade becomes small with a demand system derived from non-homothetic CES preferences. From US detailed expenditure data, they also document that import shares in expenditures do not vary across households according to their income when the levels of product aggregation are low and indirect import spending through imported inputs is taken into account.
Once it is recognized that non-homotheticity of food import demand can play a significant role in determining trade patterns and the heterogeneous welfare gains and losses from trade, the choice of non-homothetic preferences to improve trade models remains an open question. Another open question is how to use non- homothetic utility functions to capture that as consumers become richer, they spend less on food goods but also switch from low-quality food to high-quality food given the problem that one cannot interpret the high income-elastic goods as high-quality goods and the low income-elastic goods as low-quality.

2.2.4 Nutrition, tastes and trade

The works reviewed previously assume that tastes are given. However, tastes evolve with time and trade mayplay a role in their evolution. Globalization and international trade affect food

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intake through at least two channels: taste and price, with strong interactions between them which must be analyzed. Here we consider the question of the determination of food preferences and their evolution with the environment.

One mechanism through which trade can affect taste is the idea that tastes evolve but have persistence, formalized as habits. The evolution of tastes may be based on what was consumed in the past, for example during childhood, which itself was determined by past tastes and prices. Aizenman and Brooks (2008) providean illustration of this interaction between price and taste using the global wine and beer markets. They show that in 1963 grape production and latitude explained consumption of wine relative to beer. This applies much less in 2000: production and consumption have been partially decoupled due to globalization. However, despite some convergence, consumption patterns remain different while relative prices have become closer. The authors rationalize this observation using a dynamic model of consumption with habits: past consumption ofa variety defines a habit and creates a cost to deviate from this consumption level. This implies that two agentswith different consumption histories would take time to converge to similar consumption patterns despite facing the same prices.

Building on a similar idea of tastes which evolve endogenously based on past consumption, Atkin (2013) goesfurther and shows how to estimate the evolution of tastes and analyze the welfare effects of such endogenouspreferences in the context of an open economy. He formalizes tastes formation using an overlappinggenerations model where people learn to love the food (rice and wheat in the model) they were fed in childhood.Over the generations, under high trade costs conditions this implies the development of preferences for food products adapted to local agro-climatic conditions since they imply lower prices for these products. So local tastes are biased toward the comparative advantages of the food. This bias has strong implications for evaluating the gains from trade. Tastes toward comparative-advantaged food erode the caloric gains from tradeliberalization because it implies higher prices for the preferred food, with nutritional costs for poor households. Atkin (2013) estimates food tastes in a survey of Indian households as a component of the AIDS food budgetshares which cannot be explained by prices, total food expenditure, or demographic and seasonal controls andshows that they can be explained by relative resources endowments. Using the estimated demand system, he conducts counterfactual simulations of price equalization across India and confirms a reduction in the caloric gains from trade caused by a taste for the comparative advantage food.

A growing strand of literature has also started to quantify the trade adjustment costs associated with the changesin dietary patterns and associated health outcomes. For example, Giuntella, Rieger, and Rotunno (2020) studythe case of Mexico's increased imports of food from the US since the late 1980s and following NAFTA. Theyapply a shift-share approach to explain the change in the share of obesity at the state level as a function of theexposure to US food imports,

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using the initial food share expenditures as shares in a shift-share approach. Theyprove an effect of US exports on obesity in Mexico which explains 20% of the increase between 1988 and 2012. The main mechanism they identify is the price lowering effect of higher imports. Using German reunification as a clean natural experiment, Dragone and Ziebarth (2017) identify another mechanism contributing to increased body weight: availability of novel food enabled by trade. Following reunification, East Germans increased their consumption of formerly unavailable western food beyond consumption by WestGermans. This difference in consumption of novel food persisted for several years and explains significant weight gain among East Germans. Last, globalization may affect the formation of taste. Food preferences may be shaped by habit formation (e.g., sugar-rich and fat-rich food addiction) and the social transmission of preferences. If intergenerational transmission of preferences is likely to play an important role, globalization may have a growing role in food cultures because of increasing international diffusion of information and social interactions across individuals living in different countries. This social dimension of globalization has a positive effect on the national supply of animal proteins and sugar, as well as on mean body mass index, according to Oberlander, Disdier and Etilé (2017). The quantification of trade-induced costs related to food consumption represents a critical area for future research.

The body of work reviewed here illustrates that some of the conclusions related to the gains from trade in foodproducts should be qualified after considering the indirect effects of trade on nutrition, particularly in relationto the assumption of exogenous preferences for these products.

2.2.5 Limits of CES na monopolistic competition

Most trade models with imperfect competition involve the combination of monopolistic competition and CESdemand systems. This combination implies several limits such as constant markups and the irrelevance of theactions of large firms, and various extensions have been explored in the literature.

Under the standard framework, markups do not vary across destinations and firms, and the pass-through of trade cost shocks into firm prices is complete. Hence, this combination excludes any welfare effects of lower trade costs that derive from changes in profit margins. Trade models with variable markups show that this feature can be crucial for shaping the gains from trade. Indeed, the gains from trade shrink if lower trade costs induce higher market shares for dominant, high-markup producers. This markup dispersion gives rise to the misallocation of resources across firms, shrinking the gains from trade liberalization. We lack evidence on how firm-level markup adjusts to freer trade in the food industry. Vancauteren (2013) and Curzi, Garrone, andOlper (2021) are two notable exceptions. Vancauteren finds that EU harmonization of regulations, measures that facilitate trade, generate pro-competitive effects in the Dutch food

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industry and are less pronounced for small firms. Using French food firm data over the 2001—13 period and the methodology developed by DeLoecker and Warzynski (2012), Curzi, Garrone, and Olper (2021) document that more import competition lowers average markup while more input imports raise the average markup, the two effects taken together tendto offset each other. However, markup adjustments to trade vary greatly across firms. Indeed, the markup of firms belonging to the top decile of the markup distribution in the first year of the period covered increases with import competition. In addition, large firms gain much more from the higher availability of intermediateinputs than smaller firms. This suggests an incomplete pass-through of (inputs) cost reductions to prices, whichis lower for large firms compared to smaller firms. Hence, empirical evidence suggests that trade liberalizationimplying higher competition from foreign food firms or lower agricultural prices is likely to induce a reallocation of market share from low-markup food firms to high-markup food firms.

To generate variable markups in trade models, we have to consider either demand systems implying variable demand elasticity (demand side) or oligopolistic competition (supply side). Variable markup under monopolistic competition can be generated with different classes of preferences. For example, preferences canbe represented by an additively separable indirect utility function which implies that demand elasticities are variable and the price of each variety depends positively on per-capita income (Bertoletti, Etro and Simonovska2018). Using a model featuring this class of preferences, Bertoletti, Etro, and Simonovska (2018) show that for more productive firms prices are lower but markups are higher, that in line with the empirical evidence more productive firms have lower pass-through into their prices, and the welfare gains are less than one half of the gains under CES preferences.

Alternatively, a finite number of firms instead of a continuum of firms implies variable markup under a CES demand system as "granular" firms consider the aggregate price index when making pricing decisions. In the case of a CES subutility nested into a Cobb-Douglas utility and oligopolistic competition, the perceived priceelasticity of demand is no longer a constant. As a consequence, the distribution of markups adjusts to the changes in trade costs. Hence, more import competition or lower input prices are associated with an increase in aggregate productivity and also aggregate markups since less-efficient firms exit.

In reality, market structures are rather mixed for some food industries, which involve a few big firms which are able to manipulate the market, and a large number of small firms each of which has a negligible impact onthe market. Food trade models should consider this type of "mixed" structure and its consequences on trade and welfare. For example, assuming the coexistence of multi-product oligopolists and a continuum of single- product firms, Parenti (2018) shows that the consumer surplus declines with the entry to the domestic marketof a large foreign firm

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because the exit of small firms implies fewer varieties and a higher price index. However, we are not aware of applications of the Parenti approach to the food sector.

In addition, aggregate food trade is shaped by the individual behaviour of multinational enterprises. Althoughmultinational activity appears to be relatively high in the food industry (Scoppola (2021) documents that multinational food companies account for about 50% of production), we lack economic research providing knowledge on their impacts in the agri-food global value chain as well as on overall welfare and income distribution at home and in the host country. Scoppola (2021) provides an excellent discussion on the challenges and prospects of research in this area.

2.3 Discussion

The economic research of the last 20 years has helped clarify the various sources of welfare associated with agri-food trade showing the contributions of specialization (within and between countries, and between crops),inputs use, and firm selection. It has also extended the welfare framework to include issues related to product quality, endogenous preferences, and uncertainty and price volatility. However, these extensions while conceptually important may not be easily implementable due to lack of data or tractability.

More generally, trade models are useful tools to analyze welfare changes that can be expressed as changes in real income. However, many important dimensions of agri-food trade are not easily summarized as real incomechanges or when they can be it is thanks to strong assumptions that threaten their generality. Among those issues that are difficult to integrate into standard welfare measures, we can mention food security issues, non- economic adjustment costs, and environmental damages. For example, there are no obstacles to the reallocationof resources across sectors. Yet, factors used in agricultural production face high adjustment costs in the short run due to sector-specific skills and capital. Some owners of specific resources initially employed in agricultural sectors would lose from trade-related changes in the short run and this issue is too often neglected.Furthermore, standard approaches neglect the fact that the agri-food sectors are activities generating economy-wide externalities in production or consumption. Agricultural and food sectors provide productive spillovers, ecosystem services, and consumption amenities (natural amenities, food security, cultural amenities). If included in quantitative trade models, such amenities could have the potential to drastically alter standard conclusions. So to better appreciate the consequences of trade, one needs to go beyond welfare measures.

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3. Trade liberalization and labor market dynamics

The world has undergone rapid integration of people, markets and institutions in the last decades. This process, known as globalization, facilitated world trade expansion, with low-income countries being a source of cheap,competitive imports used in the production of other goods in industrialized countries, who could then generate gains in productivity via the use of intermediate inputs. Yet, as low-income countries gradually occupied a larger share in the global volume of exported goods, the world has seen also an increase in global goods tradeimbalances since the 1980s (Dorn and Levell 2021).

A net gainer in these trade imbalances has been China, who moved away from a fully centralized economy toa socialist market economy during the 1990s, which then further induced trade expansion in the following years until its accession to the World Trade Organization in late 2001. Also, trade expansion has been furtherfacilitated by falling tariffs and new technologies making communication more ubiquitous.

When it comes to advanced economies, Krugman (2008) points out that it was trade with lower-wage countriesand the increased use of intermediate inputs that enabled productivity gains. As a result, with a shrinking manufacturing sector due to competitive pressures from abroad, trade-induced structural changes in the economy of industrialized countries most likely underlie not only distributional effects of trade but also somehidden costs. When assessing these effects, trade liberalization and globalization are often considered together(Rodrik 2018a; Colantone, Ottaviano and Stanig 2022; Piriu 2021).

Ricardo’s narrative is that trade allows countries to specialize in the goods in which they are most productive,and that GDP rises in all nations adhering to free trade. Notwithstanding, as a matter of fact, free trade is not afree lunch. Particularly, the actual wave of globalization has stress-tested economies as trade permanently alters the demand for skills, increasing the demand for high-skilled workers and reducing the demand for low-skilled workers. Job displacement typically comes with constraints as workers are often unable to find a new job or relocate quickly. These frictions generate a new geography of development, so effects of increased import competition can vary by region.

Moreover, trade reform will typically induce some sectors to shrink and others to grow. The distributional effects of trade liberalization can therefore be highly heterogeneous, and can depend on country, sector, and differences in firm productivity level (Itskhoki and Helpman 2015) but also on sector-specific experience anddemographics such as age and education (Dix-Carneiro 2014).

Increased trade with low-wage countries and its consequences in terms of firms and industries has been captured quite extensively by recent research documenting labor reallocation (Bernard, Jensen and Schott 2006; Khandelwal 2010; Autor, Dorn and Hanson 2013; Utar and

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Ruiz 2013; Utar 2014; Pierce and Schott 2016; Bloom, Draca and Van Reenen 2016; Utar 2018). As shown by evidence mostly from the past decade, labor reallocation is hardly instantaneous and costless as predicted by traditional trade theories. Older trade models such as the Ricardian and the Heckscher-Ohlin models did not assume any costs associated with switching industries, and as a result, such models may place a significant emphasis on the gains from trade.[3]

Dorn and Levell (2021) argue that the gain-and-loss paradigm is a two-way street, and we should be cautious:although trade-induced labor income losses are shown to be smaller than consumer gains from lower purchaseprices, income losses disproportionately concentrate on workers in import-competing industries and regions with industries highly engaged in competitive trade, while consumer gains are somewhat predictable, comparable across skills and geographically uniform. Hence, losses are concentrated while gains are dispersed.To what extent, then, are gains and losses from trade liberalization explored and what do labor markets tell usabout the adjustment dynamics to trade liberalization?

The idea that there is a delay in reallocating labor following an exogenous shock from trade is inherent to theadjustment costs to trade liberalization. With adjustment costs, the economy starts from a tariff-distorted equilibrium. In this context, trade reform causes the steady-state value of free-trade income to increase abruptly, but factor market frictions slow the adjustment to trade liberalization, thus the economy gradually approaches the new steady state.

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[3] For instance, Felbermayr, Prat and Schmerer (2011) introduce search unemployment in a Melitz model and show that trade liberalization lowers unemployment and raises real wages as long as it improves average productivity. They arguethat this condition is likely to be met by a reduction in variable trade costs or by entry of new trading countries. Calibrating the model shows that the long-run impact of trade openness on the rate of unemployment is negative and quantitatively important. Comparable findings can be found in other Melitz-type models with frictions (Helpman, Melitz and Rubinstein 2008; Helpman, Itskhoki and Redding 2010; Egger and Kreickemeier 2009; Davis and Harrigan 2011).

Figure 1 explains how the notion of adjustment cost stems from a situation where we consider both free-tradeincome and tariff-distorted income.

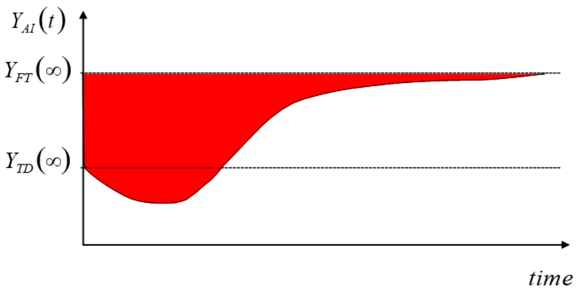

Figura 1. Trade Adjustment Costs

Source: adapted from Davidson and Matusz (2010)

The gains from trade are represented by the present discounted value of the area between free-trade income and tariff-distorted income. Therefore, the aggregate adjustment cost is the present discounted value of the area between free-trade income and actual income.

With labor reallocation, the key policy-relevant questions are whether or not workers are harmed and by howmuch, as well as whether there are costs involving moving to another

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industry or to another location if their job displacement is trade-induced. In an attempt to answer these questions, we put together a framework to guide the understanding of adjustment costs.

First, the extent of the adjustment costs of trade liberalization will depend on the unit of the analysis: effects may vary within or between firms, within sector-occupations, between sectors or within local markets. Second,distinctions will have to be made according to the type of trade relationship: importing when there is a local trade agreement in place, import shocks (supply-driven or not) under global WTO agreements, offshoring or exporting as enabled by trade liberalization. Third, effects will differ based on the setting of the analysis: an industrialized or developing country. Finally, depending on the context, labor market adjustments can largely manifest as mobility frictions or as search frictions but can also be related to human capital differentials evenafter moving into a new job.

Additionally, note that these frictions are not only relevant in trade-induced labor reallocation, but are at the heart of the structural transformation process each economy faces with economic development. As widely known, structural transformation is primarily a movement of labor from the agricultural sector (and rural areas)to the manufacturing and service sectors (and, often, urban areas) and, as such, it strongly overlaps and coincides with trade-induced sectoral labor market reallocation, particularly (but not only) in poor- and middle-income countries. From this perspective, when the agricultural labor market is the main focus of the analysis,models need to properly account for these additional forces (Tombe 2015).

In this section, the review will be organized as follows: Sub-section 3.1 summarizes the literature on trade andinequality as well as the current state of the art from both a labor economics and an international economics point of view regarding the widening of the wage structure and earnings inequality underlying important end-of-century stylized facts. To systematically review the extent of adjustment costs in recent theory and evidence,Sub-section 3.2 will further present both reduced-form approaches and structural trade models quantifying adjustment costs upon inclusion of different frictions. Sub-section 3.3 will review the hidden costs of globalization. Based on the literature presented in previous sections, Sub-section 3.4 discusses the implications for the agricultural and food labor markets, then offers a survey of the little empirical evidence on trade- induced labor reallocation in the agricultural sector. Finally, Sub-section 3.5 concludes.

3.1 Trade na inequality

Delving into the specifics of trade models with adjustment costs would first need to review changes in the wage structure and overall earnings inequality among some OECD nations. Also,

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as data has gradually becomeavailable across advanced economies, it has become reasonably easier to compare large micro datasets acrossthese countries. As a result, research on changes in the wage structure and earnings inequality in the United States and other OECD countries has been particularly fruitful during the 1980s, the 1990s and the beginning of the century. Subsequently, the following section documents changes in the wage structure of advanced economies, starting first with an exposition of the intriguing analyses of Bourguignon, Milanovic and Ravallion.

Between-country inequality has declined over time, yet average inequality within countries has edged up sincethe 2000s (Ravallion 2018). The present period of globalization is essentially seen as the joint cause of both falling inequality between countries and rising inequality within countries (Bourguignon 2016; Milanovic 2016; Ravallion 2018). A salient effect of globalization is that the lower-middle class in advanced economies has seen little or no gain from globalization, while the poor and middle class of the developing world have seen substantial gains (Milanovic 2016). Ravallion (2018) also notes that global economic integration has shifted relatively low-skilled jobs from the rich world (driving up its contribution to the within-country component of global inequality) to labor-abundant low-wage countries (driving down the between-country component of global inequality). Except for the wealthy, who have the financial and human capital to benefit from globalization, the distributional effects of globalization are centred mostly around job displacement and stagnant and falling living standards in advanced economies (Autor et al. 2013; Keller and Utar 2018; Dauth,Findeisen and Suedekum 2021; Piriu 2021). However, Ravallion (2018) argues that, as technical change is induced by global competition through trade, there is much room for independent policy making and for countries to help their poor and middle classes through education policies and social protection, thus somehowpreventing the potential arrival at a trade slowdown that might undo the progress made in terms of between- country inequality.

Since labor markets play a crucial role in the relationship between trade and inequality, we shall now look at this relationship and examine what labor markets tell us about the dynamics of adjustment to trade liberalization.

Early evidence documents the widening of the U.S. wage structure during the 1980s (Bound and Johnson 1989;Katz and Murphy 1992; Murphy and Welch 1992; Juhn, Murphy and Pierce 1993). According to Katz (1999),the overall wage distribution can be decomposed into differences in wages between groups (typically definedby skill or demographic categories) and within group wage dispersion (residual wage inequality). In answeringwhat the widening of the wage structure implied in industrialized countries, we must look at recent evidence.

Since the mid-1990s, the benefits of economic growth in the United States have been concentrated at the top end of the U.S. income distribution (Goldin and Katz 2007; Piketty 2014),

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as post-Second World War "growing together" has become "growing apart". For Germany, Dustmann et al. (2014) also note a similar dramatic development in wage inequality, consistent with other results (Dustmann, Ludsteck and Schönberg 2009; Antonczyk, Fitzenberger and Sommerfeld 2010; Card, Heining and Kline 2013). Despite a robust productivitygrowth given a decrease in unit labor costs following German reunification in early 1990s, real wages at the 15th percentile fell dramatically from the mid-1990s onwards, while median real wages started to fall from theearly 2000s onwards, and only wages at the top of the distribution continued to rise. Dustmann et al. (2014) attribute these wage restraints and the dramatic decrease in real wages at the lower end of the wage distributionto a specific feature of the German wage setting apparatus, that allowed decentralization of the wage setting process from the industry level to the firm level.

Consequently, as Piriu (2021) points out, the question is not if but to what extent trade liberalization contributedto the structural change in advanced economies and, if structural change is partly trade-induced, then what is the role of institutions in this structural change. Katz (1999) links relative wage and employment changes among different demographic and skill groups to changes in both the market forces of supply and demand, andto labor market institutions (e.g., unions and government mandated minimum wages). Katz (1999) therefore indicates that wage and employment changes are attributable, on the one hand, to supply and demand factors and, on the other hand, to institutions. Movements in within-group inequality may also reflect market forces changing the returns to (unmeasured) skills or directly result from changes in wage setting institutions that may serve to "standardize" wages within jobs and across firms and/or industries. This supply-demand- institution (SDI) explanation for wage structure changes has three parts (Freeman and Katz 1994). The first is that different demographic and skill groups are assumed to be imperfect substitutes in production.

Thus, shifts in the supply of and demand for labor skills can alter wage and employment outcomes. Katz (1999)further points out that potential important sources of shifts in the relative demand among skill groups include skill-biased technological change, non-neutral changes in other input prices or supplies (e.g., capital-skill complementarity), product market shifts, and the forces of globalization (trade and outsourcing). Sources of relative supply shifts include variation in cohort size, changes in access to education and incentives for educational investments, and immigration.

The second part is that the same underlying demand and supply shocks may have differential effects on relativewages and employment depending on differences in wage-setting and other labor market institutions. The stronger the role of wage-setting institutions and the less responsive the institutions are to changes in market forces, the more the impact is likely to fall on employment rather than on wages. Regulations governing hiring and firing as well as

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differences in educational and training institutions may also affect how the wage structure responds to market shifts.

Third, institutional changes themselves, such as product market deregulation and changes in the extent of unionization or degree of centralization of collective bargaining, can also alter the wage structure. A key issuein assessing the impact of institutional forces on changes in the wage structure is determining the extent to which the institutional changes are "exogenous" developments (such as changes in the political climate) or largely reflect responses to supply and demand changes.

Furthermore, Krugman (2008) notes a shift to lower-wage sources of imports and points out that distributionaleffects of trade may well have gotten substantially larger since studies in the early 1990s, indicating that thereis a huge gap in understanding the distributional effects of trade between the early 1990s and 2008. Here, the role of intermediate inputs comes into discussion. When firms are splitting apart their production process across several countries, they regularly make use of intermediate inputs, typically from low-income countries.This is often linked with how much of a substitute these inputs are to in-house production, technically and economically. Feenstra (2002) indicates that growth in capital or technology abroad will lead to increased outsourcing from the U.S. Considering then wage distribution, this will trigger an increase in the relative wageof skilled labor in both countries. Feenstra (2002) notes a reduction in the relative wage between non- production and production workers in US manufacturing until the early 1980s but a sharp increase thereafter.The reason for this change is an outward shift in the demand for more-skilled workers since the mid-1980s, leading to an increase in workers' relative employment and wage. Feenstra (2002) suggests that this increase in the relative demand for skilled labor occurred within manufacturing industries, and not by shifts in labor between industries.[4] Hence, there is evidence to claim that inequality is a far more complex topic when considering intra-sectoral and intersectoral dynamics as related to skill demand.

With trade, Grossman and Helpman (2018) argue that there is constant growth in the number of varieties of intermediate goods, coupled with a wide range of differences in technologies and policies. Consequently, the long-run equilibrium growth rate is higher in every trading country than in autarky, but so is the resulting wage inequality.[5] They further add that adverse distributional consequences of international integration are driven by knowledge flows and not by international trade per se, thus implying that the fastest innovator will be the one who gains the most from trade (Grossman and Helpman 2018). However, as trade and technology are difficult to separate (Fort, Pierce and Schott 2018), it follows that understanding the link between trade and labor markets can be a cumbersome endeavor, as evidence is mixed.

In industrialized countries, most studies on inequality and trade in the past two decades come prevalently from the U.S. In Europe, the primary country that has undergone significant

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compositional shifts in its labor force is Germany – not uncommon for an innovation-driven economy. Some authors (Dustmann et al. 2014; Dustmann et al. 2009; Antonczyk et al. 2010; Card et al. 2013) note that, despite robust productivity growth and unit labor cost decline for export-oriented Germany, the real wage at the 15th percentile and median real wage declined, and only wages at the top of the distribution continued to rise over past decades. As a result, the continued growth of within-country inequality could generate a backlash against globalization in advanceddemocracies and could produce instability in developing countries, particularly those with non-democratic regimes (Freeman 2011).[6] Hence, competitive pressures from abroad may not only translate into distributionaleffects but also into some hidden costs.

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3.2 Trade-Adjustment Costs: Reduced-Form and Structural Approaches

As previously suggested, trade-induced shocks from globalization can affect workers by inducing industry switching, changing location of work and occupation switching. This happens because, on the one hand, firmsthat face import competition may shrink or even exit and therefore displace workers or possibly outsource theirproduction tasks and activities; and, on the other hand, firms that gain access to foreign market should enter orexpand, therefore generating new jobs.

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[4] The within versus between distinction is consistent with (Berman, Bound and Griliches 1994).
[5] Grossman and Helpman (2018) reach the same conclusion irrespective of the assumptions on the mobility of financialcapital.
[6] More on globalization backlash and political economy implications can be found in Rodrik (2018) and Colantone,Ottaviano and Stanig (2022).

3.2.1 Reduced-form models

Import competition and manufacturing decline

In a reduced-form approach, Revenga (1992) shows how trade shocks to US manufacturing industries cause areduction in both wage and employment, where wage and employment effects differ by industry. As Krugman(2008) points out, in the years leading to the financial crisis, literature is silent about the local labor market effects of trade liberalization. Most notable, post-crisis evidence on the 'China shock' and its job-reducing effect are Autor et al.(2013), Pierce and Schott (2016) and Acemoglu et al. (2016), who find that Chinese import penetration (IP) is responsible for the contraction in manufacturing employment in the U.S. For Germany, Piriu (2021) finds greater job insecurity and a greater probability of being employed in marginal, low-paid, non-standard forms of employment for workers in import-competing manufacturing sectors. These papers, as well as the ones surveyed below, have in common the use of a shift and share empirical methodology.For that reason, Box 1 formally introduces the shift and share approach, closely following the discussion in Caliendo and Parro (2022).

The popular shift-share analysis for studying the effect of trade policy across space starts with the following considerations: different regions in a given country have different exposure to sectoral change in import tariffs;in an environment with frictions to the mobility of goods and factors, changes in trade policy may have heterogeneous outcomes according to one region's level of exposure *relative* to another region's.
The most popular econometric framework for studying the effects of trade policy across space is based on theshift-share literature, a research approach that started with Creamer (1943) to account for the impact of regionalgrowth and the regional effect of tax and regulatory policy.
The key logic is to model the impact of a (trade) shock, or shifter on given outcomes in regions that have differential exposure, ergo different shares, to the shock. The regression specification assumes the following form:

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$$y_n = \alpha_0 X_n + \alpha_1 \sum_j \omega_{nj} Z_j + e_n$$

Where, y_n, is an outcome of interest, e.g. employment, wages, and poverty; $X_n$is a set of controls, and $e_n$is theerror term. The variable Z_j is the set of shocks, or shifters, that are heterogeneous across sector *j*, and ω_{nj} is the employment share of sector *j* in region *n*.[8] In the context of trade policy, tariffs are normally used as shifters(or variations in imports), as per Autor, Dorn and Hanson (2013).

To clarify the method further, Caliendo and Parro (2022) used the example of Topalova (2010) who applied this approach to study the effects of trade liberalization in rural districts in India. Topalova (2010) exploits both the sectoral composition of economic activities across 450 districts in India and the sectoral variation in trade policy, with average import tariffs dropped from 80 to 37%, from 1990 to 1996. She runs the following regression specification:

$$y_{dt} = \alpha_0 + \alpha_1 Tariff_{dt} + Post_t + \delta_d + e_{dt} \quad (1)$$

In this specification $y_{dt}$is the outcome of interest (poverty) at the district level *d* and time *t*, α_0 is a constant, $Post_t$controls for aggregate shocks or trends that affect the economy, and δ_d are district fixed effects. The keyterm, $Tariff_{dt}$, captures the level of protection at the district level and represents the shift-share term, namely:

$$Tariff_{dt} = \sum_j \omega_{dj,91} r_t^j$$

where r_t^j are the sectoral ad-valorem tariffs while the shares (or weights) $\omega_{dj,1991}$ are defined as theemployment share of industry *j* in district *d* in the pre-shift period of 1991, or:

$$\omega_{dj,1991} = \frac{L_{dj,91}}{\sum_j L_{dj,91}}.$$

The coefficient of interest is α_1, which captures the average effect of trade liberalization on the district-level outcome. As discussed in Topalova (2010), this estimation strategy does not

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identify the overall trade impact of liberalization, but it measures the extent to which some districts are more affected than others.
More recently, Kovak (2013) uses a similar approach to study the effect of trade liberalization on wage acrossBrazilian regions, using the following specification:

$$d\ln(w_r) = \varsigma_0 + \varsigma_1 RTC_r + e_r$$

Where $d\ln(w_r)$ is the log wage in region *r*, while RTC_r are regional tariff changes. The coefficient of interest is ς_1 measuring the effects of changes in regional tariffs on earning across regions. Here RTC_r takes a shift- share form, in particular:

$$RTC_r = \sum_j \omega_{rj} d\ln(r_j),$$

where the shifter $d\ln(r_j)$ is the change in tariff across sectors *j*, and the share ω_{rj} is the weight of each industryin each region, given by

$$\omega_{rj} = \frac{\frac{L_{rj}}{L_r}\frac{1}{\beta_{rj}}}{\sum_{jr} \frac{L_{rjF}}{L_r}\frac{1}{\beta_{rjF}}}$$

where β_{rj} is the share of labor payment in gross output in industry *j*. Note that these shares are equal to one inTopalova (2010), i.e. she assumes that there is no heterogeneity in the labor payment related to gross output across industries. Kovak (2013) finds that regions exposed to the largest tariff declines experience smaller wage growth relative to regions experiencing smaller tariff cuts.
In addition, Kovak (2013) develops an economic theory to justify the specification of the shift-share term, based on a small-open economy and the specific-factor model. Caliendo and Parro (2022) extend this economictheory to allow for imperfect regional labor mobility, by assuming that moving to location *n* entails a multiplicative cost ε_n that is an *i.i.d.* draw from an extreme value Fréchet distribution with shape parameter ν,
that can be interpreted as an amenity shock. The modelling framework is useful because it carries implications
for the interpretation of the estimated coefficient.
In a nutshell, the first interpretation of the estimated coefficient in the shift-share approach is that the specification does not measure level effects. Indeed, being based on a difference-

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in-differences research design, the coefficient can only be interpreted as the deviation from aggregated effects, i.e. the effect of a change in tariffs in a given market relative to the average effect of the change in tariffs in the economy. Building on Kovak (2013), Caliendo and Parro (2022) show that, with the share variable constructed the estimated coefficient can have important consequences for the effect estimation and its economic interpretation.[9]

Export expansion and job creation

More recent evidence on how trade policy induces not only job losses but also job gains can be found in Feenstra, Ma and Xu (2019), whose reduced-form estimates suggest that job gains due to US export expansionlargely offset job losses due to Chinese import competition, resulting in a net gain of 279 thousand jobs over 1991-2011. Nonetheless, at the commuting zone level, findings seem to converge to Autor et al. (2013), in thatjob gains and losses are roughly balanced though slightly on the loss side (68 thousand jobs, with a substantialrange around this estimate). Similar results, though for Europe, are in Dauth, Findeisen and Suedekum (2014) and Dauth, Findeisen and Suedekum (2017), who find job losses in the import-competing German manufacturing sectors and gains in the export-competing manufacturing sectors across German local labor markets, hence trade has a stabilizingeffect in the case of Germany.

Feenstra and Sasahara (2018) provide a quantification of the impact on U.S. employment from imports and exports during 1995-2011. Using the World Input-Output Database, their findings show that U.S. exports ledto increased demand for 2 million jobs in manufacturing, 0.5 million in resource industries, and a remarkable

4.1 million jobs in services, totaling 6.6 million, so total labor demand increase due to merchandise exports was 3.7 million jobs. In comparison, U.S. merchandise imports from China led to reduced demand of 1.4 million jobs in manufacturing and 0.6 million in services (with small losses in resource industries), with totaljob losses of 2.0 million.

[7] This box represents a summary of the Caliendo and Parro (2022), Section 2.3.

[8] Across the literature, other than employment share, other kind of share are used, such as different crops land share,as in Bräuer, Hungerland and Kersting (2021).

[9] Specifically, they develop the analysis under three different cases: (1) with non-tradable industries, (2) when the production function is not unit-elastic, and (3) under the presence of intermediate goods and input-output linkages in production. This shows how the shift share term changes structure, and how the estimated impact can be interpreted depending on that. On the interpretation of the shift share regression analysis, see also Adao, Kolesar and Morales (2019) who derive a structural interpretation of the regression coefficient and discuss the meaning of the fixed effects.

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Evidence from developing countries

Reduced-form approaches capturing adjustment dynamics in developing countries are Topalova (2007) and Kovak (2013), who show that trade shocks can have differential local impacts in India and Brazil, respectively. Surprisingly, also findings from developing countries indicate that relocation costs will ultimately affect employment in local labor markets, with workers being unable to take advantage of the differences in wages due to moving costs. This may be particularly important when considering cross-border distributional effects of trade liberalization. Rather, gains in developing countries seem to be in terms of rising working conditionsand the decline of child labor (Cigno, Giovannetti and Sabani 2018).

Evidence involving trade agreements

In the years following the Uruguay Round, Gaston and Trefler (1997) show that, although employment contracted during 1989-93 and real exports and imports contracted over most of the period, Canadian job losseswere not caused by the U.S.-Canada Free Trade Agreement. FTA tariff cuts account for no more than 15 per cent of the Canadian job losses.

However, recent evidence in Hakobyan and McLaren (2016) suggests that Mexican imports as enabled by theNorth American Free Trade Agreement (NAFTA) affect US wages for workers in import-competing sectors and that these distributional effects are much larger than aggregate welfare effects obtained in other studies.

Moreover, in line with evidence above and contextual to current trade policy issues, Leonardi and Maschi (2021) indicate that NTMs protection managed to mitigate the negative US employment effect of import exposure, but has no effect on local wages, which is consistent with the mobility of workers across local areasuntil wages are equalized.

Offshoring, skill-biased technological change and labor market adjustments

Trade reform in developing countries can contribute to the growing skill premium through skill-biased technological change, but also to an increase in sector-specific returns to skill in sectors resulting from biggertariff reductions (Pavcnik et al. 2002). Moreover, Edmonds, Pavcnik and Topalova (2006) show there are declines in child labor and increases in school attendance in developing countries, but effects become smallerfor children living in districts more exposed to tariff cuts. This is consistent with the evidence in Cigno et al. (2018) regarding a decrease in child labor and an increase in skill premium following trade liberalization in developing countries. In addition, Boulhol (2009) shows how globalization can reduce labor market rigiditiesthrough resource reallocation triggered by capital mobility, which in turn encourages labor market deregulation. However, these studies refer primarily to positive effects from trade liberalization

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in developing countries (Artuç, Porto and Rijkers 2019), yet effects are not always positive in advanced economies, as shown.
Furthermore, switching occupations comes at a cost to workers, as per Ebenstein et al. (2014) reduced-form estimates showing that US blue-collar workers in routine-task manufacturing occupations move into service sectors following an increase in offshoring to low-wage economies. Yet, what Artuç and McLaren (2015) structural model estimates show in addition to Ebenstein et al. (2014) are overall welfare effects, pointing to indirect downward pressure on all blue-collar wages through the dynamic response to the offshoring shock.

3.2.2 Structural models

Considering dynamics in trade models is not trivial. Traditional, bare-bones theoretical models exhibit steady-state properties, assuming the existence of two sectors and steady-state wages which can be equalized only if the steady-state size of the two sectors is equal. Here, wages in the import-competing sector will decline and eventually start to rise, whereas export-competing sector wages will rise sharply and start to decline over time.Adjustment to trade-induced shocks will be slow because of the idiosyncratic shocks, and hence, workers who wish to change industry of employment will wait to do so due to high moving costs. In terms of welfare, assuming that intersectoral labor supply is greater than zero and that we wish to maintain a larger share of the economy in the export sector, then the net benefit to workers in the export sector will be larger than the net cost to workers in the import-competing sector. However, models of this class are based on a small open economy with a finite number of sectors and homogenous goods, no intra-industry trade or trade in intermediate inputs.
Conversely, when considering multiple-country, multiple-sector models, with heterogenous products and complex input-output linkages, as in the current extension of Eaton and Kortum (2002), dynamic adjustment takes a different level of significance. Most notably, Caliendo, Dvorkin and Parro (2015) combine a labor- market dynamic model with a rich Eaton and Kortum (2002) model for 38 countries, 22 sectors and 50 states in the United States. There are idiosyncratic costs of adjustments due to worker mobility across industries andsectors. Each sector produces a continuum of goods, with the productivity of each good's production in each state and country given by the realization of a Fréchet distribution (Eaton and Kortum 2002), so that each localeconomy both exports and imports some of the goods in each industry (Caliendo et al. 2015). In every sector-state cell, the expected lifetime utility of a worker goes up at the date of the revelation of the China shock, relative to the pre-shock steady state, even for workers initially in the most vulnerable industries or states. However, McLaren (2017) notes that this result may not hold up, just as the original finding of Artuç, Chaudhuri and McLaren (2010) did

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not hold up once a distinction is made between high-skilled and low- skilled workers. It could be, as in the work of Artuç and McLaren (2015), that once that distinction is permittedin the model, low-skilled workers in the most-affected sectors or locations will be worse off. Nonetheless, McLaren (2017) points out that the contribution of Caliendo, Dvorkin and Parro (2015) is substantial becausethe machinery in their study makes such an inquiry possible.

Since the skill level of workers seems to play an important role in the extent of the effect, we shall now turn to evidence in Artuç and McLaren (2015). Simulating a trade shock (as per Artuç, Chaudhuri and McLaren (2010), an offshoring shock and a combination of the two, Artuç and McLaren (2015) find that the trade shocklowers the expected lifetime utility of all non-college-educated workers who are initially employed in manufacturing, regardless of their occupation. However, every other group of workers in both educational classes benefits. Notably, college-educated workers in manufacturing suffer a dramatic drop in real wage in all occupations at the date of the liberalization, but their long-run real wage is slightly higher than the pre-liberalization wage, and their improved option value is enough to make them barely better off (Artuç and McLaren 2015). This backs up the idea that a dynamic model is needed to evaluate welfare effects.

On the other hand, the offshoring shock induces manufacturers to shift production-worker labor demand toward foreign workers and away from domestic workers, pushing down wages for manufacturing-sector production workers for both educational classes Artuç and McLaren (2015). Yet, since the number of non- college-educated exceeds the number of college-educated workers, this determines a fall in the non-college- educated worker wages in all other sectors over time. In turn, this reduction in blue-collar wages throughout the economy raises college-educated workers' wages over time. As a result, blue-collar workers' welfare falls,whereas almost all college-educated workers' welfare rises (Artuç and McLaren 2015), which is consistent with (Ebenstein et al. 2014) and adds to the polarizing behavior of the U.S. wage structure that Goldin and Katz (2007) discuss.

Artuç, Chaudhuri and McLaren (2010) propose a Ricardo-Viner Model with adjustment costs of labor relocation and idiosyncratic shock and find sluggish reallocation of workers from trade liberalization alongsidesharp movement of wages, with short-run response overshooting the long-run response by a wide margin. Notwithstanding, workers from import-competing sectors do not necessarily lose due to the increase of optionvalue (relocation in other expanding sectors), which is relevant in the discussion on the welfare effects of tradeliberalization. Whether a worker benefits from liberalization or not depends much more closely on which sectorthe worker is initially in rather than on the worker's educational class. Additionally, Dix-Carneiro (2014) points out that trade-induced labor transition when moving from one sector to another is costly, and

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evidence whetherthis might imply altered dynamics with overlapping generations is still to be developed.
In a model[10] assessing GE effects of the China shock with Eaton-Kortum assumptions and Artuç and McLaren(2015) labor mobility frictions and idiosyncratic shocks, Caliendo, Dvorkin and Parro (2019) introduce a keymethodological innovation in counterfactual analysis, expressing the equilibrium conditions in relative time difference, like a difference-in-difference approach in econometrics.[11] The approach needed minimum parameters to conduct counterfactual analysis, such as trade elasticities, migration elasticity, and the intertemporal discount factor. Studying the rise in Chinese import shocks across the U.S. labor market by sector and state Caliendo, Dvorkin and Parro (2019) find that the China trade shock resulted in a reduction ofabout 0.55 million U.S. manufacturing jobs, about 16% of the observed decline in manufacturing employmentfrom 2000 to 2007. Workers relocate to construction and the services sectors that expand due to the access tocheaper intermediate inputs from China. U.S. welfare increases by 0.2% (in the long run), but there is strong heterogeneity across labor markets, which exhibit a welfare impact in the range of −0.8% to 1%. This allows to infer that labor reallocation is heavily time costly.
On the other hand, in a study using a heterogeneous-worker, multi-sector model that allows for labor mobility
– a Roy model of labor with a Frechet distribution as in Lagakos and Waugh (2013) – and different group classes (Arkolakis et al. 2012; Costinot, Donaldson and Komunjer 2012), Galle, Rodríguez-Clare and Yi (2017) show that the China shock increases average welfare but some groups lose five times the average gain.Findings are similar when considering endogenous labor force participation and unemployment (Galle et al. 2017).
Building an equilibrium model of a small open economy with labor market frictions and imperfectly enforcedregulations where heterogeneous firms sort into the formal or informal sectors, Dix-Carneiro et al. (2021) estimate a model using Brazilian data. They show that trade openness decreases informality in the tradeable sector, and there would be an understatement of productivity gains when omitting the informal sector. Also, trade openness increases welfare when informality of the labor market is repressed, and repressing informality increases productivity but at the expense of employment and welfare.
We have now seen how the set of assumptions can change the estimates of a structural model. Structural models aim at recovering adjustment costs and, since labor is a major factor in such models, it makes sense tolook at adjustment to trade with labor market frictions. In this case, labor-related adjustment costs can be dueto search and mobility frictions that slow down or prevent resources from allocating efficiently, but they can also be linked with human capital differentials even after moving into a new job, ergo human capital frictions.In addition to the

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above, Box 2 lays out the labor-specific content of trade models that encompass labor market frictions, and discusses wage, inequality and employment effects, among others.

Box 2. The Role of Labor Market Frictions in the Adjustment to Trade
Mobility and search frictions

Theoretical two-good, two-country trade models generally give welfare gains from trade but do not typically consider mobility and search frictions. Innovations as in Fernandez-Blanco (2012) still assume a Ricardian two-good, two-country economy in which farmers produce their products but require intermediaries to exchange their products in the goods market (hence the intermediation market is frictional whereas the goods market is perfectly competitive) and opening the economy to international trade always leads to welfare gains. But how perfect is factor search in an open economy with adjustment costs?
For example, a worker changing employment faces two potential sources of mobility frictions: moving from one industry to another and moving between informal and formal employment (Hollweg et al. 2014). Search frictions, on the other hand, can be inferred by looking at the growth rate in the number of workers that a firmmeets before filling its vacancy (Martellini and Menzio 2020). Other than that, the existence of search frictions introduces the complication of intra-firm bargaining (assuming a multiple-worker firm), while mobility frictions add to between-industry competitive pressures and possibly welfare.
When introducing offshoring of an activity performed by a factor of production, search frictions arise. In a two-sector, general-equilibrium model with offshoring and search frictions labor mobility, Mitra and Ranjan (2010) find that wages increase and sectoral unemployment decreases upon offshoring in the presence of perfect intersectoral labor mobility. Nevertheless, with imperfect intersectoral labor mobility, unemployment in the offshoring sector can rise, with an unambiguous unemployment reduction in the non-offshoring sector. Imperfect labor mobility can result in a mixed equilibrium in which only some firms offshore, with unemployment in the offshoring sector rising.
Furthermore, search frictions also complicate intra-firm bargaining and therefore may turn particularly important in the debate on GVC vulnerabilities. Timely evidence in Krolikowski and McCallum (2021) regarding welfare, trade elasticities and international search costs quantifies the effects of search frictions andadd goods-markets frictions. Using a GE dynamic model with heterogeneous exporting producers and identicalimport retailers on U.S. and Chinese data, results suggest that reducing international search costs to their domestic levels raises U.S. and Chinese welfare by 5.6% and 4%, respectively, reducing the trade elasticity from -3.2 to -5.5 relative to a model without search frictions.

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With mobility frictions, workers are subject to costs related to switching industries (Revenga 1992; Hakobyanand McLaren 2016), relocation for work (Topalova 2007; Kovak 2013; Autor et al. 2013) and switching occupations (Ebenstein et al. 2014; Cortes and Gallipoli 2014; Liu and Trefler 2011). In addition, a considerable amount of evidence on mobility frictions is based on trade liberalization in developing countrieswith rigid markets (Goldberg and Pavcnik 2007), including worker displacements and difficulty to absorb trade-displaced workers following tariff cuts (Menezes-Filho and Muendler 2011) as well as regional tariff cuts leading to a decline in formal sector employment and earnings in local labor markets (Dix-Carneiro and Kovak 2017).

In industrialized countries, the most notable example of the role of mobility frictions is that of Caliendo, Dvorkin and Parro (2019) – introduced above – who capture labor mobility frictions, goods mobility frictions,geographic factors and input-output linkages in determining equilibrium allocations, and show that the U.S. gains in the aggregate, but the effects on welfare and employment vary across U.S. labor markets due to tradeand migration frictions. Estimated transition costs to the new long-run equilibrium are also heterogeneous andreflect the importance of accounting for labor dynamics.

Other previous studies recovering mobility costs that workers face to switch sectors is Artuç, Chaudhuri and McLaren (2010) – which in point of fact underlies the later developed models in Artuç and McLaren (2015) and Caliendo, Dvorkin and Parro (2019). Artuç, Chaudhuri and McLaren (2010) estimate that the welfare effects of trade shocks translate into high costs for workers moving between sectors. In other words, there is aslow adjustment of the economy and sharp movements in wages in response to trade shocks. However, they indicate that import-competing workers can still benefit from tariff removal, as liberalization lowers their wages in the short and long run but raises their option value.

Further studies estimating mobility costs are Artuc, Lederman, and Porto (2015) and Dix-Carneiro (2014). Based on Artuç, Chaudhuri and McLaren (2010), Artuc, Lederman, and Porto (2015) estimate a dynamic model of sectoral employment for a large sample of developing and developed countries. Their estimates showthat labor mobility costs are negatively correlated with per capita GDP and positively correlated with less- developed, low-quality labour markets and hence with poverty rates. They argue that countries only reach close to the steady state after 6 years and the higher the mobility costs are, the longer this transition takes. Thisimperfect adjustment is costly. Overall, estimates of trade adjustment costs vary widely across countries. On average, the costs of adjustment to a trade shock in the food and beverage sector are as high as the actual welfare impacts caused by that shock. The median cost of adjustment is roughly half the actual welfare effects.Interesting, Artuç, Lederman and Porto (2015) Artuc, Lederman, and Porto (2015) also showed that trade adjustment costs are

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increasing with the share of employment in agriculture, and decreasing with the employment share in manufacturing and service sectors.
Estimating a structural dynamic equilibrium model of a multi-sector economy with overlapping generations, heterogeneous workers, endogenous accumulation of sector-specific experience, and costly switching of sectors, Dix-Carneiro (2014) finds that sector-specific experience is imperfectly transferable across sectors and costs are highly unequal across the population. Then, in a counterfactual trade liberalization experiment, findings show (1) a large labor market response following trade liberalization but the transition may take several years, (2) delayed adjustment reduces potential aggregate welfare gains, and (3) trade-induced welfare effects depend on initial sector of employment and on worker demographics such as age and education.
As for the relationship between trade and inequality, using linked employer-employee data for Brazil, Helpmanet al. (2014) show that there is wage dispersion due to search frictions and wage inequality within sector- occupations for workers with similar observable characteristics. The within sector-occupation inequality is driven by wage dispersion between firms, which is in turn related to firm employment size and trade participation. See also Helpman, Itskhoki and Redding (2010) on wage dispersion between firms and wage inequality.

Human capital frictions

Labor market adjustments can also be related to human capital differentials even after moving into a new job (Utar 2018). In agriculture, the issue related to human capital represents one of the most important intersectoral reallocation costs because agricultural workers are usually low-skilled, on average. This could generate unemployment. Other models linking trade and the skill premium are Albrecht, Lang and Vroman (2002), Yeaple (2005), Davidson, Matusz and Nelson (2006) and Cigno, Giovannetti and Sabani (2018).
Using Danish matched worker-firm data, Hummels et al. (2014) find that offshoring increases (decreases) thehigh-skilled (low-skilled) wage, while exporting increases the wages of all skill-types. The net wage-effect oftrade varies substantially within the same skill-type. Conditional on skill, the wage-effect of offshoring variesacross task characteristics. Contextually, Hummels et al. (2014) also estimate the overall effects of offshoringon workers' present and future income streams by constructing pre-offshoring-shock worker-cohorts and tracking them over time.

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[10] Presented earlier as Caliendo, Dvorkin and Parro (2015), now formalized as Caliendo, Dvorkin and Parro (2019)..

[11] Structural models for counterfactual analysis incorporating labour market dynamics, largely rely on extensions of the firm-heterogeneity trade models of Eaton and Kortum (2002) or Melitz (2003). These models are normally solved usingexact hat algebra, firstly proposed by Dekle, Eaton and Kortum (2007). See Section 1 of this deliverable for details. Caliendo, Dvorkin and Parro (2019) extend this approach to *dynamic* exact hat algebra.

3.3 Hidden Costs

Possibly among the first studies in the last decade that relates trade policy to individual outcomes is that of Geishecker, Riedl and Frijters (2012), whose findings show an increased job insecurity among German workers due to offshoring to low-wage countries. Their results indicate that offshoring to low-wage countriessignificantly raises job loss fears whilst offshoring to high-wage countries somewhat lowers them. Offshoringto low and high-wage countries together can account for about 13% of the total increase in job loss fears between 1995 and 2006. High-skilled workers are more sensitive to offshoring although their objective job loss risk is lower relative to low-skilled workers, which Geishecker et al. (2012) argue reflects the fact that they have more to lose from unemployment.

McManus and Schaur (2016) focus on the welfare costs of import competition. In a population of plant establishments that face the risk of shutdown, their results suggest that Chinese import exposure in the U.S. affects welfare through changes in overall mental and physical well-being. Additionally, McManus and Schaur(2016) analyse U.S. manufacturing workers' health and show that occupational safety worsens at firms facing greater shutdown risk due to import competition. This translates into a greater injury risk which, in turn, costsworkers a reduction in annual wages.

In addition, other evidence on how import competition may affect health includes: (1) mental health effects inBritain (Colantone, Crinò and Ogliari 2019; Lang, McManus and Schaur 2019); (2) physical and mental healtheffects, including worsened health behaviour, decreased health care utilisation and increased hospitalisation for a range of conditions in the U.S. (Adda and Fawaz 2020), (3) worsened mental and physical health and increased morbidity (Lang et al. 2019), (4)

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lower fertility, gender inequality in the family-market work balance and negative effects on female long-run earnings in Denmark (Keller and Utar 2018), and a rise in obesity andharmful eating behavior (Giuntella et al. 2020) from trade in foods in the NAFTA agreement.

Furthermore, the link between trade policy and a reduction in skill premium is well depicted by recent evidencein Cigno et al. (2018) and Autor, Dorn and Hanson (2019). Though both converge when it comes to the reduction of the workers' skill premium in advanced economies, the former also notes a decrease in child laborin developing countries (Cigno et al. 2018), while the latter sticks to the adverse effects most studies find whenstudying the hidden costs of globalization in industrialized countries. More specifically, Autor et al. (2019) find that import competition takes a toll on men's employment opportunity and, in doing so, it impairs their social functioning. Similarly, there is a wider female-male mortality gap seemingly deriving from this differential in social functioning.

More recently, Pierce and Schott (2020) investigate the impact of a large and persistent economic shock on "deaths of despair" and find that areas more exposed to a plausibly exogenous change in international trade policy exhibit relative increases in fatal drug overdoses, specifically among whites. Authors show that these results are not driven by pre-existing trends in mortality rates, that the estimated relationships are robust to controls for state-level legislation pertaining to opioid availability and health care, and that the impact of the policy change on mortality coincides with a deterioration in labor market conditions and uptake of disability insurance (Pierce and Schott 2020).

In a reduced-form approach, Piriu (2021) shows that import competition decreases overall fertility among individuals working in the German manufacturing sector, amounting to roughly a fifth of German employment.Though overall fertility declines, effects differ by gender. Men's fertility declines with reduced male employment opportunity, as men are more likely to be employed in a low-paid or marginal job, more likely tobe employed in a small enterprise and experience career stagnation, and less likely to be employed in the occupation or trade for which they were initially trained. On the other hand, women also have reduced employment opportunity via lower job autonomy, higher job and financial insecurity, and an increased probability of being employed in a marginal, atypical form of work, but this instead translates into higher fertility outcomes for women, as women may find it more rewarding to substitute work with having a child given the scarce employment prospects and working conditions (Piriu 2021). Effects are particularly strongerfor women in low- and medium-low technology sectors, who make up the majority of female workers in German manufacturing. This, again, draws attention not only to the labor market outcomes per se but also to the individuals' working conditions in a globalized world.

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Finally, other than impacts on different health dimensions, marital status, household structure, and fertility, there is growing evidence showing that the current wave of globalization increases also political polarization.This is often called globalization backlash, i.e. a political shift of voters and parties in a protectionist and isolationist direction. Evidence of this globalization backlash are reported for different countries, such as the US (Autor et al. 2020) and Europe (Colantone and Stanig 2018) and recently extended to 23 advanced democracies by Colantone et al. (2022). Overall, the picture that emerges is that globalization is a significant driver of the backlash, by means of the distributional consequences entailed by rising trade exposure and labourmarket adjustments. However, other drivers, such as technological change and migration, are also at work in driving this protectionist backlash.

3.4 Evidence and Implications for the Agri-Food Labor Market

There is little empirical evidence studying the impact of the actual wave of globalization on the agricultural labor market. Given the large fraction of workers employed in the agricultural sector in developing countries,several studies in LDCs have clear implications for the agricultural sector (Topalova 2010; Costa, Garred J. and Pessoa 2016). Yet, when the agricultural labor markets in developed countries are considered, there are only a couple of current studies and, surprisingly, none on countries in the EU, specifically.[12] However, two recent historical analyses on the UK (Heblich, Redding and Zylberberg 2021) and Prussia (Bräuer, Hungerlandand Kersting 2021) study the pace of agricultural labor reallocation to other sectors and geographical areas byexploiting the grain invasion from the Americas in the second half of the 19th century.
In what follows, we first summarize results from the scarce empirical evidence in developed countries. Next, we discuss some interesting country case studies that investigated how relevant trade shocks affected the agricultural labor markets in developing and emerging (commodity-rich) countries, also from an historical perspective. The section also considers the literature on the agricultural income gap – i.e. the large labor productivity differences between agricultural and non-agriculture sectors – because some of the current interpretation of this stylized fact

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relies on the specific frictions agricultural workers face in the re-allocation to the manufacturing sectors and/or urban areas.

3.4.1 Evidence from developed countries

He (2019) represents one of the few empirical applications investigating to what extent trade shocks affect theagricultural labor market of the U.S., to which we give specific attention. The study is based on a reduced- form approach along the lines of Autor et al. (2013). However, it is different in several respects, in that it considers both import competition and export-induced growth (Feenstra et al. 2019) while working with sectoral and also individual labor data. The analysis uses a shift-share approach to exploit cross-regional variation in agricultural export (and import) exposure stemming from initial differences in agricultural specialization, as well as temporal variation in predicted US exports from exogenous tariff reductions in destination countries.

The starting point of the analysis is the mixed evidence of existing studies on the impact of US agricultural export expansion on the labor market. On the one hand, the agricultural trade multipliers reported by the United States Department of Agriculture (USDA) indicate that agricultural exports in 2017 required 1.1 million full-time civilian jobs, including 795 000 jobs in the nonfarm sector (USDA, 2019). On the other hand, the analysisof Kilkenny and Partridge (2009) and Weber et al. (2014) shows insignificant or weak impacts on farm income from exports activities on regional employment.

The main findings of He (2019), are as follow. Commuting-zone-level estimates indicate that a 1% increase inagricultural exports leads to a 0.302% increase in farm employment but has no significant impact on nonfarmemployment. The latter finding goes in an opposite direction to the current assumption of the input–output andCGE models that agricultural exports generate nonfarm employment growth in the U.S. Interestingly, individual-level estimates show that, in response to agricultural export demand shocks, natives with a collegedegree are more likely to start farm activities and become self-employed. By contrast, non-natives without a college degree are more likely to become hired farmworkers. This result is interesting because it mimics, to some extent, some similar findings in the manufacturing sector, confirming that the actual wave of globalization induced a skill-biased change in the labor demand also for the agricultural labor market.

The paper also assesses the overall impact of agricultural import shocks on farm employment. Results show that a 1% increase in agricultural exports increases farm employment by 0.738%, while a 1% increase in agricultural imports decreases farm employment by 0.974%. Hence, consistent with findings in Feenstra et al.(2019) for the US manufacturing sector, the impact of

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agricultural import shocks is larger than that of export shocks on farm employment. However, the magnitude of the export elasticity of employment in the agriculturalsector is smaller than that in the manufacturing sector.[13] Starting from these estimates of labor elasticities to trade shocks (exports and imports), and considering the entire 1991–2017 period, He (2019) finds that job gains due to changes in US agricultural exports are slightly larger than job losses due to agricultural imports, resulting in a net gain of around 0.24 million farm jobs.

[12] Two reasons may potentially explain the few studies investigating the impact of trade liberalization on the agricultural labor market in developed countries are: (1) the low share of agricultural workers in those countries, and (2)the lack of real disruptive trade shocks affecting these countries in the last decades. See Ingo (1995) for an analysis of the low trade liberalization potential of the agricultural sector of the 1994 Uruguay Round Agreement. See Greenville (2015) for evidence showing only small increase in agricultural market access from preferential trade agreements (PTAs).

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3.4.2 Evidence from developing and emerging countries

Moving to studies on developing countries, there is abundant evidence on the effects of trade shocks with direct implications for the agricultural labor market. We first review the study of Topalova (2010) on India, acountry without a comparative advantage in agriculture, then we move to Costa et al. (2016) study on Brazil and Porto (2008) on Argentina, two commodity-rich countries.

The work of Topalova (2010) is highly relevant, as it represents one of the seminal papers using the shift-sharetrade exposure measure in a reduced-form approach (summarized in Box 1). The starting point of Topalova (2010) is the discrepancies of current predictions from standard trade theory (Heckscher-Ohlin model) when it comes to the impact of trade on factors demand, i.e. with perfect factor mobility gains from trade should flow to the abundant factors, such as unskilled labor in a developing country. By contrast, there has been growing empirical evidence showing exactly the opposite, namely trade liberalization appears to reduce the wages of

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unskilled labor even in a labor abundant country, thereby widening the gap between the rich and thepoor (Goldberg and Pavcnik 2007). A crucial feature of this literature is the speed with which factors are reallocated across sectors of the economy. Clearly, the slower this process is, especially for labor, the higher the trade adjustment costs and the rise in poverty and inequality will be.

The paper exploits the sudden and extensive change in India's trade policy in 1991, extending the contributionof Topalova (2007) by including nontariff barriers (NTBs) and by measuring how loss of trade protection affected consumption of households across the entire income distribution. Results show that rural Indian districts more exposed to trade liberalization through their employment mix experience slower progress in poverty reduction, where the effect is particularly sizeable. For example, compared to a rural districtexperiencing no change in tariffs, a rural district experiencing the mean level of tariff changes saw a 2 percentage points increase in poverty incidence and a 0.6 percentage point increase in poverty depth. In addition, in a parallel paper Edmonds, Pavcnik and Topalova (2010) demonstrate that one of the mechanisms that reduce labor reallocation in the most affected rural district is the impact of trade liberalization on the schooling decisions of children: trends of rising schooling and declining child labor were attenuated in the more exposed rural districts.[14]

Furthermore, in a typical Indian rural district, the labor share in agriculture before the tariff reform was 0.814(see Table 1 in Topalova (2010)). Thus, the high adjustment costs due to labor immobility in the most affectedrural districts is largely a problem of the agricultural workers, thus allowing us to reiterate the challenges posedby the interference of labor search frictions in determining adjustment costs, as explained in previous sections.Note in addition that, excluding cereals, the agricultural tariffs reduction of the Indian trade reform has been significantly larger than the tariff reduction in the manufacturing sector (see Figure 1 in Topalova (2010)).

Two additional interesting results come out from the study of Topalova (2010). First, the trade liberalization impact on poverty is also channeled by consumption patterns, not just labor immobility across more and less affected rural districts, though the magnitude of the labor market effect is larger. Second, the impact of trade liberalization is most pronounced in Indian states where inflexible labor laws impeded factor reallocation across sectors, stressing how law-making and labor market institutions can also interfere with job search and adjustment – therefore creating more friction.

Finally, a peculiarity of the identification approach of Topalova (2010) is worth noting, because it applies to the majority of the reduced-form approaches studying the different geographic impact of trade shocks (see Box1). In the Indian trade reform of 1991, tariffs for different industries were reduced by varying levels, and at different times, inducing differential exposure to trade liberalization across (sectoral heterogeneous) Indian districts. The paper establishes

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whether changes in district-level poverty and levels of consumption across the income distribution, before and after the trade reform, are related to the reduction of trade protection apportioned at the district level. Thus, this difference-in-differences approach does not measure the level effectof liberalization on poverty and consumption across India as a whole. Instead, it measures the relative effect of liberalization on districts that were more or less exposed to the trade shock. Thus, the paper does not answerthe question of whether India benefited from trade liberalization, but instead whether certain areas and certaingroups of people within these areas capture more of the gains or suffer more of the losses following liberalization.

Most studies on the effect of China on the economies of other countries have focused on the import competitionshock associated with the massive growth of the Chinese manufacturing (exporting) sectors. However, Chinais also an increasingly large consumer of foreign goods and therefore capable of potentially altering world demand. Costa et al. (2016) test this hypothesis considering the heterogeneous effects on both the supply-side and demand-side of 'China shocks' for the case of Brazil, a developing-country labor market with a (resource- based) comparative advantage in the agricultural (and extractive) sector.[15] Indeed, in several developing countries the trade pattern with China can be characterized as a shift towards a commodities-for-manufactures trade relationship with a sharp increase in China's overall importance in developing countries' foreign trade.[16]Thus, understanding the labor market effects of this trade shock is for several reasons interesting. Specifically,the paper examines the changing labor market outcomes of regions producing manufactures affected by risingChinese import supply and localities specializing in (agriculture) raw materials demanded by China.[17]

Brazil provides an excellent context for a study of China's impact on developing countries' labor markets, particularly because of its geographical heterogeneity and local labor markets that have different patterns in comparative advantages, thus allowing for identification of the heterogeneous effects of the China trade shocks. With this aim, Costa et al. (2016) follow the approach of Autor et al. (2013) to generate predictions about the wage effects of the China supply and demand shocks across regions. The empirical strategy is the shift and share methodology. In particular, the paper compares locations with different initial comparative advantages, tracing the fortunes of regions whose basket of industries faced steeper increases in Chinese supplyor demand, as compared to locations whose industries have been relatively unaffected by China's emergence.

The main results are stark, showing that labor markets in 'loser' import-competing regions indeed appear to have suffered from Chinese import competition via slower growth in manufacturing wages. However, it is alsothe case that 'winner' regions have gained from Chinese export demand of agricultural and other extractive products, through faster wage growth and shifts in the local economy towards formal jobs. These results are consistent with intuition and

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theory, showing that a local labor market at the 80th percentile of the shock to Chinese demand, experienced growth in average wages that was approximately 0.93 percentage points higher between 2000 and 2010 as compared to a region at the 20th percentile. At the same time, while the estimated effects of Chinese import competition on average wages are statistically insignificant in most specifications, the paper finds a significant negative impact of imports from China on the wages of manufacturing workers. For a local labor market at the 80th percentile of the 'China supply shock' relative to one at the 20th percentile,wage growth in manufacturing sectors was 0.82 percentage points lower over the course of the decade.

Costa et al. (2016) considered also decadal changes in several other key indicators of local labor markets, suchas employment rates, sectoral composition, informality, and migration. Overall, the paper does not find robustevidence of an effect of either 'China shock' on local employment rates. However, there is a robust finding showing that increased demand from China is associated with a rise in the share of employed workers in formaljobs. Thus, as with wage growth, an increase in formality is likely to have improved worker well-being in 'winner' regions: because workers in the informal sector do not have access to benefits such as unemploymentinsurance, paid medical leave and pensions, formalization may be interpreted as a rise in nonwage compensation.

As for the impact of the China shocks on migration, results do not detect clear and robust effects on both (net)in-migration or out-migration in regions positively (negatively) affected by the China shocks. These results are different from those of Dix-Carneiro and Kovak (2019) who find that Brazilian in-migration responds to the China shock while out-migration does not. Finally, Costa et al. (2016) also investigated the impact of the China shocks on (wage) inequality within Brazilian local labor markets. The main findings suggest that regionsthat suffered from import-competition from China are associated with an increase in local wage inequality, although this result is not robust. Meanwhile, the paper does not find a strong effect of (agricultural) export expansion to China on wage inequality in those regions with agricultural comparative advantage.

Finally, the work of Porto (2008) on Argentina, a resource-based country with a comparative advantage in theagricultural sector, is extremely useful to illustrate the impact world trade liberalization in agriculture, on wageand unemployment. The paper simulated the effect of an increase of 10% in agri-food prices in Argentina, in presence of individual labor supply responses and adjustment costs in labor demand. Main findings show that:

i. the employment probability would increase by 1.36 percentage points, matched by a decline in the unemployment probability of 0.75 percentage points and an increase in labor market participation of 0.61 percentage points; ii. the unemployment rate would decline by 1.23 percentage points; iii. expected wages would increase by 10.3%, mostly due to higher employment probabilities. These results are important, becausethey confirms that the gains

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from trade are not only revealed by higher market wages, but also by lower unemployment, thus highlighting the importance of unemployment and labor supply responses in empirical work on trade policies.

[13] A potential explanation for the smaller agricultural export elasticity of employment is that migration costs for farmersin rural areas are higher than for manufacturing workers. Therefore, the farm labor market is less responsive to demand shocks, see He (2019).

[14] Results in Edmonds, Pavcnik and Topalova (2010)on the decline of child labor following trade liberalization areconsistent with Cigno, Giovannetti and Sabani (2018)..

[15] Results in Edmonds, Pavcnik and Topalova (2010)on the decline of child labor following trade liberalization areconsistent with Cigno, Giovannetti and Sabani (2018).

[16] Although the import side of the China trade shock has often been met with suspicion by policymakers and commentators of industrialized countries, the impressive growth in China's demand for agricultural and other commodity products has not always been treated with similar enthusiasm. Costa, Garred J. and Pessoa (2016) conclude that this low enthusiasm of commodities-for-manufactures trade relation is partially unjustified, because the losses in some Brazilian labor markets from Chinese manufacturing imports do not outweighed the gains to others from the concurrent boom in commodity exports.

[17] Like Costa, Garred J. and Pessoa (2016),, the paper of Dauth, Findeisen and Suedekum (2014) studied with a similar approach the impact of rising imports from and exports to China and Eastern Europe on local labor market in Germany.However, Dauth, Findeisen and Suedekum (2014) study a developed-country context in which agricultural and extractive sectors are relatively

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unimportant, and so focus on the effects of these trade shocks on the manufacturing andservices sectors.

3.4.3 Trade liberalization and the agricultural labor market from a historical perspective

This section reviews two recent historical studies by Heblich et al. (2021) and Bräuer et al. (2021) that investigate the impact of the first wave of globalization (1850-1913) on the labor markets in UK and Prussia.Both papers exploit the trade shock associated with the grain invasion from the Americas to study the pace of agricultural labor reallocation to other sectors and geographical areas.

The contribution of Heblich et al. (2021) focuses on the distributional consequences of trade using the 1846 Repeal of the Corn Laws. This large-scale trade liberalization process opened UK domestic markets to the "grain invasion" from the new world resulting from the late-19th century improvements in transport technology, particularly due to the advancement of steamships. The paper exploits information from a newly created, spatially-disaggregated dataset on population, employment by sector, land and property values, and welfare transfers for around 11,000 parishes in England and Wales between 1801 and 1911. The paper providesnew theory and evidence on the distributional consequences of trade by focusing on the uneven geographical incidence of trade shocks.

The paper awakens interest for several different reasons. First, it exploits a very large-scale international tradeshock – the "grain invasion" that happened in the second half of the 19th century. Second, it uses granular spatial data over an extended period of time. Third, the analysis considers regional exposure to this trade shockusing an exogenous agroclimatic measure of the suitability of these regions for wheat cultivation. This is an important innovation in comparison of the standard shift and share approach commonly used by this literature.

Empirically, the paper exploits the marked difference in agroclimatic conditions between the Western and Eastern parts of England and Wales. The more rugged Western areas typically have thinner and more barren soils. In contrast, the Eastern parts of the country are in the rain shadow of mountains, with lower cloud cover,less precipitation, and higher average temperatures. Due to climate and soil conditions, Western locations aremore suitable for grass (and hence the grazing of cattle and sheep), while Eastern locations are more suitable for the cultivation of grains (historically, mainly wheat). Starting from the difference in agroclimatic conditions, the paper exploits information about land wheat suitability from the United Nations Global Agro-Ecological Zones (GAEZ). For each parish, the Authors computed mean wheat suitability across 5 arc-minutepixels within its geographical boundaries and use this exogenous measure to

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provide causal evidence on the impact of the grain invasion on the distribution of economic activity across sectors and regions.

The main findings suggest that the trade shock led to a population redistribution from rural to urban areas, andthus, to a structural shift away from agriculture and a substantial change in the relative price of land and buildings. Specifically, in the first half of the 19th century, rural locations with high and low wheat suitabilityexhibit similar population growth trajectories over time. Following the grain invasion in the second half of the19th century, Heblich et al. (2021) observe a sharp decline in population growth rates across rural locations with high (relative to low) wheat suitability. At the end of sample period (1911), the paper finds a cumulativereduction in the high-wheat suitability locations' relative population of around 20 percent. The paper also develops a counterfactual quantitative trade model reversing the grain invasion. Heblich et al. (2021) use the model's predictions for changes in population and the value of land and buildings to estimate the model's parameters structurally. The estimation implies substantial population mobility showing that allowing for migration from rural to urban areas is central to quantitatively matching the observed moments in the data.

In addition, the paper finds a robust negative relation between the change in wheat share before and after the trade shock against pre-shock wheat share, but a positive relation between change in permanent pasture shareagainst pre-shock wheat share. This additional finding is relevant, because it provides support to the idea thatthey are not picking up a common decline in all agricultural activities, confirming that the grain invasion disproportionately affected corn-growing regions leading to a reallocation of economic activity within the agriculture sector, i.e. from corn-growing regions towards grazing of cattle and sheep.

A second recent historical analysis of the first wave of globalization is the one of Bräuer et al. (2021), who study the economic and political effects of a large trade shock in agriculture during the 1871-1913 period in Prussia. The paper shows that the trade shock accelerated the structural change in the Prussian economy mainlythrough migration of workers to urban areas. However, differently from current studies that systematically detected declining per capita income and political polarization in areas more affected by trade exposure, Bräueret al. (2021) do not find such geographical heterogeneity. Hence, the negative and persistent effects of trade shocks we see today are not a universal feature of globalization but largely depend on labor mobility frictions.

The paper applied the same approach of Autor et al. (2013), showing that globalization also caused regional decline: a one standard deviation increase in the trade shock corresponds to a decline in employment growth by 0.5 percentage points per year corresponding to 40% of one standard deviation in the dependent variable, hence a relevant effect. However, instead of absorbing the losses, workers migrated to urban areas in Germany. Importantly, the level of

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migration at that time was four times as high as today in the US after the China shock. Thus, neither the average income per capita of those remaining in the county nor their voting behavior or deathrates was affected by trade shocks.

Econometrically, Bräuer et al. (2021) match the increase in trade with Prussia's agricultural census containingthe cultivation areas for various crops within each county. By linking the crop shares with national trade statistics in a shift-share approach, they compute an exposure measure of competitive pressure that each German county faced from abroad. Then, they compare the performance of different rural counties with different crop profiles and thus different exposure to world market shocks. Yet, because import competition is potentially endogenous, they compare the competitive gains of the US and Argentina – by far the biggest import sources – in the German market with those in Italy. Italy works well for comparison market, as it is another newly formed, rapidly industrializing country at that time.

Bräuer et al. (2021) proposed an intuitive interpretation to the finding that high worker mobility was crucial for mitigating the heterogeneous impact of the trade shock in the Prussia case-study. Using detailed regional statistics on skill level by migrants' region of origin, they argue that workers also needed little occupation- specific human capital when taking up factory jobs and the low-skilled formed the majority of migrants. In addition, they provide some suggestive evidence that unskilled workers, especially, found jobs in competitiveindustries like machinery and chemistry. In contrast, occupation and sector specific human capital are crucialfor the adjustment process from import competition today: while workers today still switch occupations, theydo so within quite narrowly defined fields.

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3.4.4 Agricultural productivity gap: labor frictions, seletion and trade costs

In the first wave of globalization, the heterogeneous effect of trade shocks was partially mitigated by the abilityof agricultural workers to migrate from rural to urban areas, from agricultural to other sectors of the economyBräuer et al. (2021), but also within the agricultural sector (Heblich et al. 2021). Yet, this large inter-sectoral

(and within-sector) agricultural labor mobility appears significantly lower today, particular to developing countries, contributing, among other things, to the well-known stylized fact of agricultural productivity gap,

i.e. a large difference in agriculture to non-agriculture labor productivity (Gollin, Lagakos and Waugh 2014).

A large body of literature documents that studying agriculture is critical for understanding cross-country income differences. There are two main reasons for this (Rivera-Padilla 2020). First, while poor countries aremuch less productive in aggregate output per worker, productivity gaps are particularly large in agriculture. Second, despite these large productivity gaps, poor countries allocate a high share of their labor force to agriculture (Caselli 2005; Restuccia, D.T. and Zhu 2008). When combined, the two prompt a key question: why do poor countries devote so much labor to such an unproductive sector?

The persistency of the agricultural productivity gap is a characteristic of both developing and developed countries (Herrendorf and Schoellman 2015). For example, a recent study of the World Bank (2018)documented important differences in agricultural vs. non-agricultural labor productivity also within EuropeanUnion member states. Figure 2 documents this stylized fact, showing that non-agricultural labor productivity,on average, is more than two times higher than agricultural labor productivity.

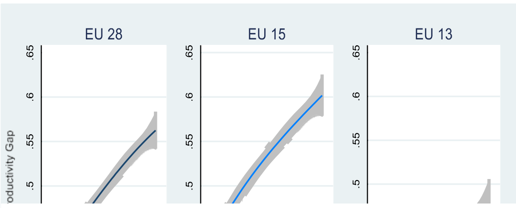

Figure 1. Evolution of agricultural productivity gap in the EU28, EU15 and EU13 countries

Source: Authors adaptation from World Bank (2018), based on Eurostat and ARDECO dataset.

Notes: The figures show the evolution of the (smoothed) average agricultural productivity gap measured as the ratio between agricultural value added per worker and non-agricultural value added per worker. Fitted (colors) lines and the respective 95% confidence interval are computed using Stata's command for local polynomial regression, using regional productivity gap at NUTS 2 level.

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BATModel
better agri-food trade modelling for policy analysis

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Although agricultural productivity gap is somewhat shrinking overtime and with the level of development, theEU numbers are not much different from the situation of developing and emerging countries (Gollin et al. 2014; Tombe 2015; Alvarez 2018).
This large productivity gap may have important implications for understanding aggregate productivity growth. With minimal assumptions on production technologies, it suggests that labor is misallocated across sectors, particularly so in developing countries or in poor regions of rich countries.[18] By reallocating workers out of agriculture, where the value of their marginal product is low, and into other activities, aggregate output would increase even without increasing the number of inputs employed in production. These gains could be particularly large in developing countries or poor EU regions, where agricultural productivity gaps and sharesof employment in agriculture are (still) large (Gollin et al. 2014).
In the last decade, more and more studies started to investigate the main sources of this agricultural productivitygap systematically, with the aim to better understand the extent to which it represents a real misallocation problem. In general, there could be three main explanations behind the agricultural productivity gap. First, measurement problems, particularly in agricultural value added, as suggested by Herrendorf and Schoellman (2015) for the US agriculture.[19] Second, the existence of some barrier preventing movements of workers across sectors due to labor market frictions, in which case wage gaps between agriculture and other sectors indicate unexploited potential gains from the reallocation of workers out of agriculture. Another possibility is selection,namely that workers in agriculture are characteristically different from those in non-agriculture, in which casewage gaps cannot be considered as evidence of potential wage gains (Lagakos and Waugh 2013; Alvarez 2018)for such explanation using cross-country vs Brazilian micro-data, respectively). A third possibility is related to trade costs, as recently put forward by Tombe (2015) and Rivera-Padilla (2020), who show that productivitycosts of domestic labor market distortions are higher in an open-economy framework than in a closed-economyone. Specifically, trade amplifies the productivity costs of labor distortions in poor countries by 40 percent. Most importantly, trade costs directly contribute to cross-country productivity differences, and agricultural trade costs account for roughly 25 percent of the aggregate differences in productivity gap between rich and poor countries.
The last point is interesting also from the rich country's point of view. Because evidence of "misallocation" ofagricultural labor exists also in developed countries, and particularly within the EU countries (see Figure 2), apotentially interesting research question is to measure the extent to which trade costs in agriculture, notoriouslyvery high (Olper and Raimondi 2009; Gaigné and Gouel 2022) could explain a relevant fraction of this potential source of labor misallocation. For example, Albrecht and Tombe (2016) applied this logic to Canadawithin country trade, showing

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that the agricultural sector is the one with a higher increase in productivity as an effect of reducing internal trade costs.

[18] Misallocation is not only a problem of the agricultural sector. Several recent papers discussed issues of misallocationacross industrial sectors and even across firms within industry. For example, a recent strand of literature uncovered
important firms' markup heterogeneity with potentially relevant welfare implications (see, e.g., Edmond, Midrigan and Xu (2018)). Evidence of misallocation in the food industry are documented by Curzi, Garrone and Olper (2021) forthe French market, studying in addition their relationship with import competition.

3.5 Conclusion

Despite the major divide between neoclassical models and models incorporating frictions, or that between models with intersectoral allocation and intra-sectoral allocation, recent years have seen tremendous developments in how trade economists understand the dynamics of labor response to trade shocks. Upon examining the relationship between trade and inequality in Section 3.1, this review discusses the new techniques that have been implemented for estimating structural models of labor market dynamics, and how these are crucial for analyzing welfare and distributional effects of trade (Section 3.1). Global economic integration has shifted relatively low-skilled jobs from the rich world to labor-abundant low-wage countries, thus decreasing between-country inequality but increasing within-country inequality. Evidence so far shows that the distributional effects of globalization are centered mostly around job displacement, and stagnant and falling living standards in advanced economies, thus further increasing the gap between the rich and poor in industrialized countries. Besides, it appears that evidence mostly points to large costs of switching industries and occupations in response to a trade shock.

Furthermore, with a shrinking manufacturing sector due to competitive pressures from abroad, trade-induced structural changes in the economy of industrialized countries most likely underlie not only the distributional effects of trade but also some hidden costs. As seen in Section 3.3, these hidden costs concern increased mentaland physical health risks, obesity and morbidity, lower fertility, greater job insecurity, decreased working conditions and impaired social functioning.

Concerning the agricultural sector, to date there are only a few studies investigating the impact of trade shockson labor market dynamics in developed countries, yet none focusing on EU countries. From this perspective, it is necessary to start to fill this research gap. In addition, given the persistency of the agricultural productivitygap also in developed countries, future analyses should better figure out to what extent these productivity gaps are the result of an effective

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resource misallocation, versus other potential explanations stressed by the recentliterature, such as labor market frictions and selection or the high trade costs of agricultural and food products.

[19] Herrendorf and Schoellman (2015) argued that the gaps between the marginal value products of agriculture and non- agriculture are considerably smaller when measured through wages than through labor productivities. In addition, theyargued that labor productivity in agriculture is severely mis-measured in the US. Differently, working across countries, Gollin, Lagakos and Waugh (2014) demonstrated that agricultural value added or labor inputs measurement problems cannot account for the agricultural productivity gap.

4. Ex-ante indicators moving from welfare to well-being indicators

This section looks at welfare indicators from the perspective of simulation models used in ex-ante policy assessments. Compared to the previous two sections focused on teasing insights from observed past developments, ex-ante models as used in BATModel (global CGE and PE models) provide more room for integrated assessments with many endogenous variables or indicators. To avoid opening Pandora's box of indicators we start by structuring our approach in a wider debate on moving beyond monetary measures and GDP in particular, defining what, where and when to measure well-being as well as touching on the issue of aggregation (Section 4.1). We then outline our foreseen ex-ate indicator framework for measuring the well- being of counterfactual agri-food trade policies, which are the focus of the BATModel project (Section 4.2). We then conclude this chapter by describing potential sources of indicators looking from a stakeholder as wellas a model perspective and outline an approach to summarize the wide variety of potential indicators in a moremanageable dashboard format (Section 4.3).

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4.1 What, where and when – from narrow welfare to broad well-being

The standard (economic) view on trade agreements is that they enhance efficiency by exploiting comparativeadvantages and increasing productivity through freer trade. While acknowledging the general conclusion thatthose in import competing industries will be harmed (Rodrik 2018b) we should not forego economic growth from free trade, just like we do not forego growth from technical change making products redundant (Rodrik 2018c). The public view on liberalizing trade, however, turned from general disinterest into active public opposition of specific (TTIP, CETA) trade agreements in the early 2010s. While a majority of Europeans stillconsider free trade positive (Young 2019), it signals interest beyond economic gains and losses.
Growing concern about trade agreements did affect the formulation of the EU's trade strategy. In part, this may be a way to signal its willingness to manage adverse impacts of globalization seen as contributing to the recent rise in populism (Young 2019) and political polarization (see section 3.3). The EU trade strategy also explicitly aims to raise global social, environmental and food safety standards to foster the Sustainable Development Goals (SDGs) (European Commission 2017, p.4) and create a level playing field for EU farmershaving to comply with the EU's environmental, food safety, animal welfare and social standards (European Parliament 2016, p.17). The latter will be even more relevant given the high ambition of Green Deal policies currently taking shape.
These wider concerns fit in a global trend of trade agreements moving (far) away from reducing traditional trade restrictions at the border, reaching for deep integration and no longer fitting the traditional analysis of whether efficiency gains are sufficient to cover losses of those left behind (Rodrik 2018c). Before taking on the task of defining an operational definition that moves beyond GDP or efficiency, we need to address three main questions: **what** do we need to measure (well-being definition), **where** do we measure impacts (spatial variation in well-being) and **when** do we measure impact (temporal variation in well-being). In addition, we shortly touch upon the trade-off between the number of indicators and ease of use, i.e. whether or not to **aggregate** indicators.

4.1.1 "What" to include – broadening welfare to well-being

Economic analyses traditionally use the term welfare to denote well-being related to the utility derived from consumption. With utility being unobservable it is measured by choices people make. This **welfarist** approachleads to a conventional approach of defining human well-being in terms of consumption choices (Conferenceof European Statisticians 2013). This is reflected in the common focus on GDP and related measures like household income to measure changes in welfare. However, even in terms of measuring efficiency, GDP is a flawed measure and there are

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several ways to correct for its failings. These can come first from sharpening thedefinition of production by capturing quality changes and better measuring services output, both of which areincreasingly important in modern economies and generally underestimated while weakening the link betweenreal income or consumption and material use. The second source is externality measures, like reduced exposureto air pollution or increasing amounts of leisure, which are included in the broader well-being assessments.

The seminal report by Stiglitz et al. (2009) integrates this welfarist approach with two alternative approaches:subjective well-being and Sen's functioning and capabilities approach. The resulting framework addresses theshortcomings in terms of measuring human well-being without discarding the insights that can be obtained from consumption-based indicators. **Subjective well-being** provides a shift from the materialistic definition of traditional welfare to a subjective evaluation along two dimensions: a cognitive evaluation where people take stock of their life or specific domains (like family, work, finances) and a report of their current (positive and negative) feelings or affects. **Sen's functionings and capabilities** stress the achievements a person has made (like education, or health) and the opportunities available to people (capabilities). The latter places a strong emphasis on freedom to act or agency of individuals (Conference of European Statisticians 2013; Stiglitz et al. 2009). As daunting as this may seem in terms of arriving at operational measures of well-being, this integrative framework has strongly influenced currently used indicators on which we can build, like the UN SDGs[20] and the OECD's How's life?[21].

Broadening welfare to well-being thus does better justice to people's experiences of the quality of life while possibly loosening the link to material resource use needed for addressing the current global challenges of getting up and close (if not over) planetary boundaries while the world population is still growing and many still live in dire poverty. In terms of agri-food trade, it provides an avenue for a more balanced perspective onimplications of changes in trade, positive as well as negative. Recast in this well-being framework the resistance towards the Investor State Dispute Settlement in TTIP and CETA may have to do more with concerns on governance than direct material concerns. Including well-being indicators in an ex-ante trade policy assessment may support detection of public concerns missed by current trade assessments and allow a search for adjustments that better serve the well-being of European citizens. It does require multiple measuresor indicators as there is no single measurement capturing the well-being of members of society impacts (Stiglitzet al. 2009, p.12).

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4.1.2 Where to measure well-being – “here” versus “there”

Apart from defining the relevant indicators in terms of content we also need to address the unit or level of analysis. Most consolidated global databases work at the national level building on at least in part harmonizednational statistics. National-level data provide a basis for comparisons or benchmarking against high performing nations (which may help in interpreting well-being indicators in terms of performance when cleartargets to strive for are unavailable). Combined with a causal model they can provide the basis for assessing the impacts of national interventions on third countries. For example, by modelling the impact of EU trade policies (“here’) on global trade flows in a CGE model impacts on well-being in third countries (“there”) canbe assessed.

There is another important dimension to the unit of analysis, namely the heterogeneity of households and evenindividuals within households that are crucial for determining changes in well-being. While harder to quantifyin a multi-country setting due to the lack of harmonized and regularly updated databases with the required micro-level data, capturing as much sub-national diversity as possible is key for a meaningful well-being assessment. Furthermore, the diversity across the population, as well as the links across measures, need to be accounted for. The joint impact of multiple disadvantages for sub-groups in the population do much more harmthan the sum of their impacts (Stiglitz et al. 2009, p.12). Capturing the possible diverging impacts across the population also seems to be key to addressing the lack of trust in national (average) statistics that conflict withchanges in the well-being of sub-populations.

As mentioned in section 2, the impact of trade-induced changes will not be the same according to the incomeof the household or sub-population, as the share of expenditures allocated to food varies with the income. Theheterogeneity of the households in one country or sub-population is important feature to deal with.

Another source of heterogeneity is the selection effect mentioned in section 2 when presenting trade models based on firm level-analysis. The selection effect leads to the reallocation of factors to the most productive firms, leading to the exit of the less productive firms. This will lead to gains from trade at the aggregated level, as the average productivity will increase. Nevertheless, it will also lead to a reallocation of workers for instance, from one firm to the other, from one industry to the other or from one region to the other. In case offrictions, as shown in section 3, this will lead to hidden costs, such as unemployment and a potential decreasein well-being.

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[20] https://unstats.un.org/sdgs/indicators/database/;
[21] https://stats.oecd.org/Index.aspx?datasetcode=HSL

4.1.3 When to measure well-being – "now" versus "then"

In addition to the level at which well-being is measured the temporal dimensions is important. Following the Brundtland definition of sustainability current activities should not threaten the ability of future generations to achieve a similar level of well-being as currently enjoyed. Measurements based on historically observed indicators can address changes in future well-being by assessing changes in quantities and qualities of "stocks"of natural, physical, human and social capital that are passed to the future, as proposed in Stiglitz et al. (2009).In this case, the time dimension is addressed indirectly through the ability of future generations to sustain current levels of well-being.

Consistent with this forward-looking perspective is the concept of adjusted net saving (ANS) or genuine saving. In general, savings and investment are important measures for understanding the dynamics of capital accumulation which enable future generations to generate well-being. Since the definition of wealth in this new framework is much broader than that of capital, ANS has also a broader definition by considering how much a nation is saving for the future in terms of physical, human, and environmental capital. ANS adjusts national net savings (total domestic saving less the depreciation of produced capital) for education expenditures (a proxy for investment in human capital), natural resource depletion (energy, mineral, forests) and environmental damages (CO2 and particulate emissions) (World Bank 2011).

Adding social and environmental capital stock changes to savings in the ANS connects it to notions of sustainable welfare based on future consumption potential. According to the Weitzman's Rule (Weitzman 1976) the intuition behind seeking a connection between Net National Product and welfare, in the sense of thediscounted sum of utilities, is that current net investment adds to future consumption potential. GDP is then not suitable as an indicator of national well-being, because it lacks an adjustment for depreciation or appreciation of capital stocks. Loosely speaking, the standpoint in this line of reasoning is that a proper notionof income, which is at one's disposal for consumption, is like an interest income on a fixed stock of capital defined in a broad sense as to include social capital and natural resources.

Ex-ante simulation models like those in BATModel can directly assess the time dimension as they simulate changes in the global economy over time. Depending on the topic these time-horizons can be in the near future(for example assessing achievements of SDG targets by 2030 and 2050

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in Philippidis et al. (2020)) or furtherahead in time for integrated sustainability assessments (for example up to 2100 in terrestrial biodiversity assessments in Leclère et al. (2020)). The extent to which these forward-looking projections capture changesin the different types of capital stocks varies. Changes in natural and physical capital tend to be taken on boardin an endogenous manner, i.e., decisions made by agents in the model affect the stocks, as these are relatively easily addressed by the economic and environmental models used in these studies. Changes in human and social capital are much less well measured and generally treated as exogenous in these projections, if at all. The common approach is to impose projections of demographic changes and human capital as expressed by education level from demographic models (for example the projections by Lutz et al. (2018) used in the SharedSocioeconomic Pathways (SSP) scenarios) on population and labour force variables. These developments arethen kept fixed in all counterfactual scenarios. Building on the evidence that rising temperatures may affect humans as well, recent work is started to include the impacts of heat stress on agricultural labour productivity in CGE-based simulations (Saeed 2021) which could introduce an additional feedback loop between climate change and human capital.

4.1.4 To agregate or not to aggregate – usability versus scope an precision

Moving from a single indicator like GDP (or equivalent variation) to a broader definition of well-being introduces an unavoidable tension between the number of indicators used and how they are weighed against each other which implies a form of aggregation to a final score. The persisting dominance of GDP as a (implicit) gauge of well-being seems due to its simplicity coupled with a correlation with well-being indicatorslike reductions in poverty rates. Despite its sharply criticized weaknesses, it has effectively turned into a practical "proxy of everything" for policy-makers (Stiglitz, Fitoussi and Durand 2018). Measuring well-being, however, requires multiple indicators. Even if one would opt for replacing GDP with a single subjective well-being measure reported by individuals an aggregation problem arises. Such a single well-being measure needsto aggregate over individual well-being scores (as specific groups in society may experience radically differentchanges in well-being as highlighted in sections 2 and 3) and address the impact on the well-being of future generations which cannot yet be included in current well-being measurements. We thus need to deal with various indicators that may be moving in opposite directions.

Three approaches to this aggregation challenge can be found. The first is not to aggregate, which for exampleappears the choice of the UN statistical office that reports on 558 data series that are associated with 247 indicators, 169 targets and 17 SDGs with no clear guidance on how to derive the SDG progress by country or globally[22]. The implicit message seems that scores on all

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558 series matter, but such a large number of data points is too overwhelming to provide any practical guidance.

At the other extreme, we find approaches aggregating a series of indicators in a single score. A mix of 120 official and additional indicators are aggregated into a single SDG index score as part of the annual SustainableDevelopment report tracking global progress towards the SDGs (Sachs et al. 2021). Another example is the UNDP's Human Development Index (HDI) published as part of the annual Human Development reports (UNDP 2020). The HDI takes a simple average of life expectancy at birth ("long and healthy life", expected and mean years of schooling ("knowledge") with GNI per capita ("decent standard of living") to get a single index score. While the HDI has been successful in getting governments into action to improve their international ranking it has been criticized for glossing over critical inequalities by using national average statistics (Stiglitz et al. 2018). Attempts at developing more refined HDI measures capturing inequalities or adding environmental scores were less successful. More sophisticated measures generally make less intuitivesense, reducing their power of communication.

Any composite indicator introduces a weighting of the underlying data series. In case of no explicit weights the number of series per composite matters. In the case of the HDI, the "knowledge" dimension has two measures of educational attainment while the other two dimensions have only one measure. As a result, the education measures get less weight than life expectancy or GNI per capita. One may argue that stakeholders know best what weights to attach, as in the case of the OECD's Better Life Index (BLI). Here users attach weights on 11 topics after which a personalized BLI is computed[23]. These weights provide new data on what topics matter to different groups of people[24]. Weighting procedures are generally explicitly described and thustransparent in a technical sense. The normative implications of these choices are however rarely justified (Stiglitz et al. 2009). This calls for at least some sensitivity tests on whether the aggregation scheme affects overall outcomes and could be an argument for allowing stakeholders to express their weights. The latter mayprovide a focused approach to exploring stakeholder positions as weights are to be defined on the same set ofdata series, highlighting shared and contrasting views on what matter.

A middle ground between no aggregation and a single composite indicator is to provide a dashboard of indicators (which themselves may be composite indicators). The rationale here is that a dashboard highlights trade-offs instead of cancelling them in a single composite index. It also acknowledges that different indicatorsserve different purposes (e.g. impact on human or planetary well-being) and allows for local context to determine which of the dashboard indicators matter most (Stiglitz et al. 2018). But then again one faces the need to make hard choices in selecting indicators – a dashboard with 558 data series is not of any practical use.

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For practical use by policy-makers, the rule of thumb appears to be around 7 but definitely not more than 10 top-level indicators, the choice of which is a national policy decision and cannot be determined on technical grounds. Even with a small number of top-level indicators, there will be more disaggregated data series neededto compute the dashboard. This may be addressed by allowing a drill-down of indicators, as is for example possible with the SDG index. Keeping the practical use and communication strength in mind intuitive aggregation procedures are preferred. The SDG index, for example, is based on simple averages after testing that more refined and theoretically preferred but less tractable approaches do not alter the rankings (Lafortuneet al. 2018). The reasoning here is that communication power matters more for the overall index than methodological precision. For the same reason, data series that are highly correlated are kept in the SDG index,while the index construction protocol in Béné et al. (2019) excludes them to avoid giving undue weight to theunderlying driver.

4.2 Outline of na ex-ante framework for broader welfare implications of trade policy

Our aim of constructing a broader measurement of welfare implications that can be used in ex-ante assessmentsof trade policy adds some additional requirements on top of the overall concerns with measuring well-being outlined above. It requires quantification of (changes in) trade policy to allow incorporation in the quantitativeassessments by ex-ante simulation models. The use of particular simulation models also limits the type of indicators that can be captured in the ex-ante framework. We first outline the challenges in quantifying changesin trade policies, followed by a set of operational requirements on well-being indicators in an ex-ante framework aimed at assessing trade policies by describing the foreseen steps in BATModell well-being impact

assessments and concluding this section by outlining an approach to define targets needed to measure progresstowards well-being.

4.2.1 Quantifying aggregate changes in trade policies by deriving policy indexes

Trade policies include many different instruments (tariffs, quotas, antidumping duties, technical regulations, etc.) which may affect different aspects of the agri-food supply chain (primary producers, food processors, traders, consumers, etc.). Trade policies furthermore vary across countries and will change over time in ex- ante simulations. Furthermore, most simulation

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models aggregate countries into larger model regions further complicating the seemingly simple question "how should we measure the stance of a country's trade policy?".
Elements that define a theoretically consistent aggregate policy index of trade restrictiveness include the following: (*i*) the *policy coverage* (e.g. tariffs, import quotas, border and domestic policies, etc.); (*ii*) the *scalaraggregate*, i.e. the policy instrument into which the policy measures covered are translated (e.g. tariff- equivalent measures, subsidy-equivalent measures, quota-equivalent measures, etc.); and (*iii*) the *reference point* for the 'equivalent impact' we are interested in (e.g., iso-welfare measures, iso-income measures, broaderwell-being definitions etc.). The two main hurdles to quantifying trade policies are **conversion** and **aggregation** problems.
As trade policies include many different instruments we need to convert these into a common metric. A typicalapproach is to transform trade policies into ad valorem equivalents (AVEs). In principle this addresses the issue of policy coverage, summarizing policy instruments applied on imports of a particular good by their AVE. There are two complications with the AVE approach. First, as any trade policy has impacts in differentareas (producer or consumer welfare, volume of trade, efficiency loss, etc.), there is no perfect solution for converting them into AVEs. Starting from the seminal contribution by Bhagwati (1965), the literature has shown that there is not such a thing as a "full equivalence" (in terms of all relevant economic effects) betweentariffs and import quotas. Second, trade policies do not target a single product. A typical tariff schedule coversthousands of tariff lines that need to be summarized in one aggregate and economically meaningful measure. In addition, for economic modelling, individual tariff lines need to be converted into aggregates that conformto higher-level aggregation matching production and consumption data generally not available at tariff line level detail.
Cipollina and Salvatici (2008) classify trade policy indexes proposed in the literature in three categories: incidence, outcome and equivalence. These categories differ in two main aspects: the existence of an equivalence criterion and the use of a counterfactual approach. The definition of an equivalence criterion implies that the construction of an index depends upon the purpose of the index itself (the 'what' question previously discussed). The use of a counterfactual approach implies that the calculation of the index does notonly rely on observed data but also requires the use of statistical or equilibrium models in order to assess whatwould have happened after a policy change.
Incidence measures are based on the intensities of the policies themselves without considering the rate at which it is translated into specific impacts. As "self-contained" assessments of the policies, they are easily derived from direct observation of the policy instruments. The level or dispersion of tariffs and the frequencyof the various types of non-tariff measures are typical examples of incidence measures. Although these indexesare far from satisfactory, aggregate

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policy commitments are usually expressed as incidence measures. More sophisticated indexes introduce “variables” (typically the weights to be used in the aggregation) different fromthe policies under consideration. As policy-makers do not want compliance influenced by events out of their control more sophisticated indices are not useful for monitoring adherence to trade agreements.

Outcome measures are based both on policy variables and “weights” – such as trade, production orconsumption shares, GDPs, etc. – to be used in the aggregation process. Some economic effects of existing policies are thus taken into account, though these indexes remain “a-theoretic” since they are not computed according to some “equivalence criteria” (e.g., welfare or volume of imports). However, there are outcome measures, for example the trade-weighted average tariff, that do have an interpretation as first-order approximations to some “true” (equivalence) indexes.

Equivalence measures provide results that are equivalent to the original data in terms of the information we are interested in, namely the impact on welfare or broader well-being. The greatest advantage of this class of measures is that they are unequivocal because their definition is predetermined. These indexes provide an assessment of how far actual observations are from other hypothetical equilibria. As a consequence, explicit model structures and/or estimated parameters are needed for their computation. Since they are not only basedon observed data (as in the case of the outcome measures), they require some maintained assumptions in termsof model/methodology.

Models allow the counterfactual computation of an index of restrictiveness that is “equivalent” to the actual policies in terms of the chosen impact. Econometric approaches are used for ex post analysis, while partial orgeneral equilibrium models allow for the creation of ex-ante counterfactual scenarios. As a consequence, equivalence measures are not only dependent on the structural features of the economy, but they are “model- dependent” in that the value of the index will vary as the underlying modelling choices and parameters change.On the other hand, theoretically sound indexes provide benchmarks that are useful for the interpretation of themost widely used outcome measures.

The trade restrictiveness index (TRI), developed by Anderson and Neary (1994), is a uniform tariff-equivalent,iso-welfare measure.[25] The trade restrictiveness quantity index (TRQI) proposed by Chau, F’are and Grosskoff(2003) also adopts domestic welfare as the reference point but it is a quantity-based equivalent measure basedon the deviations of observed trade flow from what they would have been had the economy been trading freely.

The mercantilistic trade restrictiveness index (MTRI) relies on the idea of evaluating trade policy using trade volume as the reference standard. It is defined by Anderson and Neary (1994) and

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(Anderson and Neary 2003)as the uniform tariff that yields the same volume (at world prices) of tariff-restricted imports as the initial vector of (non-uniform) tariffs.[26]

For effective protection, theoretically sound equivalence indexes have also been defined. Anderson (1998) proposes a distributional effective rate of protection (DERP) as the uniform tariff which exerts on the return to specific factors an effect which is equivalent to the initial tariff structure. The same approach can be used todefine an index which is able to measure the impact of protection on the ability of sectors to compete with other industries: the output effective rate of protection (OERP).

Antimiani et al. (2013) focus on carbon emissions computing the uniform tariff on all emitting sectors which produces the same impact as does the initial differentiated tariff structure. In particular, they start from a given goal, either in terms of carbon leakage reduction or competitiveness protection, and use a CGE model to compute the sector-specific ad valorem tariffs that would allow these goals to be reached.

Laborde, Martin and van der Mensbrugghe (2017) developed and applied optimal aggregators for the real- world case of multiple countries and commodities with much more detailed information on trade than on production and consumption. They show that different aggregators are needed for expenditure on imported goods and tariff revenues.

The large number of applications carried out in recent years could be classified according to severaldimensions: type of equivalence (e.g., welfare, profits, etc.); type of model (econometric, partial, or general equilibrium); type of metrics (price or quantity); and type of assessment (absolute or relative measures).

4.2.2 Requirements for broad welfare measurements in an ex-ante framework

The discussion on broadening welfare yields the insights that we not only need to be specific about "what" wemeasure, but also distinguish impacts "here" versus "there" which addresses the regional dimension central tointernational trade. Furthermore, we need to be clear about "now" versus "then", addressing both current or short run impacts, as well as long run impacts and (where possible), account for adjustment costs.

To arrive at an operational list of requirements for welfare measurement in an ex-ante framework,Section 4.1largely draws on i) Stiglitz et al. (2009) with further detailing of the needs from policy makers in Stiglitz et al.(2018), ii) a critical review of indicator frameworks for the sustainability of food systems by Béné et al. (2019)and iii) the approach followed for broad welfare measurement to support policy-making of the three Dutch planning agencies (CPB, PBL and SCP 2021). This results in four groups of requirements on the indicators inthe BATModel ex-ante well-being framework:

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1. **Dashboard of 3-9 top-level indicators, at least one per SEE domain, for wich a target is defined**
   - No single composite index to highlight the presence of trade-offs;
   - At least one indicator for the **S**ocial, **E**conomic and **E**nvironmental (SEE) domain to assure abroad measurement of well-being;
   - "Choose we must", a limited number of top-level indicators (which may be composite indicators) to avoid unmanageable "shopping lists of indicators" which provide no guidance on intervention impacts nor design;
   - For each indicator, a target can be defined to not only assess whether well-being is increasingor decreasing but also allow comparisons across countries.

2. **Indicators linked to agri-food production, trade, or consumption modelling**
   - Indicators need to have a connection to the scope of the BATModel project focusing on agri-food trade;
   - Indicators need to be available from the CGE and PE models in BATModel to allow ex-antemodelling of the causal links with the agri-food trade.

3. **Contextualized indicators**
   - Indicators need to have a connection to the scope of the BATModel project focusing on agri-food trade;
   - Indicators need to be available from the CGE and PE models in BATModel to allow ex-antemodelling of the causal links with the agri-food trade.
   - Impacts "now" and "then" need to be represented if there is an adjustment period (futurebenefits) or long run dagame (future costs);
   - Normative implications of weighing in composite indicators need to be made explicit;
   - Weighing in composite indicators needs to allow for amendments by users.
4. **Indicators technical requirements for measurement and aggregation**
   - *Conceptual relevance*: indicators need to have a link, direct or indirect, to agri-food
   - *Explicit selection process*: make selection criteria of indicators explicit
   - *Measurable*: can be quantified based on available and recent data
   - *Representative*: are available for a representative set of countries (not just high-income)
   - *Comparable*: can be compared across countries (possibly after normalization, scaling etc.)

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- *Avoid replication or cross-correlation*: no high correlation between indicators to avoid unbalanced weighing.
- *Check sensitivity to aggregation procedure* for composite indicators define an aggregation procedure based on the characteristics of the data (e.g. whether components are compensatoryor not, whether they have some correlation among them or not) and check the sensitivity of outcomes to alternative aggregation methods.
- *Choose the most communicable robust aggregation*: select the most tractable (and thus communicable) aggregation method that does not alter the ranking from the technically preferred method.

The first requirement addresses the inevitable tension between broadening the set of indicators to do justice tothe multi-dimensionality of well-being versus a small number of indicators needed for policymaking discussions with stakeholders. Too many (and too complex) indicators stifle the debate and limit the usefulness of the analysis for decision-making support. The motivation here is to avoid that analysis and discussion drownin a sea of indicators pointing in every possible direction. Note that the selection of the indicators then becomespart of the analysis and needs to be motivated. It can reveal important information on the preferences of the analysis or stakeholder as it ranks the available indicators to some extent. We also require that each indicator of well-being is defined relative to a target so we can judge whether movements are in the desired direction. We additionally impose a comparison of scores across countries as the use of other indices (like GDP or the HDI) have shown to stimulate action by raising competitiveness among countries.

The second requirement limits the rather overwhelming possible list of well-being indicators to those that havea bearing on agri-food production, consumption, and trade. Note that this allows for indirect impacts as well, for example on employment, incomes, or greenhouse gas emissions. It does for example exclude indicators onavailability of public health services or representation of minorities in parliament. It also limits the BATModelex-ante indicators to those that can be modelled by the CGE and PE models in the project.

The third requirement stresses the need to contextualize the analysis, which is even more key considering thefirst requirement of limiting the number of indicators in the dashboard. There is no one-size-fits-all set of 9 well-being indicators that does justice to analyses of agri-food trade. Here we also include the option of usersof the dashboard to amend the weights in composite indicators as any weighing scheme has normative implications that cannot be settled through a technical approach.

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The fourth group highlights requirements on the data and construction process to obtain reliable indicators. It also aims to maximize broader use by non-experts through including communicability of preferred aggregationmethods of composite indicators.

[22] https://unstats.un.org/sdgs/unsdg
[23] https://www.oecdbetterlifeindex.org/#/11111111111
[24] https://www.oecdbetterlifeindex.org/responses

[25] Most applications of the TRI use a general equilibrium approach though it may still be calculated in a partial equilibriumframework (Bureau and Salvatici 2004; Kee, Nicita and Olarreaga 2006).
[26] Even if the MTRI is a general equilibrium index, also in this case a partial equilibrium applications have been provided(Bureau and Salvatici 2005).

4.2.3 SEE well-being impact and provide a view on economic dynamics of agri-food trade policies

In this section, we outline the foreseen process of selecting and quantifying ex-ante well-being indicators. Figure 1 summarizes the process of arriving at a contextualized assessment of well-being from the BATModel simulation models. The overall aim of the process is to provide a flexible framework where from a long list of potential indicators typically available from simulation models a small number is selected that is most relevantfor the case being analysed.
We frame the SEE well-being indicators within the SDGs as these provide a close to universal agreement on indicators spanning Social, Economic and Environmental dimensions of well-being. While there are an overwhelming and constantly increasing number of official data series (558 at the time of writing) we will include non-official SDG data series as well. In part because official SDG data series are not available from the models, while related indicators are. But also because in some instances relevant indicators are not (yet) part of the official SDG indicator database. This is in line with the approach of the SDG index, where for example for SDG2 (Zero Hunger) measures of obesity are included as these are the diet-based challenge facedby high income countries. We do impose the requirement on any well-being indicator included in the framework that it can be defined in terms of progress to a target, to allow a clear view on whether developmentsare on track to improving the well-being of people and the planet.

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Step 1 in the process is to define the ex-ante scenario that will be analysed with the simulation models. The key challenge here is to define the objective of the scenario, i.e. what needs to be changed in agri-food. Thisobjective is likely to provide guidance on the relevant indicators. A policy, for example, targeted at increasing wages will logically be assessed in terms of the amount of employment and income it generates. A policy focussed on agri-food trade liberalization, on the other hand, will likely be assessed in terms of theadditional trade volumes it generates and the subsequent economic and other impacts. The second key component, and often a challenging one, is to define the instrument that will be employed to reach the objective. This requires a theory of change, detailing how the instrument is expected to generate the objective. Possibly this can be made context dependent, which would help in grouping regions for analysingimpacts “here” versus “there” or highlighting short-run and longer term impacts (addressing “now” versus “then”). Insights from studies of observed impacts of interventions, like those reviewed in section 2 and 3 can provide input for the choice of instrument and to formulate expected impacts.

In the case of scenarios simulating changes in trade policy, the quantitative representation of trade policies inthe model setting becomes relevant. As the simulation models generally do not operate at full country and tariff line level policies that vary by product and country need to be aggregated into a model compatible representation. The general approach here is to use aggregate outcome measures of trade policy. For example, the tariffs included in the GTAP database used by the global CGE models are aggregate applied AVE estimates including specific tariffs and import quotas (Aguiar et al. 2019), relying on data of trade volumes and values to derive the AVEs. Liberalization of trade, for example through a regional trade agreement, is then represented by a reduction in the tariff rates in AVEs. In contrast, the CAPRI model has amore detailed representation distinguishing ad-valorem and specific tariffs, tariff rate quotas special import regimes (for example for cereals). The choice of model in the simulation thus affects the representation of trade policies.

Step 2 implements the scenario in one or more simulation models. Here we assume implementation of thescenario in the models available in the BATModel project. As the ambition of BATModel is to provide allmodel extensions to the modelling community via de BATmodules from WP7 this step could also involveother simulation models suited to the process outlined in Figure 1.

Step 3 then provides an analysis of patterns in a wide range of indicators. The availability of indicators depends on the model choice in step 2. A PE model like CAPRI can provide agricultural detail not available from the CGE models, whereas the CGE models provide economywide impacts beyond the grasp of PE models like CAPRI. Models like CGEbox and MAGNET are

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effectively modelling platforms where the structure and scope of the model, and thus the availability of indicators, can vary by application.

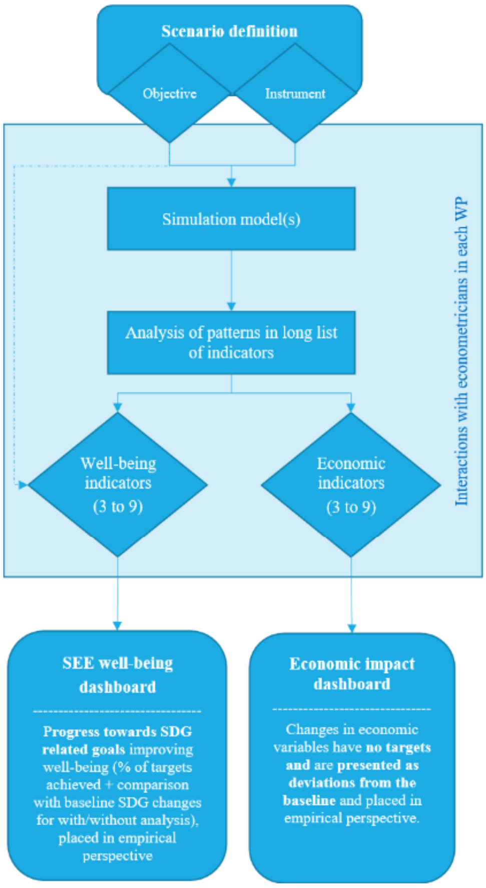

Figure 3. The envisaged process from scenarios to a contextualized indicator dashboard

Step 1: Define the agri-food (trade) scenario to be assessed in terms of (a) policy objectives and (b) policy instruments to be used

Step 2: Run the scenario in one (ormore) of the BATModel simulation models (CGEbox, MAGNET, MIRAGE or CAPRI)

Step 3: Provide first analyses of a long list of indicators in terms of direction and amount of change and in terms of correlation to support indicator selection for dashboards. Where possible check indicator changes against empirical evidence to gauge plausibility.

Step 4: (a) select 3 to 9 well-beingindicators with at least one per SEE domain; (b) select 3 to 9 economic indicators. The policy objectives may provide additional guidance in this selection.

Step 5: Visualize the impact of thepolicy scenario in terms of progress towards the SDG-based well-being indicators, flanked by adashboard showing changes instandard economic indicatorsrelative to the baseline (no intervention) scenario. Both dashboards also contain (where relevant and possible)contextualization of the resultsfrom an econometric perspective.

In any case, the models will provide a much wider range of indicators than those to be included in the dashboards. An analysis of patterns in the indicators may support the selection of appropriate indicators. Thisanalysis will focus on identifying indicators with a strong response to the policy intervention (upwards or downwards) and analysing correlations among indicators. The latter is meant to avoid replication of almost similar measures in the dashboard, but may also help to select indicators representative of a group of similar indicators. Specifying outcomes

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in terms of indicators this step also allows the computation of equivalence measures of trade policies, i.e. quantify the stance of (alternative) trade policies in terms of their impact on welfare or broader well-being. Where possible indicators will be checked against the available empirical evidence, drawing also on rich literature reviewed in sections 2 and 3.

Step 4 then uses the objectives of the scenario, the analysis of indicators and known concerns of stakeholdersin the particular case (if known) to derive two groups of indicators. The first group are 3 to 9 well-being indicators related to the SDGs and defined in terms of progress towards targets. The second group describes core economic adjustments induced by the policy. Their role is to provide a bridge to the currently common set-up of trade policy analyses while providing a view on economic drivers of changes observed in the well- being indicators. As the ex-ante models do not cover the model specification diversity that matter for welfareand well-being outcomes as discussed in section 2 and 3, where possible the selected indicator developments will be placed in context based on insights from econometric studies. These can for example point to divergingdirections of change relative to econometric studies, but it may also be cautionary remarks on heterogeneous impacts on different types of firms or labourers hidden by the aggregate representations in the models.

Step 5 then presents the ex-ante impact of the trade policy in two dashboards. The well-being indicators are framed in terms of progress towards targets, to allow assessment of whether well-being is improved or not. Note that as we do not strive for a single measure of well-being the overall conclusion on well-being may stillbe indeterminate with progress made towards some targets and deteriorations in others. Furthermore, where relevant and possible the ex-ante modelling results will be placed in perspective by highlighting how the limitations of the ex-ante models (like model structure and level of detail) may result different insights than those obtained from econometric studies.

While less of a clear policy message may result, the approach highlights trade-offs that need to be addressed, and may give rise to a redesign of the policy intervention to ameliorate the impact. The contribution of an econometric perspective through the process from model development to the analysis of results aims to enrichthe analysis further, pointing to how modelling limitations may affect results and providing better guidance for context-specific policy advice.

Alongside the well-being dashboard, the economic indicators show more traditional measures of changes in the economy. These indicators are not necessarily expressed in terms of targets. Food prices, for example, maybe a key concern for policy-makers but has no obvious target as high food prices may bode well for farmers but not for consumers (and vice versa). Apart from providing more familiar results for policy-makers (like GDP changes), these economic indicators may also give insight into the drivers of changes in well-being, or caution against distributive

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consequences. A rise in GDP (economic indicator), for example, may be accompanied by a loss of jobs through the mechanisms detailed in section 3 (well-being indicator).

4.2.4 Deriving targets for well-being indicators

The SEE well-being impact dashboard aims to provide a visual overview of the progress towards improving well-being based on ex-ante indicators. This first requires a selection of well-being indicators for which the desired direction can be unambiguously determined. Then an approach has to be designed to deal with the wide variety in units of measurement and possibly derive composite indicators. None of these steps is straightforward, but fortunately we can build on the documentation of the calculation of the SDG index whichprovides a pragmatic approach. We will shortly outline the approach here, indicating where we plan to divergefrom the SDG index methodology. For full details on the methodology see the technical documentation of theSDG index in Lafortune et al. (2018) and the statistical audit of the methodology by JRC (Papadimitriou, Neves and Becker 2019).

The first general difference in the BATModel SEE well-being impact dashboard is the use of ex-ante indicatorswhereas the SDG index is derived from observed data. To place the projected changes in indicators in perspective we may include observed indicator values in addition to the ex-ante projected indicator values. Such a combination of historic and projected values could provide a first sense check on the validity of projected values. The second general difference is in regional granularity. Where the SDG index is computedat the national level, the simulation models generally use a mix of individual countries and regional aggregatescomprising multiple countries. This may considerably affect the spread in indicator values as there are fewer regions and only regional averages will be available for the aggregated regions.

In terms of **indicator selection** we take a different approach than for the SDG index which has two fixed setsof indicators: one with global (165 countries) coverage, one OECD only. They also keep cross-correlated indicators because of policy relevance. The BATModel SEE well-being impact dashboard imposes the requirement defined earlier of 3-9 upper level indicators with at least one for each SEE domain to assure a broad assessment of well-being. The selection of particular indicators is flexible, allowing users to tailor to theconcerns relevant for the case or region of concern. It can thus be the case that different indicators are used tomeasure social well-being in high income and lower income countries. As outlined in Figure 1 we aim to provide an analysis of patterns of change to support this choice of indicators. We also exclude economic indicators which are input (as opposed to output or outcome) indicators, like SDG17 indicators on merchandise flows, from the well-being dashboard (as done in the SDG index as well) but add

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these to the list of indicatorsfor the accompanying economic dashboard in case they are relevant in specific applications.

In terms of **index scores,** we do not censor extremes (like the bottom 2.5th percentile) as this would amount toexcluding regions that have been included in the model set-up can thus be expected to be relevant for the analysis (else another regional aggregation would have been chosen). We aim to use the various normalizationprocedures outlined in the SDG index. As official and globally shared quantitative targets are only available for part of the SDG related indicators this process may be less straightforward for the ex-ante framework. Aiming for two dashboards of which only the SEE well-being impact is defined in terms of targets, however, should ease this process. It avoids, for example, putting a desirable level on indicators like revealed comparative advantage. The choice of arithmetic mean for composite indicators is appealing from a communication point of view. It must be tested for robustness against other weighting procedures as we havea rather different set of indicators. We do aim to follow their aggregation procedure from data series to SDG scores, although our SDG scores will not be compatible due to a different coverage of data series.

In terms of **dashboard colours,** the traffic light approach (green – yellow – orange – red) is appealing from acommunication point of view. It does pose challenges in terms of assigning appropriate thresholds. Instead, we may aim for an approach based on scoring the progress towards achieving maximum well-being building on the normalization of indicators when computing scores. This would result in a dashboard presentation similar to the SUSFANS visualiser[27]. Such an approach, however, would not offer the colouring used in the SDG index to highlight SDGs requiring action based on the average of the two worst indicators by SDG. Thusin the case of 10 indicators of which 8 are green and 2 are red the SDG dashboard score will be coloured red in the SDG index approach. This avoids (to some extent) substitutability for composite indicators. The scoringin the SUSFANS visualiser hides diverging developments for composite indicators. Finding a way of flaggingworsening indicators is thus a point of attention when developing the dashboard.

4.3 Sourcing well-being and economic indicators

Balancing the need for a broad well-being assessment without drowning in a sea of indicators the framework outlined above is cast as a process instead of listing a set of pre-determined indicators. This is also in line withthe objective of BATModel to provide better tools for policy analysis. A shortlist of indicators needed for a manageable assessment will never do justice to the wide variety of stakeholder concerns policy-makers face in practice. We can, however,

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provide an indication of the type of relevant indicators for assessing agri-food trade policies, drawing on existing analyses and the availability of indicators from the models included in BATModel. Below we shortly outline these sources and provide an approach to derive relevant targets for well-being indicators.

4.3.1 Revealed stakeholder interests: EU's trade strategy and SIAs of trade policies

Two key sources to get an idea of the concerns of the EU member states and other stakeholders can be derivedfrom the EU trade policy and the Sustainable Impact Assessments (SIA) done by DG trade as part of the European better policy initiative.
The most recent communication on EU trade policy dubbed "and open, sustainable and assertive trade policy",explicitly aims to support the sustainability commitments from the Green deal and SDGs (European Commission 2021), signalling concern with broader well-being looking beyond GDP. The importance of broader well-being concerns also becomes apparent when listing the global trends or challenges explicitly identified in the EU trade policy description:

- Sustainability commitments from the **European Green deal**;
- UN Sustainable Development Goals (**SDGs**);
- Mitigation of **negative impacts of economic adjustments** that are not as transient as expected, notablyinequalities in living standards, employment or wages and working conditions from globalisation, technological change, and global value chains;
- Rapid **rise of China** with a state-capitalist model that may undermine green transition of European energy-intensive industries;
- **Green transition** needed to combat climate change, biodiversity loss and environmental degradation;
- Lack of **decent work in global supply chains** (including violations of freedom and poor working conditions);
- **Changes in nature of trade** away from goods due to increased importance of servicification and digital technologies requiring IP protection;
- **Resilience of interconnected economics** highlighted by COVID-19 pandemic raising concerns on diversification of supply (domestic & external), strategic reserves and access for vulnerable populationgroups;
- **Economic power of the EU** in terms of its share in global GDP.

Part of these objectives overlaps, for example, the Green Deal, SDGs and climate change concerns all includemeasures of GHG emissions. There is an explicit concern with the impacts of economic adjustments and a move to GVCs on employment-based inequalities, through

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employment, wages or working conditions. This may help focus the selection (or development) of social indicators from SDGs to those linked to employment. In terms of environmental concerns, a connection may be needed between trade policies and the extent to which the green transition is hampered. This could be captured by indicators linked to climate, biodiversity and pollution or other types of environmental degradation. Finally, for the economic dashboard usual suspectsappear like relative changes in GDP, prices (important for accessibility alongside the income changes), and regional sourcing of strategic products (i.e. trade flows and domestic supply). The reference to the changing nature of trade from goods to services also highlights concerns on measuring changes in quality, which is moredifficult but also more important for services than for goods (Stiglitz et al. 2009, p.11).

While the EU trade strategy outlines an EU overall perspective on the objectives of trade policy, SIAs are commissioned by DG Trade for specific trade agreements. There are currently 31 SIA reports available from DG Trade[28], ranging from a 1999 WTO assessment to 2020 FTA with Australia. SIAs aim to capture the concerns of stakeholders in the EU as well as partner countries, potentially providing a more balanced view than the EU commission perspective laid down in the EU trade strategy. There is no single provider nor approach in SIAs – each study is commissioned case by case to different contractors and with different scopesresulting in a large variety in terms of depth. If we take the length of reports as a proxy for scope and/or depthvaries from 96 pages for a 2007 EPA assessment covering 77 ACP countries to 506 pages for the 2016 Environmental Goods Agreement (EGA) with a subset of WTO members. Ex-ante scenarios using GTAP- based global CGE models are already used as early as the second SIA of an association agreement with Chile (Arkell et al. 2002) but always complemented with other analyses to highlight concerns (social, environmental)or product detail (e.g. tariff line impacts) not captured by the CGE models used. This use of complementary methods supports the BATModel approach of combining simulation and econometric models for complementary insights.

We illustrate this multi-pronged SIA approach combining quantitative and qualitative analyses and the resulting rather bewildering list of indicators from various sources with the SIA of Mercosur (Mendez-Parra et al. 2020). With 412 pages it is the third largest report signalling a recent and comprehensive analysis. The 2016 EGA assessment is longer (506 pages) but has a strong environmental bias, while the 2017 TTIP (495 pages) reflects a concern with a single country (USA) likely resulting in a high-income bias in the assessment.

Mendez-Parra et al (2020) combine different Mercosur scenarios from GDYN, a GTAP-based dynamic globalCGE model, with a literature review on the expected impacts of Mercosur, recent trends in statistics with details beyond the grasp of GDYN (like on poverty and income inequality) and more qualitative measures (like the presence of commitments to strive for gender equality). Such a combination of methods is typical forthe SIAs aiming to address a wide

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variety of concerns in the detail needed to properly reflect stakeholder concerns. The first WTO SIA (Kirkpatrick and Lee 1999) already pulled together data from a wide variety of quantitative and qualitative sources. But where Kirkpatrick and Lee (1999) focus on six indicators to capture real income (net fixed capital formation, employment), equity and poverty (health and education, gender inequalities), and environmental quality (biological diversity, other natural resource stocks,) the impacts of Mercosur are described in terms of 194 indicators. Further contrast is the concise presentation of overall economic, social, and environmental impacts by region in each chapter (scored as positive, negative or no change from the base condition), highlighting trade-offs and synergies in the WTO analysis. The Mercosur study does summarize to some extent by listing policy recommendations by area of concern in the concludingchapter, but it does not place quantitative assessments of impacts in each domain alongside each other makingit hard to identify trade-offs (a word which does not appear anywhere in the document). While the dashboard of impacts in the WTO assessment provides a sense of trade-offs at a glance, the underlying methodology forarriving at these scores is not clear.

To get a sense of the breadth of indicators in a SIA, their operationalization in terms of measurement, and possible data sources we describe the indicators reported in the 130 tables and 124 figures of the Mercosur SIA. We use chapter headings as an indication of the domain being represented by each indicator, classifyinghuman rights as social and sectoral analyses as economic to align with our SEE well-being impact framework.

Table 1 summarizes a total of 102 social indicators grouping them into seven themes (employment, working conditions, poverty & income inequality, access to goods and services, health, indigenous populations, and gender inequality). Looking across the table there is a wide variety of indicators as one may expect from indicators representing the social dimension of well-being.

[27] Visualisation tool developed in the SUSFANS project, available at https://www.susfans.eu/susfans-visualizer.

[28] https://ec.europa.eu/trade/policy/policy-making/analysis/policy-evaluation/sustainability-impact- assessments/

Table 1: Social indicators in the Mercosur SIA (total number of indicators =102)

Nr	Units	Data

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	Theme: Employment		
1	Unemployment	%	26c, 12a
1	Informal employment	% of employment	16a, 26a
1	EU employment supported by extra-EU exports	Millions of jobs	17
	Theme: Working conditions		
1	Union density	% union members of employees	16b
1	Union concentration	High-Low	27
23	Reports of different types of violations of working rights (e.g. right to strike, murder of union leaders, forced labour)	Countries with one or more reviewed cases	16c
1	Freedom of association	Index	27
1	Labour rights	Index	27
	Theme: Poverty & income inequality		
3	People below poverty line ($ 1.90 or $5.50/day)	Millions (2011 PPP), %	26c, 26a
1	Risk of impoverishing expenditure for surgical care	% of population	26a
1	National income inequality (GINI)	26a	
3	Regional inequality (regional GINI relative to nationalGINI, regional GINI, distribution of GINI in regions)	GINI	26a
1	Real income per capita growth	% per region and percentile	17
1	Commitments to the Right to an Adequate standard of living	Yes or no by commitment	
	Theme: Access to goods & services		
6	Access to goods (e.g. fridges, TV, mobile phone, clean cooking facilities)	% of households by percentile of income distribution	17, 26a
4	Access to services (e.g. sanitation, electricity, clean water, clean cooking)		26a
1	People living in slums	% urban population, by country	26a
	Theme: Health		
4	Hunger & malnutrition (undernourished, under/overweight, stunting)	% of population (by region or sub-group)	26a
3	Diseases (anaemia, mental disorders)	Per 100,000 people (or sub-group)	26a
3	Causes of death (non-communicable diseases, suicide,living conditions)	% or mortality rates (by sub-group)	26a, 15
5	Health care availability (universal health care coverage,number of medical staff and hospital beds, HIV therapy coverage, immunisation rates)	Index, number per 100,000 people	26a, 18

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4	Health care costs (domestic general health expenditures, out-of-pocket payments, medicine prices (by type or bydisease)	% of GDP , % population spending more than 10% of household income, deviation from mean prices	26a, 18
1	Commitments to the Right to health	Yes or no by commitment	4
	Theme: Indigenous population		
1	Newly demarcated land (Brazil)	Km2 by year	2
2	Employment indigenous population (sectoral structure, unemployment)	%, by female, male, rural, urban	25
1	Infant mortality rate by indigenous and non-indigenous	% population group	25
1	Access to adequate living conditions (overcrowding,inadequate water sources, inadequate sanitation)	indigenous versus non-indigenous	25
4	Education (illiteracy, average years, school attendance,fluency in traditional & official languages)	%, years (by age group or rural/urban)	25
1	Commitments to the Rights of indigenous peoples	Yes or no by commitment	4
	Theme: Gender equality		
1	Gender inequality index	Index 0-1	11, 24
2	Health (mortality rate, life expectancy)	rate, years (by sex)	11, 24
1	Education (progression to secondary school)	% by sex	11, 24
4	Employment (unemployment, non-agricultural wage employment, vulnerable employment, employment bysectors)	% by sex	26a
1	Time spent on unpaid work	% by sex	26a
1	Commitments to Gender Equality	Yes or no by commitment	4

Source: Authors summary based on indicators reported in tables and figures for social and human rights impacts of the Mercosur ((Mendez-Parra et al. 2020). Numbers in first column refer to the number of different indicators by type. Datasource numbers refer to: 2 = AgenciaBrasil, 4 = Authors, 11 = European Commision, Gender Equality Strategy, 12a = Eurostat, 15 = IHME - Global Burden of Disease, 16a = ILO, 16b = ILO – ILOSTAT, 16c = ILO – Normlex, 17 = Literature, 18 = MedBelle, 24 = UNwomen, 25 = WITS, 26a = World Bank, 26c = World Bank - Poverty & Inequity database, 27 = World Justice project.

Despite their variety, for most indicators a desirable direction of change can be identified making them suitablefor a dashboard signalling progress towards improved well-being. A declining percentage of people living in slums, for example, would indicate an improvement in social well-being. There are exceptions, like the shareof jobs depending on extra-EU trade or the union density (as a decrease in union density may reflect a changein workers preferences for organizing

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themselves and not necessarily signal a decrease in working conditions).The wide variety in terms of units signals problems in deriving composite or aggregate measures of social well-being from these indicators.

From the economic modelling perspective, there are quite a number of indicators that are out of reach of the current state of models employed in BATModel. In this sense, it is telling that none of the indicators is sourcedfrom the GDYN CGE model used in the study. This also implies that the indicators reported are observed in the past and their response to the future trade agreement is not captured, they are thus not ex-ante indicators. Some of the employment indicators may become available with the planned extensions in BATModel (like (un)employment, national and by sector and/or gender). Many indicators require household level detail not currently available in the global CGE models, like income inequality (GINI), poverty, access to goods and services, health expenditures. Others require within household detail (like the prevalence of diseases like anaemia for women and children). While these can potentially be addressed by macro-micro model combinations (which are beyond the scope of BATModel), there is a substantial group of indicators out of reach of economic models. These are the ones like violations of working conditions or government commitments to international treaties. One way to address such indicators may be tracing goods through the global economy (which is in reach of the global CGEs), and associating non-economic characteristics to these goods. An example of such an approach can be found in Alsamawi et al.(2017), allocating occupational safetyand health incidents to final demand by region based on international trade flows.

Finally, there are indicators grouped as social based on the heading under which they appear in the Mercosur SIA analysis which could also be classified as economic. Examples are (un)employment rates and real incomedevelopments. Classification of indicators in the SEE impact domains may thus be ambiguous and potentiallydepend on the unit of measurement or stakeholder concerns. Real income, for example, could be an economicindicator when reported at the national level but as a social indicator when reported at the sub-national level to highlight inequalities in income development. This again signals the need for a flexible framework where indicators can be selected and positioned in the SEE well-being impact framework based on the specific context of a study.

Table 2 summarizes the economic indicators reported under economic or sectoral impacts. There is much lessvariation than for social indicators. There are about half as many indicators (51) of which many are variations on reporting on imports (7) or exports (7) which are sourced from 7 different databases varying in time horizon (ex-ante from GDYN, observed from the others), regional decompositions and product detail (from total values to model sector, FAO agricultural sector, HS6 and HS8). While the GDYN model contributes substantially to the

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economic indicators, providing ex-ante indicators (reported as % changes from a baseline) as also aimed for in BATModel, these are complemented by more detailed data from other sources. In part, these supplements are already included in the BATModel modelling. MAGNET, for example, includes FAOSTAT production data allowing agricultural production to be expressed in both monetary and physical units. Employment is also reported as an economic indicator, underscoring the ambiguity of classifying some indicators by SEE domain.

The most notable difference with the social indicators is that for most economic indicators no clear desirable direction of change in well-being can be identified. For imports flows, for example, an increase can be seen as negative (loss of competitiveness) or positive (diversification of supply). These indicators may therefore be more suited for the economic dashboard than judging progress towards increased well-being. There are also some agricultural production characteristics reported under economic indicators which may be more fitting under the environmental heading (land use, livestock density, GHG emissions). Finally, there are typical product concerns with Mercosur, reflected by the indicators for registration and sales of motor vehicles, again pointing to the need for flexibility to tailor indicators to particular contexts.

Table 2: Economic indicators in the Mercosur SIA (total number of indicators =51)

Nr		*Units*	*Data*
	Theme: domestic economy		
1	GDP	% to baseline, levels	14
1	Welfare	2011 EUR	14
1	Invest	% to baseline	14
2	Consumption (by sector)	thousand tons, % expenditures, % tobaseline	14,12a,7,13a
1	Consumer prices	% to baseline	14
2	Real wages (skilled, unskilled))	% to baseline	14
3	Employment (by sector, skilled/unskilled)	% to baseline	14
4	Production (sector aggregates, sector)	% to baseline, % of GDP, tons	14,19a,12a,13b
1	Stock variation (FAO commodities)	thousand tons	13b
2	Motor vehicle (registrations, sales)	numbers, %	1,3
4	Company characteristics (extra-EU imports andexports by company size)	Number of firms, %	12b
	Theme: Trade & trade barriers		
7	Imports (total, by source region, sector share in total, type of service, over time, annual growth)	% to baseline, euro, %, tons	14,26b,25,13b, 23,6,12a

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7	Exports (total, by source region, sector share in total, type of service, over time, annual growth)	% to baseline, euro, %, tons	14,26b,25,13b, 23,6,12a
1	Trade balance	Euro	12a
1	Revealed comparative advantage (products)	Index	23
1	Intra-regional trade index	%	12a
2	Share of customs and import duties in totalrevenue collection (total, by source region)	%	26b,25
2	Tariffs (MFN, HS6, product)	AVE	22,25
2	Barriers to service trade (mode, type of service)	STRI index	26d,19c
	Theme: Natural resource use		
3	Land use (total, type (agricultural, meadows, pasture))	million ha, %	13b
2	Livestock (stock, density)	heads, heads/ha	13b
1	GHG emissions by milk production	Tons	13b

Source: Authors summary based on indicators reported in tables and figures for economic and sector impacts of the Mercosur ((Mendez-Parra et al. 2020). Numbers in first column refer to the number of different indicators by type. Datasource numbers refer to: 1 = ACEA, 3 = ANFAVEA, 6= COMEXT, 7 = Country household surveys, 12a = Eurostat, 12b
= Eurostat - TEC database, 13a = FAO, 13b = FAO - FAOSTAT, 14 = GTAP-GDYN, 19a = OECD, 19c = OECD – STRI data, 22 = TRAINS, 23 = UN Comtrade, 25 = WITS, 26a = World Bank, 26b = World Bank - WDI, 26b = WorldBank - STRI data.

Table 3 completes the analysis of the Mercosur SIA by summarizing the 41 environmental indicators. These indicators are very skewed towards climate concerns with 18 variants of GHG emission indicators and an additional 4 indicators decomposing GHG emissions using a Log Mean Divisia Index (LMDI). The LDMI decomposes changes in GHG emissions (in tons of CO2 equivalents) into a composition (i.e. change in input structure) and scale (change in production level) effect computed from GDYN projections and emission intensities from the EDGAR. The other environmental damage indicators are not connected to the GDYN projections and thus reflect historic observations. Some of these may be covered as ex-ante indicators as the modular platforms of CGEbox and MAGNET include environmental modules covering part of these environmental concerns (lie physical land use from which deforestation rates may be deduced, or various typesof electricity production including renewable sources).
Apart from the environmental damages and production related themes, the third theme covers legal contexts which are beyond the reach of the economic models in BATModel (examples are counts of countries being signatories to international agreements or number of patents linked to climate change). As with the social indicators, most environmental indicators (apart from

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wood-based production) have a clear desirable directionin terms of increasing well-being and are hence suited for the SEE well-being impact dashboard.

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Table 3: Environmental indicators in the Mercosur SIA (total number of indicators ==41)

Nr	Indicator	Unit	Data
	Theme: Legal		
1	Multilateral Environmental Agreements signed	yes or no	28
1	International partnerships in patents linked toclimate change mitigation	% of co-inventor countries in total patents	19b
1	Climate Laws, Institutions and Measures Index (CLIMI)	CLIMI index by log GDP/capita PPP	8, 26b
1	Patents applications related to climate changemitigation	% of total climate patents by type, by country	19b
	Theme: Production & forest loss		
1	Wood & paper products (roundwood, sawn wood, wood pulp, recovered paper, wooden pellet, wood based panels, other fibre pulp, paper & paperboard)	million tons	13b
1	Electricity sources	% total electricity	26b
2	Forest cover loss	1,000 hectares, annualised % loss	13c, 21
	Theme: Environmental damage		
18	CO2 emissions (total, per capita, by sector, by type(CO2, CH4, N2O))	% to baseline, tons, share of CO2, annualgrowth rate	5,14, 9a, 9b,26b
3	Environmental performance index (EPI) (total, bysub-category)	index by log per capita GDP, PPP, index	10,26b
2	Pesticides (intensity, amounts)	kg/ha, by income/capita PPP, by years and countries	13b
2	Nitrogen fertilizer (intensity, amounts)	kg/ha, by income/capita PPP, by years and countries	13b
2	Air pollution - Particular Matter (PM2.5)	mean annual exposure by country in micrograms m3, % of population above WHO guideline	26b
2	Solid waste (amount generated, collection rate)	log kg/capita/day by log income/capita PPP	17,26b
4	LMDI decompositions (CO2, CH4, N2O, totalGHG)	tonnes CO2 compared to baseline by source (composition, scale)	9a,14

Source: Authors summary based on indicators reported in tables and figures for environmental impacts of the Mercosur ((Mendez-Parra et al. 2020). Numbers in first column refer to the number of different indicators by type. Data source numbers refer to: 5 = CAIT, 8 = EBRD, 9a = EDGAR, 9b = EDGAR - CO2 Emissions by countries and sector database,10 = EPI, 13b = FAO - FAOSTAT, 13c = FAO - Global Forest Resources Assessments, 14 = GTAP-GDYN, 17 = Literature, 19b = OECD - OECDSTAT, 21 = TerraBarsilis, 26b = World Bank - WDI, 28 = WTO - MEA Matrix.

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The description of the Mercosur SIA indicators provides a flavour of the type of indicators currently includedin assessments supporting DG Trade negotiations. The largest variety is found in the social dimension, with most indicators being beyond the current (direct) reach of the models used in BATModel. The economic indicators used in the SIA largely fall within the scope of the economic simulation models in BATModel andcan thus inform the economic impact dashboard. As in the SIAs additional analyses complementing the modelsimulations may be needed to get assessments at the detailed level needed to address stakeholder concerns. Inpart, these may be covered by complementary econometric results and model extensions foreseen in BATModel, but trade policy assessments to guide policy analyses will always require context and qualitativedetail not provided by economic simulation or econometric models like the ones in BATModel. Casting the indicators in a context-specific dashboard flexible enough to highlight (sub-)regional and sectoral concerns asproposed in the BATModel ex-ante indicator framework, provides a contribution to the existing results available from the SIA used by DG Trade. Such a framework can highlight trade-offs and synergies difficult to detect from the large number of reported indicators in the SIAs.

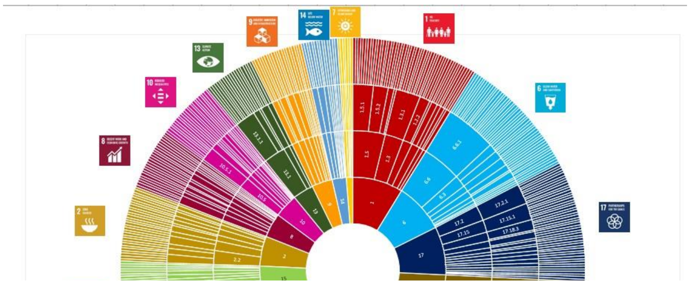

Figure 2. SDGs have high variability in number of series (4th outer ring), indicators (3rd ring), targets (2nd ring) and goals (1st inner ring) – SDGs sorted by largest number of data series (from SDG1, End Poverty to SDG7 Energy)

Source: Authors' elaborations based on the SDG database (https://unstats.un.org/sdgs/indicators/database/ accessed August 2021)

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4.3.2 SDG-based well-being indicators

The EU trade policy explicitly aims to support the SDGs which cover a kaleidoscope of indicators on the current and future well-being of people and the planet. These are thus a logical source for identifying well- being indicators, in part overlapping with concerns addressed in the SIAs. The focus on working conditions in Table 1, for example, falls within the scope of SDG8 (Promote sustained, inclusive, and sustainable economicgrowth, full and productive employment, and decent work for all).

As stated earlier the measurement of progress towards the SDGs is recorded by 558 data series[29]. These seriesmap 247 indicators, 169 targets and 17 goals as visualized in Figure 2. While the UN database provides the concordances from series to goals it does provide an aggregation procedure to summarize progress by SDG ina single number. From Figure 2 we can, however, already deduce that any aggregation including all data serieswill introduce significant implicit weighting: SDG7 (Ensure access to affordable, reliable, sustainable and modern energy for all) has only 6 data series whereas SDG1 (End poverty in all its forms everywhere) has 49.Part of these 49 series for poverty is furthermore likely to be correlated including for example proportion of people below international poverty lines and the proportion below national poverty lines.

Selecting only a few SDG data series for our SEE well-being impact framework does not appear to do justiceto the multi-dimensional character of the SDGs while presenting too many data series will make the results unusable. The second requirement on identifying indicators for the SEE well-being impact dashboard definedabove may be of help here, focusing on SDG data series that have a connection (direct or indirect) to agri-foodtrade and are available from the models in BATModel.

We, therefore, identify potential SDG indicators and associated data series in the two steps from the most recent version of the database at the time of completing this report where the total number of data series has increased to 752 (Figure 3 in section 4):

1) Identify which of the 247 SDG targets are directly or indirectly affected by agri-food production, trade,or consumption;
2) Identify for the agri-food related indicators which associated data series (these contain the actual dataneeded to build the indicators) are available from the BATModel models, either currently or by a model extension in line with foreseen work in BATModel (further discussed in section 5);

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In step 1 we identify 183 SDG indicators with no (clear) link to agri-food. The reasons for this classification are grouped into 6 main causes varying from indicators of various illnesses and causes of death to legal and administrative decisions like signatures to international treaties. The remaining 64 indicators with a link to agri-food cover only 14 of the 17 SDGs, excluding SDG4 (Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all), SDG5 (Achieve gender equality and empower all womenand girls) and SDG16 (Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels).
For all remaining 64 indicators we have one or more data series in the recent version of the SDG database (DSD v1.7, released on 20 Dec 2021). These data series, however, cannot all be covered by the simulation models. Of the 211 data series associated with the 64 agri-food related SDG indicators, 137 are outside the scope of the BATModel simulation models. The current coverage of SDGs by the simulation models and their possible extensions in BATModel are further discussed in section 5 focussing on the project's contribution toa broader welfare measurement of trade policies.

5. BATModelcontributions to measuring broader welfare implications of trade policy

This section deals with the way BATModel will contribute to the measurement of well-being implications of trade policies. The following section presents the screening of SGD indicators presented in the previous sectionand the link with BATModel foreseen work. As trade policies affect well-being through different channels, itis important to pay attention to the type of policy indicators that can be provided through simulation models, especially those involved in BATModel. Then, we present the main directions of the work foreseen in the different components of BATModel, focusing on the potential contributions of each work package and look ahead towards an extension for a better understanding and measurement of well-being implication of trade policies.

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[29] This is the number of data series when accessing the database in September 2021, Series are added regularly. The latest version of the database can be found at https://unstats.un.org/sdgs/UNSDG/IndDatabasePage and includes 752data series. This more recent version is used in the analysis of coverage of by BATModel models.

5.1 Current SDG data series available from the simulation models

Figure 2 summarizes the screening of SDG indicators for links with agri-food production trade or consumptionand identifying associated data series available from BATModel simulation models (currently or after foreseenBATModel extension). The first distinction between indicators is the lack of sub-national heterogeneity at household (N=29), producer (N=6) or sector (N=20) level. Poverty measures linked to SDG1, for example, require data on the distribution of income over households, which are not available from the CGE models based on national data. Heterogeneity can also refer to the productivity of small-scale producers or the numberof livestock breeds (both linked to SDG2). Combining current and possible extended coverage of the simulation models 11 out of the 17 SDGs have at least one ex-ante data series. In addition to the 3 SDGs excluded in step 1 for lack of linkage to agri-food, an additional 3 SDGs are excluded due to lack of ex-ante coverage of official data series: SDG1 (End poverty in all its forms everywhere), SDG6 (Ensure availability and sustainable management of water and sanitation for all), SDG14 (Conserve and sustainably use the oceans,seas and marine resources for sustainable development).
Note that this assessment is based on checking for the availability of the official UN data series associated withthe SDG goals. The models may still provide indicators that are relevant for the SDGs, despite not being part of the official list. The SDG index, for example, adds a 2.8% obesity rate as a target under SDG2 (Sachs et al.2021). The MAGNET SDG insights module for example adds developments of agricultural wages versus thecereal price as an indicator of poverty under SDG1.

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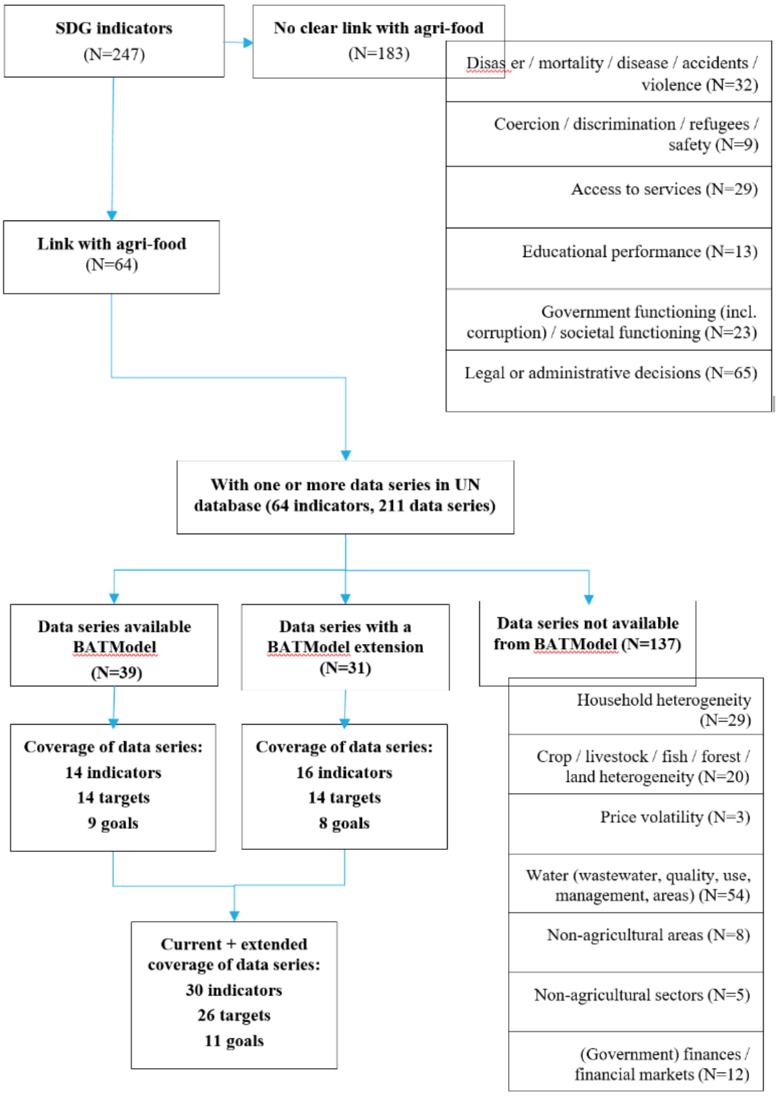

Figure 3. Screening SDG indicators for link with agri-food production trade or consumption and identifying associated data series available from BATModel models (currently or after foreseen BATModel extension).

Source: Authors' elaborations based on the SDG database V1.7 (https://unstats.un.org/sdgs/indicators/database/ accessedJanuary 2022)

Figure 3 summarizes the data series which currently can be derived from the simulation models in BATModel,grouping them by target and SDG goal. The series effectively cover regular economic measures like the shareof sectors or labour

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in GDP, trade flows, taxes, subsidies, tariffs, and private household income (at the nationallevel). In addition, there are several series reflecting past work of the model teams on climate change and environmental damage, providing measures on various GHG emissions and land use.

Table 4: SDG data series currently available from the BATModel simulation models (N=39)

	Goal		Target	N=	Data series
2	Zero hunger	2.a	Increase investment in agricultural productivity in developing countries	3	Agricultural share in GDP, export subsidies, government expenditures
		2.b	Correct and prevent trade restrictions and distortions in world agricultural markets	1	Agricultural export subsidies
7	Affordable & clean energy	7.2	Increase substantially the share of renewable energy in the global energy mix	1	Renewable energy share in the total final energy consumption
		7.3	Double the global rate of improvement in energy efficiency	1	Energy intensity level of primary energy
8	Decent work & economic growth	8.1	Sustain per capita economic growth in accordance with national circumstances	1	Annual growth rate of real GDP per capita
9	Industry, innovation & infrastructure	9.2	Promote inclusive and sustainable industrialization	3	Manufacturing size (GDP, per capita, valued-added)
		9.4	Upgrade infrastructure and retrofit industries to make them sustainable	3	CO2 emissions (fuel, GDP, manufacturing value-added)
10	Reduced inequalities	10.1	Achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average	1	Growth rates of household expenditure or income per capita
		10.4	Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality	1	Labour share of GDP
12	Responsible consumption & production	12.c	Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions	6	Fossil fuel taxes and subsidies (consumption and production)
13	Climate action	13.2	Integrate climate change measures into national policies	2	GHG emissions (Annex 1 and non-Annex 1 countries)
15	Life on land	15.1	Ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services	3	Forest and total land area

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17	Partnerships for the goals	17.11	Significantly increase the exports of developing countries	4	Developing countries shares in global merchandise and service exports & imports
		17.13	Enhance global macroeconomic stability	9	GDP, exports, capital, tax revenue, household income (growth rates, share in GDP)

Source: UN SDG database V1.7 (accessed January 2021), authors' elaborations.

In addition to these SDG data series, the simulation models provide a wide range of other economic and non-economic indicators. Annex 2 summarizes the key topics addressed by the various models in BATModelBATModel, providing a sense of the wide variety of indicators already available.

5.2 Type of policy indicators in BATModel simulation models

Trade has been and continues to be identified as one of many economic mechanisms that can promote sustainable development although the links with economic, social, and environmental objectives are not unidirectional or unconditional (Helble and Shepherd 2017). Trade policies affect well-being through differentchannels, which makes it crucial to set a proper methodology providing a sound measurement of their impact.

An important instrument in this respect is provided by policy indicators defined in a general equilibrium setting and computed using simulation models. The seminal contribution by Anderson and Neary (1994) introduces index numbers for policy variables which formalize the major issues in summary statistics in international trade policy - that is, how to summarize different forms of trade policies over thousands of different tariff linesin a single figure (see the discussion in Section 4.2.1) – as the search for an index number that preserves the essential connection between the information being aggregated (e.g., tariffs, tariff-equivalent quotas) and the economic, social or environmental variable of interest. A typical example is provided by the Trade Restrictiveness Index (TRI) that aggregates trade barriers holding constant the level of real income (which under standard neoclassical assumptions coincide with welfare) and correspond to the uniform tariff that if applied to all goods would yield the same real income (welfare) as the actual tariffs.

Making trade an effective means through which many of the specific goals and targets that have been agreed upon can be achieved requires action on a broad front. A common denominator of such actions should be to reduce the costs of trade so that firms can source the inputs they need to be competitive and give households better access to a range of products and services that will

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improve their welfare, ranging from food security to health (Hoekman 2017). This aspect is particularly relevant in a context where, with the growth and spread of international linkages, the production processes are fragmented and dispersed among many different locations in various countries (Global Value Chains, GVCs) and about one half of global exchanges pertains to intermediate products (that is, parts and components used as inputs in the production of final goods for end consumers). As exports of goods and services rely on inputs from abroad, producers' competitiveness in international markets is negatively impacted by tariffs on imports since they reduce access to the most efficient inputs (Cattaneo et al. 2013; Taglioni and Winkler 2014; Fusacchia, Antimiani and Salvatici 2021).

The design of appropriate trade policy measures consistent with SDGs requires a full understanding of the characteristics of the current production paradigm in terms of the organization of international value chains and production networks; accordingly, quantifying the effects of trade policy requires an enhanced analytical framework that takes international input–output linkages into account to assess the implications trade costs have on competitiveness at national and sector levels (Antimiani et al., 2018). The Foreign Value Added TRI (FVA_TRI) provides a synthetic measure of trade protection capturing the effects that the tariff structure has on imported intermediate inputs used by domestic firms to produce exported goods and services (Fusacchia etal. 2021).

These developments are based on a prior decomposition of trade in value added (Antimiani, Fusacchia and Salvatici 2018) included in the CGEBox (that will be included in MAGNET as an outcome of the BATModel project) and are already available to be included in BATModel simulation models. Trade policy affects the welfare (real income) of households by impacting the prices of the goods and services they buy and those that they produce, either directly (such as agricultural products) or indirectly, by working in a given sector (Hoekman, 2017). Under the latter aspect, what is relevant from the perspective of income and growth in the agriculture sector is the domestic value added (i.e., the remuneration of primary factors) which is embedded in goods and services internationally traded.

The power and flexibility of the techniques developed in modelling GVC-related trade and production within a CGE context open the way for further extensions in the direction of the multi-dimensional footprint of consumption to disentangle effects "here" versus "there" of final demand. Firstly, a protection index can be defined to evaluate how trade costs on imports impact export performance. In line with the developments by Feenstra (2017) who extends the concept of effective protection to reflect the impact of import tariffs on the foreign inputs in an industry's exports, an index of tariffs which equals the uniform tariff that yields a constant volume of gross exports (X_TRI) can be defined. Such an index measures the impact of the trade policy on a country's ability to export (Deliverable 4.1).

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In the same vein, a Domestic Value Added TRI (DVA_TRI) corresponds to the protection index for the domestic value added embedded in exports and quantifies the impact of trade policy on the income-generatingrole of exports. However, a consistent portion of agricultural is indirectly exported embedded in other sectors'exports. Since the agricultural value added only partially depends on exports of agricultural products, two additional indexes can be defined to distinguish the value added directly exported (DVAD_TRI) from the valueadded exported embedded in non-agricultural products' exports (DVAI_TRI).

Finally, applications can be envisaged regarding the estimation of demand-based and trade-related emissions of pollutants. As a matter of fact, once the link is traced between the location of environmental impact and theprocesses that led to the impact fuelled by demand for goods and services elsewhere in the world, it is possibleto identify the countries and sectors that contribute most to the carbon load of international trade (Cappelli et al. 2021). This information is potentially relevant to the design of trade policies aimed at mitigating climate change. A tariff-equivalent of emission-intensity in traded goods could be an instrument to unveil the effective impact of trade policy on worldwide emissions.

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5.3 Broadening welfare measurements in the course of the BATModel project

When assessing the availability of SDG indicators in figure 3, we already looked ahead towards extensions that may be possible based on the planned BATModel work. Whether these extensions can be realized will depend on data availability and focus of future BATModel work in each work package, but the summary of possible new SDG data series in Table 5 may help guide the shaping of this future work. The following sectionssum-up for each component of the BATModel and work package, the work planned.

5.3.1 Component 1: Assessing gains and losses from trade policy

WP1, Measuring distributional and sustainability impacts of trade policy
The work in WP1 will aim at measuring the impacts of trade policies on several indicators that are rarely or never accounted for in existing trade models concerning value added, employment, environment, health, distributive effects between and within sectors and agents but also interactions between climate change, tradeliberalisation and GHG mitigation policy. This work will be based on recent literature presented in previous sections that shows emerging efforts to reassess the benefits and costs of trade liberalisation and will use newmethods to estimate the benefits or the costs, with a growing focus on labour market adjustments and on other“hidden costs”, such as health issues (see section 3 for more details)
This work package will provide an extended impact assessment of trade reforms that go beyond traditional economic welfare analyses by including micro-evidence-based impacts in existing simulation models that address broader societal concerns.
As case studies, it will bring a better understanding of the impact of trade liberalisation on labour market outcomes (including worker health and the effects on unemployment) and selected SDG indicators. The analyses will focus on the agri-food sector with a focus on France and Italy. The effects of trade liberalisationon inequality by using data on household consumption will be based on micro evidence from African households.
Based on this micro-evidence, some developments in MAGNET will be proposed in several directions (employment levels, types of labour, movements of labour across sectors, and GVC implications). Some linkeddevelopments in CAPRI and MIRAGE will add a regional dimension to the analysis, which is a key aspect ofthe environmental assessments that tend to be very location-specific.
The empirical evidence shows the importance of the “here” versus “there” dimensions for agri-food as production is concentrated (in part driven by natural comparative advantages of regions

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for specific crops) while the consumption impacts are spread globally as everyone needs to eat. The growing importance of GVCsmakes the connection between production and consumption increasingly complex. To support the tracing of production related impacts throughout the global economy a GTAP-based CGE module for tracing material flows that respects material balances will be developed. It builds on existing methods for tracing impacts, likethose used in the GVCs, refining the separation of material flows (like for example tons of biomass in case of agricultural products) from other taxes and transport margins that often are included in existing environmentaland nutritional tracing exercises (like the approach used in Chepeliev (2021)) but do not carry biomass themselves. Such consistent tracing of biomass from farm to fork improves measures of the nutritional contentof food, which is a key component for diet assessments and improves computation of material footprints whichare used in SDG8 and SDG12. Such tracing of commodities can also be used to allocate qualitative aspects ofproduction (like work accidents) to final consumption (similar to the assessments in Alsamawi, McBain, et al. 2017; Alsamawi, Murray, et al. 2017; Alsamawi, Murray and Lenzen 2014; Alsamawi, Murray, Lenzen, etal. 2014). Possible extensions linked to work on diet and health would be to use approaches from the literature to compute undernourishment (Hasegawa et al. 2018) and diet-related non-communicable disease burdens (Springmann et al. 2018) which would add at least one data series linked SDG3 not currently covered by the models. Work on diets in WP1 may also incorporate estimates of food waste if these become available (so far consistent androbust global food waste estimates have not been provided).

Adding details on employment would enhance the measurement of progress towards decent work (SDG8) andadd an indicator for SDG9 (Industry, innovation & infrastructure). There is an option for adding air pollution to the CGE models with the recent release of a GTAP-compatible database (Chepeliev 2021a) which would add an indicator for SDG11, but such work is not foreseen in the current environmental focussed work in WP1.

Table 5: SDG data series possibly available from extensions of BATModel simulation models (N=31)

	Goal		Target	N=	Data series
2	Zero hunger	2.1	End hunger and ensure access by all people to safe, nutritious and sufficient food	2	Prevalence of undernourishment (diet-based)
		2.a	Increase investment in agricultural productivity in developing countries	1	Total official flows (disbursements) for agriculture, by recipient countries

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Good health & well-being	3.4	Reduce by one third premature mortality from non-communicable diseases	2	Deaths linked to non-communicable diseases (diet-based)
Decent work & economic growth	8.2	Achieve higher levels of economic productivity	1	Annual growth rate of real GDP per employed person
	8.4	Improve global resource efficiency and endeavour to decouple economic growth from environmental degradation	6	Track material use in physical terms (GDP, capita, domestic)
	8.5	Achieve full and productive employment and decent work for all	2	Average earnings, unemployment, manufacturing employment
Industry, innovation & infrastructure	9.2	Promote inclusive and sustainable industrialization	1	Manufacturing employment as a proportion of total employment
Reduced inequalities	10.a	Implement the principle of special and differential treatment for developing countries	1	Proportion of tariff lines applied to imports with zero-tariff
Make cities and human settlements inclusive, safe, resilient and sustainable	11.6	Reduce the adverse per capita environmental impact of cities	1	Annual mean levels of fine particulate matter (population-weighted), by location
Responsible consumption & production	12.2	Achieve the sustainable management and efficient use of natural resources	6	Track material use in physical terms (GDP, capita, domestic)
	12.3	Halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains	3	Food waste (total, per capita)
Partnerships for the goals	17.10	Promote a universal, rules-based, open, non-discriminatory and equitable multilateral trading system	2	Worldwide weighted tariff-average (MFN, preferred)
	17.12	Realize timely implementation of duty-free and quota-free market access on a lasting basis for all least developed countries	3	Average tariffs (by region, preferential status, type of product)

5.3.2 Component 2: Capturing the characteristics of the agri-food trade

WP2, Emerging trade flows

In WP2, the work will aim at developing methodologies to allow trade models to create trade flows that did not previously exist due to prohibitive trade costs and tariffs ("small shares stay small" problem). Some changes and improvements in trade models will consist in working with

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more flexible demand systems that enable emerging trade flows by operationally implementing alternatives to the CES function, reflecting important contributions in the past years (Bas, Mayer and Thoenig 2017; Helpman, Melitz and Rubinstein 2008; Novy 2013). In this WP, we will develop some hybrid models at the tariff line level which will combineheterogeneous product models of the Armington family with homogenous product models based on spatial arbitrage. This implies a better understanding of the specificities of the extensive trade margin in the agricultural sector and the data necessary for detailed modelling. All the approaches proposed in this WP canbe seen as an extension of Armington modelling widely applied in existing tools and compatible with them.

The additional detail on trade flows in terms of product detail and new trade flows not observed in the past contribute to improving trade-related SDG indicators (SDG10, SDG17). The ability to capture new trade flowswill also further enhance the tracing of products through international trade developed in WP1.

WP3, Markets, quality and competition

This work package aims at incorporating product quality differentiation including both horizontal and verticalquality differentiation in trade simulation models of agri-food products. Similar products are horizontally differentiated if quality ranking depends on the consumer perception (i.e. of particular attributes such as colour or flavour) and are vertically differentiated if the products have different attributes on which consumers agreein the quality ranking (i.e. on attributes such as pesticide contamination).

From an econometrics point of view, the work will consist in estimating the joint distribution of quality and productivity. These estimations will be completed by the estimation of the effect of quality strategy (at the firmlevel) on firm output and export. The estimations will be developed on the agri-food sector, with a focus on France and Italy. Then the simulation modellers will be able to introduce quality differentiation in trade simulation models adding a new indicator currently beyond the reach of the models.

Some works will also identify the labour content of firms producing quality goods. The availability of employer-employee dataset for the French agri-food sector, a promising field of research as highlighted in section 3, will give the opportunity to link the ability of the firm to produce quality and the staff it employs and possibly some links with some indicators highlighted in WP1 regarding the labour market.

WP4, Global value chains

The main objective of this WP is to incorporate some of the most relevant GVC features – such as fragmentation of production, economies of scale, intermediate inputs and decision making

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by global agents –in CGE models. This incorporation implies combining bilateral trade data and firm level data to supply modellers with multi-regional input-output tables that reflect the heterogeneous use of foreign inputs by domestic firms. This implies combining bilateral trade data with firm-level data in order to improve the precision of existing Multi-Region Input-Output (MRIO) tables to reflect the heterogeneous use of inputs at adetailed product level (HS6). This will be one more interesting step towards the improvement of the tracing ofchanges in trade flows. This will contribute to the computation of the policy indexes mentioned in Section 5.2.
Moreover, taking into account different types of actors involved in GVCs, this work package will bring micro-evidence of some distributive effect along the chains. Some dedicated indicators measuring these distributiveeffects could be used to deepen the analysis and improve the simulation models accordingly. For instance, thework in this WP will provide estimations of firm-level and time-specific mark-up for farmers, processors, wholesalers and retailers, and the estimation of the change in firms' value-added and the upstream integrationdecision due to participation in retailer GVCs. Increased detail in modelling GVCs enhances the "here" versus "there" dimensions of all production related indicators.

5.3.3 Component 3: Behind-the-border trade policy measures

WP5, Non-tariff measures
WP5 will address the modelling of NTMs, by accounting for both the costs and benefits of these measures, asthey are often neglected in econometric and simulation analyses. The extent of the NTM impact, whether positive or negative, is an empirical question and we will investigate this through econometric estimations, thereby improving the standard gravity models in order to capture the benefits of measures in simulation models. A comprehensive approach to NTM analysis linking econometrics and simulation models will be developed. Accounting for both the supply side (fixed and variable costs of NTMs) and the demand side (withdemand-side taste shifters accounting for the potential benefits of NTMs) will provide more accurate results on the effects of NTMs. The work package will provide new estimations of ad-valorem equivalents (AVEs) tobe included in simulation models to quantify the impacts of NTMs.
By nature of NTMs and especially SPS measures, this work package will add some insights on how NTMs improve the quality of production processes in terms of health and environmental indicators for instance.

WP6, Geographical Indications
WP6 will develop new tools to incorporate GIs in trade models by also considering problems of coexistence of GIs and similar non-GI products. The existing empirical literature on GIs and trade

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rarely considers firm level or territorial effects in contrast to emerging trade models based on firm-heterogeneity. Based on a focusand French and Italian geographical indications, the work in this work package will contribute to a better understanding of the role of GI recognition in recent trade agreements on international openness (firm level performance, import-export flows, foreign direct investments, and multinationals agri-food firms' location). Through the quantification of the effects of GIs both on firm level trade and productivity and on territorial performances, the results will show insights into the distributive effects across firms, schemes and regions.

Finally, Figure 3 adds several data series for which detailed data on trade flows and trade restrictions are needed that are beyond the maximum of HS6 detail offered by the CGE models. As work is planned to improveon the measurement of changes in trade flows (WP2), product quality (WP3), NTMs (WP5) and GIs (WP6) there may be scope to enhance the detail of trade flow modelling to add such more detailed indicators (depending on data availability and computational restrictions in the models). In the absence of full coverage of tariff line trade and trade barriers proxies may be employed working from the currently available commodity detail.

To summarize the current and potential coverage of the SDGs by the BATModel simulation models Figure 4 shows the coverage of ex-ante data series by SDG. It highlights that the simulation models used combined with its agri-food focus limits the scope of the BATModel project to provide balanced coverage of all SDGs. The main limitation is the availability of global consistent databases on household and producer heterogeneityto include changes in poverty, incomes and production practices at more detailed levels in ex-ante simulations.While these can be (partially) addressed by coupling macro and micro level simulation models, suchapproaches are not included in the project nor are data available for global coverage of such more detailed modelling. Figure 3 also shows the contribution adding employment, tracing of material flows through international trade and providing a more detailed representation of trade can make to the scope of the SDG coverage by BATModel. It shoudl also be kept in mind that this assessment is based on the official list of data series, whereas the models offer many supplementary indicators that are relevant for the SDGs. The SDG insight module of MAGNET for example, provides 99 indicators linked to 12 out of the 17 SDGs. The SDG index (Sachs et al. 2021) uses 120 indicators which are also a mixture of official and supplementary indicatorsto compute the SDG index score.

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6. Conclusion

In this deliverable, our objective was to work on a conceptual framework to assess the welfare and other traderelated impacts pertinent to societal concerns and expectations of trade policies with a focus on the agriculturaland food sector. This is an important step to share a common vision of the objectives of BATModel.

To summarize, the conceptual framework is presented in 4 different sections. Section 2 proposes an overviewof 20 years of work on models of agricultural and food trade. This literature review shows how this fields of research has helped clarify the various sources of welfare associated with agri-food trade. It specifically showsthe contributions of specialization (within and between countries, and between crops), inputs use, and firm selection. It has also extended the welfare framework to include issues related to product quality, endogenous preferences, and uncertainty and price volatility. However, these extensions while conceptually important maynot be easily implementable due to lack of data or tractability. More generally, trade models are useful tools to analyze welfare changes that can be expressed as changes in real income. However, many important dimensions of agri-food trade are not easily summarized as real income changes or when they can be it is thanks to strong assumptions that threaten their generality. So to better appreciate the consequences of trade, one needs to go beyond welfare measures. Section 3 presents the state of the art in the field of trade liberalization and labor market dynamics. Recent years have seen tremendous developments in how trade economists understand the dynamics of labor response to trade shocks. Furthermore, trade-induced structural changes in the economy of industrialized countries underlie not only distributional effects of trade but also some hidden costs (increased mental and physical health risks, obesity and morbidity, …). Section 4 deals withthe outline of an ex-ante framework to account for well-being implications of trade policy. The objective is tomove from a classical welfare analysis to the use of well-being indicators in the frame of ex-ante simulation models. The indicators in the scope of this project are those of interest for policy makers. The increasing activepublic opposition to trade agreements in the early 2010 leads the EU to develop a strategy that explicitly aimsat raising global social, environmental and food safety standards to foster Sustainable Development Goals (SDGs). This section presents the available indicators and the relevant strategy to select them. One importantrequirement is compatibility with the models included in BATModel. The last section shows how BATModelwill contribute to the measurement of well-being implications of trade policies. Based on the screening of SGDindicators related to the BATModel foreseen work, we show how each work package could possibly contributeto the elaborated ex-ante framework.

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This deliverable will be shared among BATModel participants and it will feed the interactions among them. Our objective, besides the specific objectives of each work package already foreseen to improve the simulation
models involved in BATModel, is to work within a common framework and to look ahead towards extensionsthat may be possible based on the planned BATModel work. The interaction wit stakeholders, and more precisely with the end-users of the models and the policy makers involved in trade policy design and assesments will help us to reach our objectives.

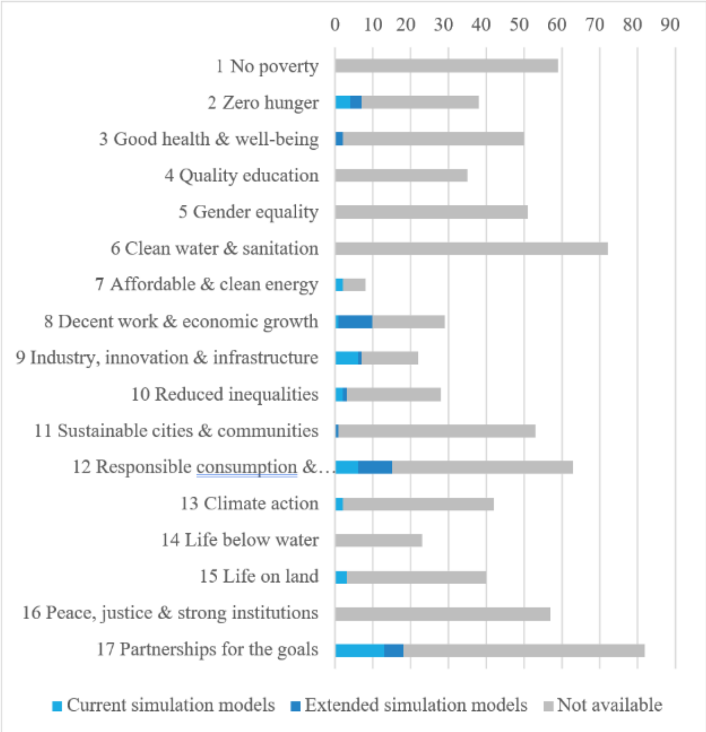

Figure 4. Number of data series from current BATModel simulation models and with potential BATModel extensions by SDG

Source: Authors' elaborations based on the SDG database V1.7 https://unstats.un.org/sdgs/indicators/database/ accessedJanuary 2022)

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8. Planned publications

Section 2 is a summary of a more detailed document. This document will be part of the forthcoming Handbookof Agricultural Economics as a chapter entitled “Trade in Agricultural and Food Products “, written by Carl Gaigné and Christophe Gouel.
Section 3 will feed some work foreseen in the following tasks of WP1 (this deliverable is the first in WP1).
Section 4 will feed the progress of work in each WP (WP2 to WP6). It may be published as a stand-alone document and be updated at the end of the BATModel project to give an overview of BATModel contributions.

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