Global Agricultural Value Chains and Food Prices[*]

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Abstract

We study the relationship between participation in global agricultural value chains (GAVCs) and food prices at the country level. Using longitudinal data on a sample of 138 countries for the period 2000–2015 and a shift-share instrumen-tal-variable design, we study how a country's participation in GAVCs in a given year relates to food price levels and volatility in that same country in the same year. We document a mean–variance trade-off in food prices, finding that participation in GAVCs is associated with a decrease in consumer food price levels but an increase in food price volatility. We show that the association between participation in GAVCs and food price volatility is likely due to a lack of diversification among suppliers—an externality resulting from the profit-maximization behavior of individual firms. Looking at a country's upstream or downstream positioning of participation in GAVCs, we find that food price volatility is associated more strongly with downstream participation than with upstream participation. Then, after developing a political economy model that takes into account various groups' preferences over both price levels and volatility, we explore policy options aimed at improving GAVC resilience.

Keywords: Global Value Chains, Agricultural Value Chains, Food Prices

JEL codes: F14, Q17, O19, E31

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[*]We are particularly grateful to Sunghun Lim for his help with the data. We thank Chris Barrett, Michele Mancini, Daria Taglioni, Aleks Schaefer, and Andrew Schmitz as well as seminar audiences at Göttingen, Iowa State, Kiel, OARES, and USDA-ERS, and conference participants at the 2022 IATRC meeting, the 2023 Economics and Management of Risk in Agriculture and Natural Resources meeting, the 2023 meeting of the Canadian Agricultural Economics Society, and the 2023 meeting of the Agricultural and Applied Economics Association for useful comments. All remaining errors are ours.

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1 Introduction

In recent years, some of the emergencies induced by the global COVID-19 pandemic and the Russian attack on Ukraine seemed to be amplified by historically high degrees of market integration and participation in global value chains (GVCs). In 2022, Ukraine was not able to ship wheat out because of the Russian blockade on the Black Sea and worries about a stark global supply shock led to surging prices on global grain markets. That same year, a COVID cluster in the port of Los Angeles put many stevedores out of commission for a few weeks and led to backed up supply chains on the import side.

Do longer GVCs and a greater dependence on international trade mean more or less exposure to global shocks? A substantial body of literature, both theoretical and empirical, shows that trade reduces long-term consumer prices in both exporting and importing regions—the well-known grains from trade—and helps reduce price volatility because of the buffering function of trade (e.g. Alessandria, Choi and Ruhl, 2021; Solingen, Meng and Xu, 2021; Sposi, Yi and Zhang, 2021; Melitz and Redding, 2014; Arkolakis, Costinot and Rodríguez-Clare, 2012). Another strand of theoretical (e.g. Turnovsky, 1974; Batra and Russell, 1974; Feder, Just and Schmitz, 1977; Newbery and Stiglitz, 1984) and empirical (e.g. Novy and Taylor, 2020; Appelbaum and Kohli, 1998) literature argues that trade can fuel domestic price uncertainty, emphasizing the exposure-increasing effect.[1] Thus, while the effects of international trade on exposure to global shocks are likely to be country- and commodity-specific, whether trade increases or decreases price volatility overall remains an empirical question.

We study the relationship between country-level participation in global agricultural value chain (GAVCs) and food prices—both food price levels and food price volatility. We focus on the agricultural and food sectors because food (i) is a necessity consumed by every consumer in all countries, (ii) is traded by all countries, (iii) is often perishable

[1] For the remainder of this paper, we use the terms "price volatility" and "price uncertainty" interchangeably to denote unexpected departures from the mean of the food price distribution. In practice, we use the coefficient of variation of the food price distribution (i.e., the standard deviation divided by the mean food price in a given country-year) to measure food price volatility.

or has limited storage potential, and (iv) is the subject of widely available data.[2] For our analysis, we rely on data from FAOSTAT for food prices and from the Eora database for GAVCs. We calculate annual within-country real food price levels and the coefficient of variation of consumer food price indices as measures of the first and second moments of the food price distribution—food price levels and food price volatility, respectively. Our empirical strategy exploits the panel nature of the data and adopts a shift-share instrumental variable to examine the relationship between the extent of participation in GAVCs by a given country in a given year and food price levels and volatility in the same country-year. This allows studying (i) the overall relationship between participation in GAVCs and food prices, but also (ii) the relationship between different types of GAVC positioning (i.e., upstream or downstream) and food prices, and (iii) how those relationship vary among groups of countries (i.e., low-, lower middle-, upper middle-, and high-income countries) and regions (i.e., East Asia and the Pacific, Eastern and Central Africa, Latin America and the Caribbean, the Middle East and North Africa, and sub-Saharan Africa).

Four distinct findings emerge from our analysis. First, and unsurprisingly given the extensive literature on the gains from trade, we find that participation in GAVCs is associated with lower food prices in our full sample. This is consistent across the upstream or downstream nature of GAVC participation, across regions, and across income groups. Second, participation in GAVCs is associated with higher food price volatility, a finding driven by upper middle-income countries. Third, countries with more downstream-producing agri-food sectors (i.e., activities closer to consumers such as food processing) are much more likely to see lower food price levels. Fourth, and finally, it appears participation in GAVCs is associated with increases in food price volatility because it leads to lower levels of diversification via greater reliance on fewer suppliers.

Our findings have a number of implications. First are the political-economy consequences of our findings, which we explore in a theoretical framework we develop in

[2] While the recent literature has referred to the two sectors—agriculture on the one hand, and food and beverages on the other hand—combined as "agri-food" (Barrett et al., 2022), we use "agricultural value chains" to refer to value chains encompassing both sectors.

Appendix 1, and which is informed by the results of our core empirical analysis. Second, international trade policy makers must recognize that there are hardly any one-size-fits-all policy solutions, as there is a fundamental heterogeneity in the strength of the mean-variance trade-off we identify between food price levels and food price volatility across types groups of countries and GAVC upstream or downstream linkages. Relying on foreign-sourced critical intermediate inputs is riskier for industries located in low-income countries than for those located in high-income countries. The policy options we discuss to reduce price volatility while expanding the gains (i.e., lower food prices) from GAVCs include supply diversification as well as strengthening the institutional frameworks that govern trade relations while avoiding suppliers in weak institutional environments.

Our contribution is fivefold. First, while previous theoretical contributions (Turnovsky, 1974; Batra and Russell, 1974; Feder, Just and Schmitz, 1977; Newbery and Stiglitz, 1984) suggest that trade and market instability may correlate both negatively or positively, there are only a few empirical applications in the trade uncertainty literature. Allen and Atkin (2022), for instance, find trade-offs between farm-income and price volatility and trade openness in rural India. Our approach offers similar evidence at the country level, highlighting that these trade-offs are markedly different for lower income countries than they are for higher-cincome countries.

Second, previous applied work on trade and uncertainty focuses on aggregated trade flow levels (e.g. Novy and Taylor, 2020; Appelbaum and Kohli, 1997), we take the analysis one step further by using data on GVCs to assess the relationship between global sourcing and country-level prices.

Third, we add to an emerging body of literature on GVCs in the agricultural and food sectors (Fiankor, Dalheimer and Mack, 2024; Lim and Kim, 2022; Montalbano and Nenci, 2022; Ndubuisi and Owusu, 2021; Balié et al., 2019; Van den Broeck, Swinnen and Maertens, 2017).

Fourth, because our application uses data on food and agriculture, we add to the literature on trade policy and food market stability (Kiloes et al., 2024; Larch, Luckstead and

Yotov, 2024; Luckstead, 2024; Gaigné and Gouel, 2022; Berger, Dalheimer and Brümmer, 2021; Gouel, 2016; Pieters and Swinnen, 2016; Rude and An, 2015; Anderson, Rausser and Swinnen, 2013; Jayne, Zulu and Nijhoff, 2006; Josling and Tangermann, 1999).

Fifth, and finally, while the agricultural economics literature on agri-food value chains has more often than not focused on studying smallholder farmers (Bellemare and Bloem, 2018; Barrett et al., 2022; Bellemare, Bloem and Lim, 2022), we look at global agricultural value chains, i.e., at agricultural value chains at the country level, and through the lens of international trade. This is especially important given existing limitations to the study of agri-food value chains at the micro level (Bellemare, Bloem and Lim, 2022; Posey et al., 2024).

The remainder of this paper proceeds as follows. In Section 2, we introduce a simple theoretical framework that relates participation in global value chains to the price level and volatility of the good produced in those value chains. Section 3 presents in turn our estimation and identification strategies. In Section 4, we present the data we use in our empirical analysis, whose results we present in Section 5 along with the results of a number of robustness checks. Section 6 discusses the potential mechanisms behind our findings and, informed by a political economy model we develop and inform by our empirical findings (Appendix 1), the policy implications of our results. We summarize and offer concluding remarks in Section 7.

2 Theoretical Framework

We are interested in the relationship between participation in GAVCs (which we will model here for the sake of simplicity as a trade-or-no-trade situation and by comparing what happens when a country imports or not), and food prices, i.e., the average food price level $p_{i\bullet}$ in country i during a given time period and food price volatility in the same country in the same year $Var(p_{i\bullet})$.[3] Allen and Atkin (2022), Baqaee and Farhi (2024), and to

[3]The subscript $\bullet$ is a placeholder; in what follows, we will be talking of p_{ii}, p_{ij}, $Var(p_{ii})$, and $Var(p_{ij})$.

some extent Elliott, Golub and Leduc (2022), offer theoretical insights on how prices relate to international trade. In essence, openness to international trade reduces the correlation between yields and country-level prices but exposes those same country-level prices to international idiosyncratic shocks Allen and Atkin (2022). These linkages are amplified and propagate upwards and downwards as well as horizontally across the multiple locations of the production process across multiple countries, driven by supply and demand shocks (Baqaee and Farhi, 2024)

For ease of exposition, we focus on a single, composite good. Assume that consumers are rational in the sense that, between two undifferentiated goods, they always choose the one with the lower price. The good can be produced either in country i or in country j. If the good is produced in country i, the consumer price of the good in country i is such that

$$p_{ii} = \mu_{ii} MC, \tag{1}$$

where $p_{ii} > 0$ denotes the consumer price in country i when the good is produced in country i, $MC > 0$ denotes the ((constant component of the, i.e., constant across countries)) marginal cost of producing the good, and $\mu_{ii} > 0$ is a random variable that is a wedge between the marginal cost of producing the good and the price of that good that arises due to market power, economies of scale, better technology, and so on in country i

Similarly, if the good is produced in country j, the consumer price of the good in country i is such that

$$p_{ij} = \mu_{ij} MC + c_{ij}, \tag{2}$$

where $p_{ij} > 0$ denotes the consumer price in country j when the good is produced in country i, $MC > 0$ denotes the (constant component of the, i.e., constant across countries) marginal cost of producing the good, and $\mu_{ij} > 0$ is a random variable that drives a wedge between the marginal cost of producing the good and the price of that good that arises due to market power, economies of scale, better technology, and so on in country j, and $c_{ij} > 0$

is a random variable that denotes the trade costs involved in country i importing the good from country j.

Lest the reader think we assume a constant marginal cost MC across countries, this is not what we assume by assuming MC is the same in both countries. Rather, MC is a basic technology available to any country, with differences in productivity between countries captured by μ_{ii} and μ_{ij}.

The foregoing leads to our first result.

Proposition 1. *For country i to import from country j instead of remaining autarkic, it has to be that $\mu_{ij} < \mu_{ii}$.*

Proof. Begin by assuming that $c_{ij} = 0$. In this case, trade takes place if and only if $p_{ii} = \mu_{ii}MC > p_{ij} = \mu_{ij}MC$ by consumer rationality. With $c_{ij} > 0$, it has to be the case that p_{ij} is even less than when $c_{ij} = 0$ in order for trade to take place, which establishes the result. □

We now turn to $Var(p_{i\bullet})$. Looking at each of p_{ii} and p_{ij} in turn, we get

$$Var(p_{ii}) = MC^2 Var(\mu_{ii}), \text{ and} \tag{3}$$

$$Var(p_{ij}) = MC^2 Var(\mu_{ij}) + Var(c_{ij}) + 2MC \times Cov(MC, \mu_{ij}). \tag{4}$$

The key to comparing variance with or without trade lies in comparing those two equations. Recall that MC is a constant but that μ_{ii} and μ_{ij} are random variables. The previous equation then simplifies to

$$Var(p_{ij}) = MC^2 Var(\mu_{ij}) + Var(c_{ij}). \tag{5}$$

From which we can derive the result.

Proposition 2. *It is not possible to determine ex ante whether $Var(p_{ii}) > Var(p_{ij})$, $Var(p_{ii}) < Var(p_{ij})$, or $Var(p_{ii}) = Var(p_{ij})$.*

Proof. To see this, note that $Var(p_{ii}) \lesseqgtr Var(p_{ij})$ depends on

$$MC^2 Var(\mu_{ii}) \lesseqgtr MC^2 Var(\mu_{ij}) + Var(c_{ij}), \text{ and} \tag{6}$$

and so the relationship between $Var(p_{ii})$ and $Var(p_{ij)}$ is ambiguous without making further assumptions on the magnitudes of MC, $Var(\mu_{ii})$, $Var(\mu_{ij})$, and $Var(c_{ij})$. □

Armed with this theoretical framework relating participation in GAVCs (i.e., whether a country imports the good or not) with prices, we now turn to our empirical framework.

3 Empirical Framework

In what follows, we first discuss the estimation strategy we adopt to study the link between participation in GAVCs and food prices. We then turn to the identification strategy we rely on to reduce the bias stemming from the endogeneity of the relationship between participation in GAVCs and food price levels or volatility.

3.1 Estimation Strategy

We estimate the relationship between participation in GAVCs by a country in a given year and (i) food price levels as well as (ii) volatility over in the same country-year. To do so, we estimate the following baseline equation:

$$\Delta p_{it} = \beta_1 \Delta GAVC_{it} + \gamma_1' \Delta X_{it} + \eta_{1t} + e_{1it}, \tag{7}$$

where p_{it} is the real consumer price level for food in county i in year t, $GAVC_{it}$ is the GAVC participation rate in the same country in the same year, and X_{it} is a vector of control variables that includes the time-variant country-level characteristics listed in Appendix Table A.1. We also include year fixed effects η_t to control for shocks affecting all countries in each given year. Lastly, e_{it} is an error term with mean zero.

In this case, the parameter of interest is β_1 which, in Equation 7, captures the association between participation in GAVCs and the real food price level. We estimate Equation 7 by first-differencing for two reasons. First, as suggested by Christian and Barrett (2024), we do so to avoid spurious results stemming from serially correlated errors when using an instrumental-variable design with longitudinal data. Second, we use the first-difference (FD) estimator in lieu of the usual fixed effects (FE) estimator given that the former has been shown by Millimet and Bellemare (2023) to be superior to the latter with longer panel data sets when it comes to mitigating endogeneity bias.

Similarly, to estimate the relationship between participation in GAVCs and food price volatility, we estimate the following equation

$$\Delta CV_{it}^{p} = \beta_2 \Delta GAVC_{it} + \gamma_2' \Delta X_{it} + \eta_{2t} + e_{2it}, \tag{8}$$

where CV_{it}^{p} is the within-year coefficient of variation of monthly prices calculated as the mean-normalized standard deviation in a given year t (i.e., $CV_{it}^{p} = \frac{\sigma_p}{\mu_p}$), which we use as our measure of price volatility, and every other variable is as in Equation 7.

Here, the parameter of interest is β_2, which captures the relationship between participation in GAVCs and food price volatility in equation 8. Again, we estimate Equation 8 by first differencing to avoid spurious results in a context where we rely on an instrumental variable with panel data (Christian and Barrett, 2024) and because it improves on the usual FE estimator with a long panel (Millimet and Bellemare, 2023).

The hypothesis tests of interest have to do with β_1 and β_2, and respectively test the null hypothesis $H_0 : \beta_1 = 0$ against the alternative hypothesis $H_A : \beta_1 \neq 0$, and the null hypothesis $H_0 : \beta_2 = 0$ against the alternative hypothesis $H_A : \beta_2 \neq 0$. To find support for Proposition 1, it has to be the case that the former null hypothesis is rejected and that $\hat{\beta 1}_1 < 0$. Proposition 2, however, is agnostic about what one should expect.

Although our baseline estimation strategy helps to account for potential sources of endogeneity by means of first differences, year fixed effects, and a number of control variables, participation in GAVCs likely remains endogenous both food to price levels and food price volatility. In the next section, we explain the design we deploy in an effort to reduce bias in the relationship between participation in GAVCs and food prices.[4]

3.2 Identification Strategy

When analyzing the impact of trade on food prices, endogeneity poses a significant challenge. One issue could be reverse causation, where changes in food prices influence trade patterns instead of being solely driven by them. For instance, rising food prices in a country might lead to higher imports to meet demand, creating a feedback loop between trade and prices that complicates causal inference.

Omitted variables present another problem, as external factors like extreme weather events, economic policies, or political instability can simultaneously affect both trade volumes and food prices. For example, a natural disaster in an exporting region may disrupt trade while also driving up global prices. Ignoring such variables could result in misleading estimates of the trade-price relationship.

Finally, data limitations and structural market features can introduce additional biases. Inaccuracies in trade or price data, along with complexities such as market concentration or price-setting behaviors, can obscure the true effects. To address these challenges, econometric techniques such as instrumental variables or structural modeling are necessary to disentangle the relationship and ensure reliable estimates.

To mitigate bias stemming from endogeneity in the relationship between participation

[4] Because the first-difference estimator also differences out the error term, it takes care of serial correlation in the error term, and so we do not cluster standard errors, since clustering would generate standard errors that are too conservative.

in GAVCs and food prices, we deploy a shift-share instrumental variable (SSIV) or Bartik IV design (Bartik, 1991). Bartik SSIVs are designed to mitigate endogeneity concerns in panel-data settings with unit and time fixed effects. These designs draw on the sub-dimension- (here, country-) specific measure of exposure at a given point in time (i.e., the "share") and the overall variation in a sub-dimension-specific variable over time (i.e., the "shift") to predict treatment variation.[5]

Our research design thus decomposes country-level participation in GAVCs into sub-dimensions of the two sectors we study, viz. agriculture as well as food and beverages, the former pertaining to activities closer to raw materials, the latter pertaining to value generation at the processing stage. We thus exploit the identity whereby shocks to GAVCs are the sum of individual country- and sector-level shocks. To do so, we modify equations 7 and 8 by using the SSIV to instrument for $GAVC_{it}$. Our SSIV is such that

$$\widehat{GAVC}_{it} = \frac{1}{exp_{it}} \sum_{k} \left(\omega_{ik,1999} \times g_{kt}\right), \tag{9}$$

where $\frac{1}{exp_{it}}$ weights the instrument by gross exports from country i at year t. The variable ω_{ik,t_0-1} represents the initial sector-specific share ($\omega_{ik,1999} \geq 0$), which defines the exposure of each observation i to global shocks in sector g_{kt}. It is calculated as the ratio of sector-specific GAVC for observation i to the sum of GAVC across all observations in 1999, i.e., $\omega_{ik,1999} = \frac{GAVC_{ik,1999}}{GAVC_{k,1999}}$. This value represents the share of the sector's contribution by country i within the total GAVC.

Regarding the validity of our IV, Goldsmith-Pinkham, Sorkin and Swift (2020) show that the Bartik IV can be expressed as a GMM estimator where the shares are used as instrumental variables. We argue that on the dynamics on the global level in the *Agriculture* and the *Food & Beverages* sectors are exogenous to country-level prices and GAVC participation. Yet, endogenous shares could compromise the validity of the instrument in case

[5] See Borusyak, Hull and Jaravel (2022) and Goldsmith-Pinkham, Sorkin and Swift (2020) for a review of the Bartik IV and SSIV methods. For notable examples of its application, see Card (2009); Autor, Dorn and Hanson (2013); David, Dorn and Hanson (2013); Nakamura and Steinsson (2014); Acemoglu and Restrepo (2020).

the variation in global shifts is not sufficient. The initial global distribution of agricultural as well as food and beverages sectors are driven by climate, soil quality, land availability, and other natural endowments that are exogenous to future food prices and sector developments. Brazil, for instance, is relatively more exposed to GAVC participation in the agricultural sector, (e.g., ethanol) because of its relative abundance of arable land, which helps it attract processing industries for grain and oilseed crops. Conversely, Switzerland is relatively more exposed to GAVC participation in the food and beverages sector because of its relative scarcity of arable land, favoring processing industries with low land intensity (e.g., confectionery, cheese). In Appendix A.3, we show that the sector shares are independent from a host of observable condounders, supporting the validity of this instrument.

4 Data

We use data on participation in GAVCs, food prices, and control variables for 138 countries for the period 2000-2015. The data come from three sources. Data on GAVCs comes from the Eora Global Value Chain Database. Consumer food prices come from FAOSTAT; to obtain real food price levels by country and compute the coefficient of variation of food prices by year, we multiply these indices by purchasing power parity exchange rates obtained from the World Development Indicators (WDI) database. Our control variables also come from the WDI database.

4.1 Global Agricultural Value Chains

The Eora multi-region input-output (MRIO) database offers country-level tracking of participation in GVCs for 26 sectoral classifications for the period 2000-2015. Using an MRIO table, it provides national estimates of value-added in trade (Casella et al., 2019).[6] Borin

[6]MRIO tables provide a comprehensive overview of all value-added activities across industries within a country that participate in global production (Hummels, Ishii and Yi, 2001; Johnson and Noguera, 2012; Johnson, 2018). This distinguishes them from national input-output account data, which primarily depict value-chain linkages within industries confined to a country's boundaries.

and Mancini (2019) use MRIO tables to construct GVC participation data, capturing all sources of value-added activities across multiple countries. In doing so, they introduce an empirical method to extract value-added exports from gross exports, allowing researchers to account for each value-added activity using cross-country input-output data.[7]

The foregoing allows measuring participation in GAVCs across countries. The data developed by Borin and Mancini (2019) provide an important advantage compared to other country-level GVC data sources, such as the Trade in Value Added (TiVA) data set and the World Input-Output Database, which only covers a subset of high-income countries. The Eora MRIO data set offers coverage of the largest number of countries compared to other data sets. For example, the TiVA data set covers 64 countries and the World Input-Output Database covers 43 countries, respectively. Moreover, the data allow decomposing GVC participation into upstream and downstream linkages.

More specifically, gross exports can be disaggregated into three primary value-added activities: domestic value-added (DVA), foreign value-added (FVA), and domestic value-added embedded in exports from other countries (DVX) (Koopman, Wang and Wei, 2014; Los and Timmer, 2018; Wang et al., 2017; Belotti, Borin and Mancini, 2020). The variable DVA represents the value of a country's exports that is generated by domestic production factors that contribute to its GDP. The variable FVA refers to the value of a country's exports that originate from imported inputs, or the use of imported intermediate inputs in the production process of exported products. Thus, FVA serves as a measure of upstream GAVC positioning within the production network. Lastly, DVX signifies the domestic value-added in intermediate goods that are further reexported by a trading partner country. It represents exported raw materials that are subsequently used in another country and then exported again to a third country, and thus measures downstream GAVC positioning.

Following Koopman, Wang and Wei (2014) and Borin and Mancini (2019), these three

[7]For similar analytical frameworks that have been developed to measure intermediate sourcing contributions of countries and sectors in GVC network, see Koopman, Wang and Wei (2014); Los and Timmer (2018); Wang et al. (2017).

value-added activities yield our GAVC participation measure for country i in year t:

$$GAVC_{it} = \frac{DVX_{it} + FVA_{it}}{Gross\ Export_{it}}. \tag{10}$$

We use the "Agriculture and Fishing" classification to assess participation in agricultural-sector GVCs and the "Food and Beverage" classification to measure participation in food-sector GVCs, respectively. The agricultural sector encompasses production related to agriculture, hunting, forestry, and fishing, as defined by the International Standard Industrial Classification, Rev. 3, divisions 01, 02, and 05. The food sector encompasses activities related to food and beverages, as specified by ISIC, Rev. 3, divisions 15 and 16.

By incorporating both the agricultural and food sectors, we construct a comprehensive measure of (total) participation in GAVCs, defined as

$$GAVC_{it}^{Total} = \frac{DVX_{it}^{agr} + DVX_{it}^{food} + FVA_{it}^{agr} + FVA_{it}^{food}}{Gross\ Export_{it}^{agr} + Gross\ Export_{it}^{food}}, \tag{11}$$

where agr and $food$ respectively denote the agriculture and food and beverage industries.

Lastly, we measure upstream participation, $\frac{FVA_{it}^{j}}{Gross\ Export_{it}^{j}}$, and downstream participation, $\frac{DVX_{it}^{j}}{Gross\ Export_{it}^{j}}$, where $j \in \{agr, food\}$. The range of all GVC participation is between 0 and 100.[8] Again, we do this for 138 countries for the period 2000 to 2015.[9]

4.2 Food Prices

Food price data are obtained from the FAOSTAT monthly food consumer price index database.[10] The FAOSTAT monthly food CPI data capture the change in the cost of food overall over time (i.e., annual year-over-year inflation relative to the corresponding month of the previous year). The FAO food CPI data set contains a complete set of time series

[8]We generate GAVC data using the STATA module `icio` following (Belotti, Borin and Mancini, 2020)

[9]We exclude 47 countries from the UNCTAD-Eora dataset due to inadequate GVC data availability and a significant absence of national employment data from the WDI database.

[10]Data are from https://www.fao.org/faostat/en/#data/CP.

from January 2001 to December 2015 which matches the span of our GAVC data.

To obtain real food price levels, we weigh the food price data with PPP exchange rates from the WDI database. We measure the annual food price level by averaging the monthly food price levels in a year. For the price variability measure, we calculate the coefficient of variation (CV) of monthly consumer food price indices in a calendar year.

4.3 Control Variables

We include an extensive set of country-level, time-varying covariates to control for (i) features of the agricultural sector, (ii) socio-economic conditions, (iii) demographic conditions, and (iv) trade policy. For the first three categories, we use data from the WDI database, spanning the period 2000 to 2015. For trade policy variables, we use Mario Larch's Regional Trade Agreements Database which includes all multilateral and bilateral regional trade agreements as notified to the World Trade Organization (WTO) from 1950 to 2019 (Egger and Larch, 2008). Appendix Table A.1 provides detailed descriptions of all variables included in our empirical analysis.

5 Results

In this section, we first present results for equations 7 and 8 and a number of robustness checks on those core results. We then present results by sector and by type of GAVC positioning (i.e., upstream or downstream) before presenting results that explore treatment heterogeneity by region and by income level.

5.1 Baseline

Table 1 shows estimation results for equation 7. While the basic FD results show a positive relationship between participation in GAVCs and the food price level, once we account for year fixed effects, we find evidence that increased participation in GAVCs is associated with lower real food prices—a relationship that is robust to including control variables as well as to instrumenting participation in GAVCs with our shift-share variable. In terms of economic significance, the estimated coefficients imply that a one percentage point increase in participation in GAVCs is associated with a decrease in real food prices of about 2 to 7 percentage points.

TABLE 1: Participation in GAVCs and food price level

Dependent Variable		Δ Log food price		
FD		OLS		SSIV
	(1)	(2)	(3)	(4)
Δ GAVC share	0.0211***	-0.0243***	-0.0237***	-0.0695***
	(0.0029)	(0.0048)	(0.0048)	(0.0175)
Agriculture			✓	✓
Demography			✓	✓
Trade policy			✓	✓
F-test (1st stage)				215.58
Observations	1,885	1,885	1,885	1,885
R^2	-0.34630	0.37598	0.39915	0.26691
Year fixed effects		✓	✓	✓

Notes: Standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. Appendix A.2 provides a full list of controls.

Table 2 shows estimation results for equation 8. Here, we find evidence that increased participation in GAVCs is associated with more price volatility once the endogeneity of participation in GAVCs is dealt with using our SSIV. In terms of economic significance, the estimated coefficient implies that a one percentage point increase in participation in GAVCs is associated with an increase in food price volatility of about 0.35 percentage points.

The association between participation in GAVCs and lower food prices is in line with

TABLE 2: Participation in GAVCs and food price volatility

Dependent Variable	Δ food price volatility			
FD		OLS		SSIV
	(1)	(2)	(3)	(4)
Δ GAVC share	0.1853***	0.0448	0.0485	0.3500**
	(0.0481)	(0.0718)	(0.0732)	(0.1649)
Agriculture			✓	✓
Demography			✓	✓
Trade policy			✓	✓
F-test (1st stage)				216.42
Observations	1,885	1,885	1,885	1,888
R^2	0.01177	0.06391	0.06606	0.04857
Year fixed effects		✓	✓	✓

Notes: Standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. Appendix A.2 provides a full list of controls.

the trade and GVC literatures and constitutes additional evidence in favor of the gains from trade hypothesis (Alessandria, Choi and Ruhl, 2021; Antràs and de Gortari, 2020; Antràs, 2020; Melitz and Redding, 2014; Arkolakis, Costinot and Rodríguez-Clare, 2012). Moreover, the magnitude of the association is reasonable considering real food price differentials among countries. For instance, in high-income countries, which usually host agricultural and food sectors that are more integrated into GAVCs, consumers spend less than 15 percent on their income on average while the national average of food expenditure in less GAVC-integrated economies can be above 50 percent (Roser and Ritchie, 2021). These results highlight the important role GAVCs can play in increasing consumer welfare and improving food security. The estimated relationship seems to come at the cost of increased price uncertainty, however. In that regard, the economies in our sample appear to be trading off mean and variance when it comes to food prices.

5.2 Robustness Checks

Appendix A.3 assesses the robustness of our core results that greater participation in GAVCs is associated with lower but more volatile food prices. Here, we provide a brief summary of the evidence in that appendix.

On the instrument relevance front, the seeming price-decreasing and volatility-increasing effects of participation in GAVCs hinge upon the relevance of the Bartik SSIV. The large F-statistics we observe in all models provide evidence that the instrument is relevant.

On the instrument validity front, with regards to the exclusion restriction, recall that our identifying assumption is that we argue that on the global sector shocks are exogenous to country-level prices, GAVC participation and other confounders. We perform several tests and robustness checks to buttress that claim, as proposed in Goldsmith-Pinkham, Sorkin and Swift (2020).

First, we estimate the model using the limited information maximum likelihood (LIML) (Anderson and Rubin, 1949) and a modification of bias-corrected two-stage least squares (MBLS) (Kolesár et al., 2015), and cross-check our inference against Ecker-Huber-White heteroskedasticity robust standard errors (SEs) and information matrix-based SEs (IM-SE). Both the estimators and standard errors are similar, providing no reason to suspect that the models are misspecified.

Second, we run a Sargan overidentification test where we use industry shares as instruments. If the industry shares are exogneous, the validity of the instrument could be compromised in case of insufficient variation in exogenous shocks. Moreover, Goldsmith-Pinkham, Sorkin and Swift (2020) show that for the exclusion restriction to hold, the industry shares are required to be exogenous. The test provides evidence that the error term is not correlated with the industry-share IVs.

Third, we examine the correlation between our observable country correlates and initial industry shares. The results are depicted in Appendix Table A.3. The models explain between 36 and 52 percent of the variation, which is relatively low given the extensive set of country-level controls. We observe strong coefficients and correlations between initial industry shares and variables relating to land and cereal production which supports our identifying assumption. Moreover, one trade policy variable also correlates with industry shares, which constitutes the mechanism under investigation. We find no indication of pathways for other supply-side or demand-side confounders to drive initial sector shares.

Finally, we estimate models that rely on industry shares from different time points covering the per-analysis period from 1991-1999 as well as one time- varying share-assumption ($t-1$). We observe peak IV relevance in 1999, but the estimates are not substantially different when we go back further in time, providing more evidence that sector distributions are indeed constant over time and driven by natural endowments.

5.3 Positioning in GAVCs

We found that participation in GAVCs is associated with more volatile food prices. To shed more light on this result, we estimate our core equations by GAVC positioning type (i.e., upstream vs. downstream) and split the sample by sector (i.e., agriculture vs. food and beverages). Appendix Table A.5 provides further evidence that our estimated relationship is similar across sectors for food price levels, but that it is driven by the food and beverages sector for food price volatility.

Table 3 shows results for Equations 7 and 8 in which treatment is a country's GAVC positioning either upstream or downstream. A country-year observation's GAVC positioning is measured as $(ln(1 + DVA_{it}) - ln(1 + FVA_{it})) \times 100$ (Amendolagine et al., 2019), which provides an index ranging from -1 to 1, where -1 describes a sector that is exclusively engaged in downstream activity (i.e., closer consumers), while 1 describes a sector that is exclusively engaged in upstream activity (i.e., closer to the producers of primary commodities).

TABLE 3: GAVC positioning and food prices

Dependent Variable	Δ log food price		Δ food price volatility	
	(1)	(2)	(3)	(4)
GAVC positioning	0.0301**	0.0287**	-0.1040	-0.1147
	(0.0129)	(0.0129)	(0.1156)	(0.1184)
Agriculture		✓		✓
Demography		✓		✓
Trade policy		✓		✓
Observations	1,885	1,885	1,885	1,885
Year fixed effects	✓	✓	✓	✓

Notes: Standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. Appendix A.2 provides a full list of controls.

We find that the overall relationship between price levels and participation in GAVCs found in Table 1 and discussed earlier stems from downstream participation in GAVCs. This is because for the overall result in Table 1 (i.e., participation in GAVCs is associated with lower food prices) and for the positioning results in this table (i.e., the more downstream a country-year observation's positioning in GAVCs is, the lower its food price level, and vice versa), it has to be that downstream positioning dominates in the data. We find no statistically significant result for food price volatility, which suggests that the relationship between GAVC positioning and food price volatility is likely not monotonic.

5.4 Treatment Heterogeneity by Income Group

In Table 4, we split the sample by region. For the relationship between participation in GAVCs and the food price level, we observe consistently negative coefficients across all income groups. While the coefficient for low-income is not significantly different from zero, the coefficients for other groups (i.e., lower middle-income, upper middle-income, and high-income) are all significantly different from zero, and the magnitude of the coefficient increases monotonically with income. This suggests that, on average the gains from trade are higher for consumers the higher the average income in a country—at least when it comes to price levels.

Results for food price volatility are considerably more nuanced. While the overall relationship between participation in GAVCs and food price volatility is positive—the higher participation in GAVCs is for a country-year observation, the more volatile food prices—this appears driven by upper middle-income countries, since the coefficients for low-, lower middle-, and high-income countries, while all positive, are not statistically different from zero. For high-income countries, many of which are very involved in the agri-food trade, this could be explained by the presence in those countries of futures and options markets whose existence helps smooth the prices of agri-food commodities (Bellemare, Barrett and Just, 2013).

These results are in line with recent findings of heterogeneous channels of the impact of GVCs across countries at different levels of development (Montalbano and Nenci, 2022; Ndubuisi and Owusu, 2021) and further corroborated by sample split models by region which are reported in Appendix A.4.3, which suggest that while our core result for food price levels holds in all regions except for East Asia and the Pacific and sub-Saharan Africa, our core results for volatility only hold in the full sample, and nowhere at the regional level, possibly due to low statistical power when conducting regional-level analyses (indeed, standard errors nearly always more than double when moving from the overall sample to sub-samples defined at the regional level).

Finally, split-sample results that estimate the relationship between positioning in GAVCs and food prices (Tables A.8 and A.9, respectively of Appendix A.4.4) suggest that our core results hold everywhere except in low-income countries (for both food price levels and volatility) and in high-income countries (for food price volatility).

To summarize, our key findings are twofold: participation in GAVCs is associated with (i) lower food prices, and (ii) higher food price volatility in our overall sample. This suggests that, on average, countries are facing a mean-variance tradeoff as a result of increased participation in GVCs when it comes to food prices. This trade-off is particularly pronounced for downstream-type GAVCs, i.e., in sectors closer to consumers, as opposed to upstream-type GAVCs, which are closer to producers.

6 Discussion

Turning to a discussion of our findings, we first provide an explanation for why a lack of diversification in value chain participation can lead to higher price volatility. Second, we discuss the welfare implications of participation in GAVCs considering the objective functions of various actors in a stylized economy on the basis of a political economy model informed by our empirical findings and which can be found in Appendix 1. Finally, we discuss various political economy issues pertaining to participation in GAVCs and international trade, and point to various ways of increasing the resilience of GAVCs.

6.1 Why Does GAVC Participation Lead to Higher Price Volatility?

One of our core findings is that participation GAVCs is associated with more food price volatility. To some extent, this finding contradicts the idea that global sourcing allows for

Table 4: GAVC participation and food prices by income group

Income group	Full sample (1)	Low (2)	Lower-middle (3)	Upper-middle (4)	High (5)
			I: Δ log food price		
Δ GAVC share	-0.0695***	-0.0101	-0.0520*	-0.0935***	-0.1000***
	(0.0175)	(0.0554)	(0.0290)	(0.0232)	(0.0220)
Agriculture	✓	✓	✓	✓	✓
Demography	✓	✓	✓	✓	✓
Trade policy	✓	✓	✓	✓	✓
F-test (1st stage)	215.58	11.378	81.594	44.946	62.730
Observations	1,885	300	494	551	540
R^2	0.26691	0.31915	0.24019	0.38700	0.39446
Year fixed effects	✓	✓	✓	✓	✓
			II: Δ food price volatility		
Δ GAVC share	0.3292**	-0.3228	0.3335	0.8112*	0.2549
	(0.1594)	(1.014)	(0.2137)	(0.4582)	(0.1621)
Agriculture	✓	✓	✓	✓	✓
Demography	✓	✓	✓	✓	✓
Trade policy	✓	✓	✓	✓	✓
F-test (1st stage)	215.58	11.378	81.594	44.946	62.730
Observations	1,885	300	494	551	540
R^2	0.05079	0.15313	0.11516	0.09294	0.07319
Year fixed effects	✓	✓	✓	✓	✓

Notes: Standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. Appendix A.2 provides a full list of controls.

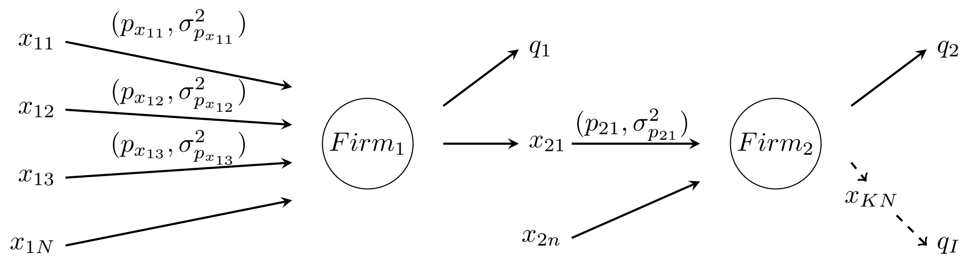

FIGURE 1: Prices and price variances in GVCs. x are inputs, p input prices, σ^2 are the variance of input prices, and q are final goods.

more resilience as inputs are more diversified. We now turn to providing a sketch of an explanation for our finding that participation in GAVCs is associated with more food price volatility.

Figure 1 depicts the problem from a firm-level perspective. In GAVCs, firms at one stage of the value chain source inputs (x_1) from N sources (N countries) and either sell output q_1 or provide an input x_2 for firms at the next stage of the value chain. Firms minimize costs $\sum^N p_{x_{kn}} f^{kn}(x_{kn})$ subject to their given production function. If firms care about uncertainty, they additionally hedge supplies by maximizing N and minimizing $Cov(p_{x_{kn}} f^{kn}(x_{kn}), p_{x_{jl}} f^{jl}(x_{jl}))$. In value *chains*, however, $Cov(p_{x_{kn}} f^{kn}(x_{kn}), p_{x_{jl}} f^{jl}(x_{jl}))$ must be non-zero because of input sequencing. Input prices and input price fluctuation at one stage of the value change will affect all subsequent stages. Similar to portfolio theory, for value chains to be resilient to shocks, the number of suppliers should be large and the correlation of input prices should be low, which maximizes the expected return. In practice, however, the prices of different versions of the same input tend to be positively and significantly correlated.

As a first assessment of N (i.e., the number of sources) in GAVCs, we consider traditional trade data. We use UN Comtrade data and select commodities at the six-digit level harmonized system (HS) code. We subset to chapters 01 - 24 (Food and Agriculture) and calculate Gini coefficients of origins for 649 commodities for the period 2010-2015. A coefficient of one implies that 100 percent of the supply of a good originates in 1 percent of countries. A value of 0 implies that all origins contribute equally to global supply. Thus,

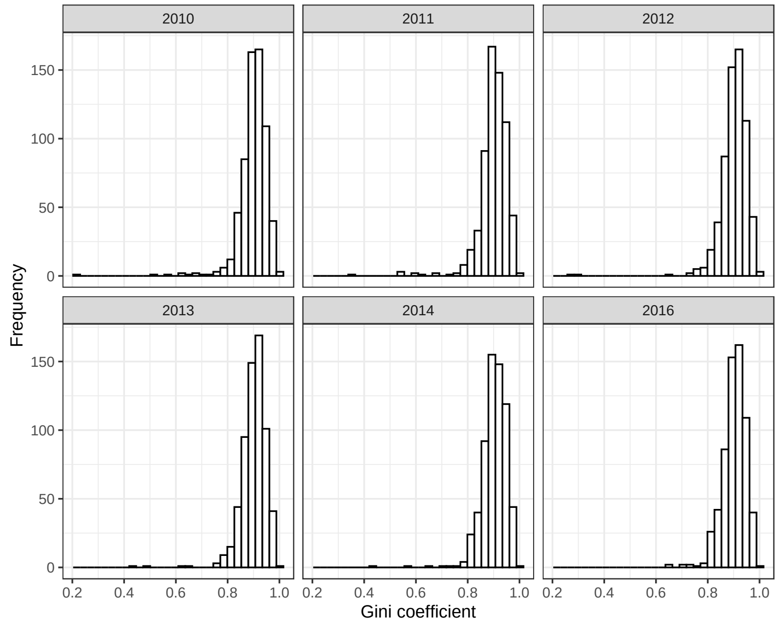

FIGURE 2: Frequency of Gini coefficients of agri-food commodities. We use UN COMTRADE data and select commodities at the 6-digit level Harmonised System (HS) code. We subset to chapters 01 - 24 (Food and Agriculture) and calculate Gini coefficients of origins for 649 commodities for the years from 2010-2015. The higher the coefficient the more concentrated (unequal) are supply countries.

the higher the coefficient, the more concentrated (i.e., unequal) are supplier countries.

Figure 2 shows the frequency of resulting Gini coefficients. Here, we observe rather high Gini coefficients, with an average exceeding 0.8. The implication of this is that global agri-food value chains are more concentrated than they are diversified. For most commodities, there are only a few countries that export those commodities.

The observation of concentrated rather than diversified agri-food supply chains finds confirmation in national-level studies. For example, Stevens and Teal (2023), Ma and Lusk (2021), Hadachek, Ma and Sexton (2023), and Wahdat and Lusk (2022) find that US agri-food value chains are concentrated, which compromises resilience to national-level shocks in those studies. At the international level, Beck, Lim and Taglioni (2024) find centrality in international firm-to-firm networks while Arkolakis and Muendler (2013) shows that most exporting firms concentrate on very few relationships and Fiankor (2023) confirms this for the agri-food sector.

6.2 Welfare Implications of Increased Food Price Volatility

Before discussing policy, it is useful to consider the welfare effects of food price volatility.[11] Our empirical results have two implications for the political economy of participation in GAVCs. First, consumers benefit from lower prices while producers do not. In addition, consumers might even draw utility from higher price volatility, while producers do not. As our empirical results suggest that greater participation in GAVCs results in lower consumer prices and higher volatility, consumers benefit more from participation in GAVCs participation than producers do.

Second, the social welfare gains from low or high prices hinges upon the share of producers and the average budget share dedicated to food purchases in a country. Our results suggest that in low-income countries, where the proportion of net sellers of food is higher than in high-income countries, trade openness tends to hurt those net sellers both by lowering price levels and increasing price volatility. Given that, it is perhaps no surprise that low-income countries have been especially reticent to liberalizing their agricultural sector.

6.3 Policy Implications

The results of this paper generate a number of policy implications. While we find support for the long-standing hypothesis that participation in GAVCs leads to lower consumer prices, our results also challenge the conventional wisdom according to which greater participation in GAVCs can stabilize prices.

Concentration in GVCs is an intuitive result on the basis of trade theory. Trade openness and GVC participation lead to gains from trade and specialization. Specialization in turn creates vulnerabilities to shocks that stem from natural events, but also from policy uncertainty. Economists as early as Adam Smith observed that "defence ... is more important than opulence" (Book IV, Chapter II, p. 465), and highlighted that specialization stands at odds with diversification. Both are standard results in trade theory.

Consequently, policies that reduce uncertainty in GVCs may come at the cost of gains

[11] Appendix A.1 formally derives the welfare effects in detail.

from trade, or lower prices. Thus, the resilience of value chains should be traded off against lower prices and accompanying short-term income effects for consumers. Lack of GAVC diversification can be seen as an externality problem: the marginal benefits of short-term cost-minimizing firms' from diversification are likely lower than the social marginal benefit from diversification. Indeed, governments often intervene in GVCs to source critical inputs in times of shortages.

Thus one policy solution could lie in internalizing the divergence between industry marginal benefits and social marginal benefits are tariff quotas that increase with increasing concentration such that when trade ties become more concentrated other, less competitive origins become more competitive. This could ensure a higher number of supply chain links. A similar mechanism could be adopted for origins with political uncertainty. Such tariffs are only applied after the import share of a given country exceeds a certain threshold and rises progressively with increasing import shares. This enables other supplier's competitiveness and contributes to diversify supply structures. (Grossman, Helpman and Lhuillier, 2023) provide further analysis on GVC diversification from a subsidy perspective.

Another way to increase resilience is to support some level of domestic supply (e.g. Solingen, Meng and Xu, 2021; Blumenschein et al., 2017). The extent of domestic supply in various stages of value chains is hard to quantify, and also comes with higher inefficiency and loss of gains from trade, viz. higher prices. Finding an equilibrium between local and global sourcing is a tall order and warrants more research.

Another volatility-reducing strategy relates to managing trade relationships. This relates to the political economy of trade and, most importantly, constitutes a reduced dependency on sectors that operate in unfavorable institutional environments. Here, another trade-off emerges—one between supporting sectors in lower-income countries, which often suffer from bad institutional environments, and keeping supply flows stable. Policy could focus on supporting strong private partnerships and building long-term business relationships among agribusinesses. At a certain extent of governance uncertainty, however, supplies from such countries are likely to impose substantially higher uncertainty than the short-term welfare effects. These are countries with autocratic governments or dictatorships. Cases in point are, for instance, the energy import concentration of some European countries that rely heavily on natural gas from Russia, or the future supply of phosphorus, a necessary nutrient for crop production, which is expected to be concentrated in Western Sahara by the end of the century, a region claiming independence, but controlled by Morocco since 1979—a situation that has led to a state of quasi permanent civil unrest (Egan, 2023).

Aside from diversifying suppliers, one general policy recommendation concerns the institutional framework that governs trade relationships. More precisely, contracts and agreements between buyers and suppliers could be strengthened with regard to risk sharing to minimize supply chain back-ups (e.e. Guo et al., 2017; Zhao et al., 2010). One reason why prices become unstable is when demand is price-inelastic, as in the case of goods such as food and energy, buyers begin hoarding during an upward market shock and sellers try to sell at the highest possible prices. Such events can be planned for in binding legal agreements, and contracts can have similar provisions, perhaps in the form of quotas that need to be fulfilled before free market price trade.

7 Conclusion

Recent disruptions in GVCs and price volatility have had serious consequences on welfare and trade policy. While the trade literature predicts that increased GVC participation drives down the prices of traded commodities, ever-increasing numbers of trade ties and shipment legs are also likely to increase market and price uncertainty in value chains because of uncertainty in various parts of the world.

We have empirically analyzed the relationship between participation in GAVCs and (i) food prices price levels and (ii) food price volatility. Our main results suggest that participation in GAVCs involves a trade-off between the mean and variance of the food price distribution. That is, greater participation in GAVCs is associated with lower food prices, but it is also associated with more food price volatility. While lower food prices are a reflection of the gains from trade, higher price volatility seems to stem from low diversification in GAVCs. As trade leads to specialization, many GAVCs are characterized by a low number of exporters, which leads to there being less resilience of GAVCs toward shocks. That said, we find that the mean-variance trade-off in food prices is heterogeneous across regions, income groups, and value chain types.

Lack of diversification in GAVCs is likely a negative externality from profit maximization by individual producers. The marginal benefit from firms diversifying their input suppliers is likely lower than the social marignal benefit of diversified GAVCs. Thus policy makers could address the problem by implementing Pigou-type and progressive tariffs that reduce concentration at the cost of lower gains from trade. In order to do so, however, they need to carefully consider the political economy of food and agriculture.

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Appendix

A.1 Participation in GAVCs and Welfare

In this appendix, we show theoretically how GAVC-particpation induced effects on food price volatility affects welfatre. Our framework consists of three agents, viz. consumers, producers, and the government. In the absence of government intervention and with a closed economy, consumers and producers interact on markets, and their optimizing behavior determines the relative price of labor w/p. When the government intervenes by opening the economy, the behavior of consumers and producers responds in part to the policy adopted by the government. The government, for its part, either adopts a policy of trade openness or not on the basis of each type of agent's indirect utility function. The solution concept thus adopted here is that of sub-game perfection: The government (correctly) anticipates how each type of agent will respond to policy, and it downstream inducts to set a policy that will ensure political stability. Whether "political stability" means a lack of social unrest or re-election of the current government is an empirical question (Bellemare, 2015), and thus beyond the scope of our analysis.

In what follows, we first present each agent type's optimization problem along with associated first-order conditions. We then set up the government's own maximization problem. There is little here that is new relative to textbook models when it comes to our three agent types. What is new is how the government will set different policies according to (i) each agent type's indirect utility function and (ii) the importance (i.e., proportion, or measure) of each agent type in the overall economy, which maps into weights for each agent type in the government's objective function.

Before proceeding with the remainder of this section, we note that we will be reusing some of the notation used in prior sections. As such, this section "resets" (or, less charitably abuses) notation. While we realize this could confuse unsuspecting readers, we also wish to use conventional notation in this section.

A.1.1 Primitives

We are concerned with two goods: food, which we denote by $x \geq 0$, and leisure, which we denote by $\ell \geq 0$. Each good has associated prices $p > 0$ and $w > 0$. We discuss preferences and technology in the next two sections, which are dedicated respectively to the consumers and the producers that make up our stylized economy. While we could add a third, composite nonfood good to our model, doing so is not necessary, and so we err on the side of parsimony by considering only food and leisure.

A.1.2 Consumers

Consumer preferences $\succsim$ are represented by the utility function $u(x_i, \ell_i)$ for consumer i, which is such that $u_x > 0$, $u_\ell < 0$, $u_{xx} < 0$, $u_{\ell\ell} < 0$, and $u_{x\ell} = u_{\ell x} > 0$. We further impose Inada conditions on food such that $u_x(0) = \infty$ and $u_x(\infty) = 0$. In other words, any consumer must consume a positive amount of food, but she can only consume so much food.

Each consumer i has an endowment of time equal to E_i^L, which she can spend either in labor L_i or leisure ℓ_i, such that $E^L = L_i + \ell_i$.

Consumer i's maximization problem is such that

$$\max_{x_i, \ell_i} u(x_i, \ell_i) \text{ s.t.} \tag{12}$$

$$px_i + w\ell_i \leq y_i + wL_i. \text{ and} \tag{13}$$

$$E_i^L = L_i + \ell_i \tag{14}$$

where y_i denotes consumer i's independent income.

Combining Equations 13 and 14, we can rewrite the budget constrain as a Beckerian full-income constraint, such that

$$px_i + w\ell_i \leq y_i + w(E_i^L - \ell_i), \tag{15}$$

where the LHS of Equation 15 denotes the consumer's expenditures on food and leisure and the RHS denotes her full-income, i.e., her labor income wL_i as well as her independent income y_i.

The FOCs of the consumer's maximization problem are such that

$$u_f - \mu_i p = 0, \tag{16}$$

$$u_\ell - 2\mu_i w = 0, \text{ and} \tag{17}$$

$$\mu_i \cdot [px_i + w\ell_i - y_i - w(E_i^L - \ell_i)] = 0, \tag{18}$$

where μ_i denotes the Lagrange multiplier on the budget constraint (and thus the marginal utility of income), whose value is equal to zero given that the budget constraint holds with equality as a result of the utility function being increasing in both of its arguments.

From Equations 16 to 18, we recover the consumer's Marshallian (or Walrasian) demand functions for food and leisure $x_i^*(p, w, y_i)$ and $\ell_i^*(p, w, y_i)$, consumer i's supply of labor $L_i^* = E_i^L - \ell_i^*(p, w, y_i)$, as well as the marginal utility of the consumer's income $\mu_i^*(p, w, y_i)$

Plugging these Marshallian demand functions back into the consumer's utility function $u(x_i, \ell_i)$ then yields the consumer's indirect utility function, which measures the consumer's welfare, such that

$$V(p, w, y_i) = u[x_i^*(p, w, y_i), \ell_i^*(p, w, y_i)]. \tag{19}$$

We are interested here in what happens when the food price level p and food price volatility σ_p change. Signing the former is relatively straightforward, since indirect utility functions are decreasing in the price of consumption goods.[12] In other words, $V_p < 0$, and an increase (decrease) in the price of food makes the consumer worse (better) off.

What about the effect of a change in food price volatility on welfare? This is captured by the curvature of the indirect utility function in the space defined by p, w, and y, such that

$$V_{pp} = \begin{bmatrix} V_{pp} & V_{pw} & V_{py} \\ V_{wp} & V_{ww} & V_{wy} \\ V_{yp} & V_{yw} & V_{yy} \end{bmatrix}, \tag{20}$$

where, as in Bellemare, Barrett and Just (2013), the diagonal terms capture the curvature of the indirect utility function with respect to a given parameter, which is related to the individual's preferences relative to the variance that parameter (e.g., V_{pp} is related to an individual's preferences over the variance of the price of food, or food price uncertainty), and the off-diagonal terms capture the curvature of the indirect utility function with respect to two parameters, which is related to the individual's preferences relative to the covariance between those two parameters (e.g., V_{yw} is related to an individual's preferences over the covariance between her individual income and the wage).

The question as regards the effect of food price uncertainty (or food price volatility), then, has to do with the sign of V_{pp}, since a consumer's coefficient of absolute price uncertainty aversion A_{pp} (Bellemare, Barrett and Just, 2013) is such that

$$A_{pp}^i = -\frac{V_{pp}}{V_y} = , \tag{21}$$

which, from Barrett (1996) and Bellemare, Barrett and Just (2013), we know is equal to

$$A_{pp}^i = \frac{x_i}{p}[\beta(\eta - R) + \epsilon], \tag{22}$$

where x_i and p are the consumer's demand for and the price of food, respectively, and

[12] Signing the effect of a change in the wage w would be more difficult, however, given that w figures in both the consumer's expenditures as well as her income, and so unlike an increase in p, an increase in w does not have an unambiguous effect on her welfare.

where β is the consumer's budget share of food, $\eta > 0$ is the income elasticity of her demand for food, R is her Arrow-Pratt coefficient of relative (income) uncertainty aversion, and η is the own-price elasticity of her demand for food. By analogy to Arrow-Pratt income risk aversion $-\frac{u''}{u'}$, A^i_{pp} is positive when a consumer is risk loving over p, it is zero when a consumer is risk neutral over p, and it is negative when a consumer is risk loving over p.

Whether A^i_{pp} is positive, negative, or neither depends on the relationship between the parameters on the RHS of Equation 22. Both $\frac{x_i}{p}$ and β will be positive for pure consumers, and following Barrett (1996), R (which usually ranges anywhere from 1 to 3 in empirical studies; see Bellemare, Barrett and Just (2013)) will usually exceed η for food overall (which is less than unity given that food is a normal good). Since ϵ is negative for food (i.e., the own-price elasticity of food is negative), then the RHS of Equation 22 will be negative, which suggests that food consumers are price risk-loving when it comes to food. This result, which runs counter to conventional wisdom, goes back to Waugh (1944), who demonstrated that (pure) consumers would be made worse off by a policy stabilizing a price at its mean. For producers, things are different. We now turn to them.

A.1.3 Producers

The only good produced in our stylized economy is food, and so the only type of producer we encounter are producers of food. Given the nature of farming in all but the most industrialized economies, we assume that the firms in this stylized economy are sole proprietorships. In other words, while a firm j's objective is to maximize profit, that profit directly feeds into individual j's (i.e., the sole proprietor of firm j) income, which determines how much individual j can consume. We further assume that firm owners are pure capitalists. That is, they do not supply any labor to the economy.

Firm j's maximization problem is such that

$$\max_{L_j} pF(L_j) - wL, \tag{23}$$

with associated FOC

$$pF_{L_j} - w = 0. \tag{24}$$

From Equation 24 we can derive the firm's labor demand function $L^*(w, p)$ as well as its profit function, which is such that

$$\pi^*_j(w, p) = pF(L^*(w, p)) - wL^*(w, p). \tag{25}$$

The textbook model of the firm typically stops here. But since we are considering firms—

that is, farms—that are sole proprietorships, we further note that the firm owner's utility maximization problem is such that

$$\max_{x,\ell} u(x_j, \ell_j) \text{ s.t. } px_j + w\ell_j \leq \pi_j^* + y_j, \tag{26}$$

where π_j^* is the profit derived from ownership of firm j and y_j denotes consumer j's independent income. This is consistent with the way Sandmo (1971) setup his study of the impacts of output price risk on profit maximization behavior.

Given that all relevant markets (i.e., food and labor) exist and are not fragmented, this is akin to an agricultural household model with separability of the profit- and utility-maximization decisions (Singh, Squire and Strauss, 1986; Bardhan and Udry, 1999), and so the problem is recursive. What this means in practice is that individual j maximizes profit on her farm, and she then maximizes her utility, which depends in part on her farm profits. This makes the problem more tractable.

The FOCs of the producer's maximization problem are the familiar

$$u_f - \mu_j p = 0, \tag{27}$$

$$u_\ell - \mu_j w = 0, \text{ and} \tag{28}$$

$$\mu_j \cdot (\pi_j^* + y_j - px_j - w\ell_j) = 0, \tag{29}$$

where μ_j denotes the Lagrange multiplier on the budget constraint (and thus the marginal utility of income), whose value is again equal to zero given that the budget constraint holds with equality as a result of the utility function being increasing in both of its arguments. From Equations 27, 28, and 29, we recover the consumer's Marshallian demand functions for food and leisure $x_j^*(p, w; \pi_j^* + y_j) = x_j^*(p, w, y_j)$ and $\ell_j^*(p, w; \pi_j^* + y) = \ell_j^*(p, w, y_j)$ since $\pi_j^* = \pi_j^*(w, p)$.

Plugging these Marshallian demand functions back into the consumer's utility function $u(x_j, \ell_j)$ then yields the consumer's indirect utility function, which measures the consumer's welfare, such that

$$V(p, w, y_j) = u(x_j^*(p, w, y_j), \ell_j^*(p, w, y_j)). \tag{30}$$

Increases in p cause the producer's welfare to increase via her production, but also to decrease via her consumption, and so whether her welfare increases or decreases in response to an increase in p will depend on her marketed surplus $M_j = F(L^*(w, p)) - x_j$ (Deaton, 1989). In other words, the welfare effect of an increase in p depends on whether j is a net seller (i.e., $M_j > 0$) or net buyer (i.e., $M_j < 0$ of food), or whether she is autarkic with respect to food (i.e., $M_j = 0$).

When it comes to food price volatility, a logic similar to that of the consumer prevails, and Bellemare, Barrett and Just (2013) have derived a coefficient of absolute price risk aversion for agricultural households whose production and consumption decisions are separable, which are identical to the producers in our stylized economy. That coefficient is such that

$$A_{pp}^j = -\frac{M_j}{p}[\beta(\eta - R) + \epsilon], \tag{31}$$

and whose sign depends on the relationship between the constituent variables and parameters. If the parameters β, η, R, and ϵ are similar to those for consumers (i.e., Equation 22), then $A_{pp}^j > 0$ for net sellers (a result consistent with the theoretical findings of Baron (1970) and Sandmo (1971), and with the empirical results in Bellemare, Barrett and Just (2013)), $A_{pp}^j < 0$ for net buyers (a finding consistent with our results in the previous section), and $A_{pp}^j = 0$ for households who are autarkic with respect to food.

A.1.4 The Government

We consider only the role of the government in allowing for the trade of food, which is the only tradable commodity in our model. As borders are opened to the international trade of food, p either decreases or stays the same (i.e., it only makes sense to import food in cases where the foreign price of food is cheaper, and exporting food does not cause the price of food to rise).

The government maximizes a social welfare function which adds indirect utility functions of pure food consumers (λ_1), households that both produce and consume food but who are net sellers of food (λ_2), households that both produce and consume food but who are net buyers of food (λ_3), and households that both produce and consumed food but who are autarkic with respect to food (λ_4), such that

$$\max_{p,\sigma_p} W = \lambda_1 E[V_1] + \lambda_2 E[V_2] + \lambda_3 E[V_3] + (1 - \lambda_1 - \lambda_2 - \lambda_3) E[V_4]. \tag{32}$$

At the risk of oversimplifying, assume the government can only choose between trade openness (o) or autarky (c). This implies that governments choose between (i) high integration in GVCs (under trade openness) or (ii) little to no integration in GVCs (under autarky), which results in p and σ regimes that have different welfare impacts depending on the composition of the economy. In other words, the government compares the LHS and RHS of the following equation

$$W_o(p_o, \sigma_{po}) \lesseqgtr W_c(p_c, \sigma_{pc}), \tag{33}$$

and chooses whichever state of trade openness or autarky and GVC integration that yields the highest social welfare. All welfare states have specific uncertainty in their realization of price levels, which in turn determine individual utility functions of the agents. The measures through which government set trade and GVC integration include trade policies, trade agreements, subsidies and other instrument that incentivize (or dis-incentivize) participation in agri-food GVCs by producers.

Given that, considering only the food price level, consumers and producers who are net buyers of food will benefit, producers who are net sellers of food will lose out, and producers who are autarkic will neither benefit nor lose out from the international trade of food.

Our empirical results have two implications for the political economy of participation in GAVCs. First, consumers benefit from lower prices while producers do not. In addition, consumers might even draw utility from higher price volatility, while producers do not. As our empirical results suggest that greater participation in GAVCs results in lower consumer prices and higher volatility, consumers benefit more from participation in GAVCs participation than producers do.

Second, the social welfare gains from low or high prices hinges upon the share of producers and the average budget share dedicated to food purchases in a country. Our results suggest that in low-income countries, where the proportion of net sellers of food is higher than in high-income countries, trade openness tends to hurt those net sellers both by lowering price levels and increasing price volatility. Given that, it is perhaps no surprise that low-income countries have been especially reticent to liberalizing their agricultural sector.

Given that, considering only the food price level, consumers and producers who are net buyers of food will benefit, producers who are net sellers of food will lose out, and producers who are autarkic will neither benefit nor lose out from the international trade of food.

A.2 Descriptives

TABLE A.1: List of variables and data sources

Description	Source
Consumer prices, food indices (2015 = 100)	FAOSTAT
midrule GVC participation (%) by sector	UNCTAD-Eora
GVC downstream participation (%) by sector	UNCTAD-Eora
GVC upstream participation (%) by sector	UNCTAD-Eora
Population ages 0-14 total	World Development Indicators
Population ages 15-64 total	World Development Indicators
Population ages 65 and above total	World Development Indicators
Population density (people per sq. km of land area)	World Development Indicators
Population growth (annual %)	World Development Indicators
Population female	World Development Indicators
Population male	World Development Indicators
Population total	World Development Indicators
Rural population	World Development Indicators
Urban population	World Development Indicators
Price level ratio of PPP conversion factor (GDP) to market exchange rate	World Development Indicators
GDP growth (annual %)	World Development Indicators
Arable land (hectares)	World Development Indicators
Land area (sq. km)	World Development Indicators
Number of Regional Trade Agreements (RTA) by country	MLRTA Database
Number of Customs Unions (CU) by country	MLRTA Database
Number of Free Trade Agreements (FTA) by country	MLRTA Database
Number of Economic Integration Agreements (EIA) by country	MLRTA Database
Number of Partial Scope Agreements (PSA) by country	MLRTA Database
Country Region category	the UN Standard Country Codes

Notes: See https://www.ewf.uni-bayreuth.de/en/research/RTA-data/index.html for MRTA.

A.3 Robustness Checks

Our identification strategy relies on a shift-share instrumental variable. Our identifying assumption is that the within-country distribution of industry shares is independent from food prices, food price volatility, and unobservables. We argue the distribution between the agricultural and food and beverages sectors is driven by natural endowments, and thus exogenous to both.

To help establish the claim that this assumption is valid, we conduct several robustness checks. We follow the tests proposed in Goldsmith-Pinkham, Sorkin and Swift (2020) to assess the validity of our exclusion restriction. This entails estimating alternative models where we check for homogeneity in estimates across sectors,[13] testing for overidentification, and assessing the correlation between various correlates and industry shares. Finally, we construct SSIVs relying on shares that date further back in time and one SSIV that is time varying.

A.3.1 Alternative Models under Homogeneity

One way to assess the validity of the SSIV to alternative estimators by estimating by limited information maximum likelihood (Anderson and Rubin, 1949), by modification of bias-corrected two-stage least square (MBTSL; see Kolesar et al., 2015), and the information matrix-based standard errors (IM-SE) as a first check of the specification of our models. Table A.2 shows the respective estimates and regular SEs, Ecker-Huber-White heteroskedasticity-robust SEs and IM-SE. Both the estimators and standard errors are similar to our core results, providing no reason to assume that the models are misspecified.

TABLE A.2: Alternative IV Estimators (TWFE and Country Correlates)

	β	SE	EHW-SE	HTE-robust SE	IM-SE
OLS	0.049	0.051	0.068		
BARTIK TSLS	0.329	0.159	0.266	0.267	
LIML	0.329	0.158	0.267		0.160
MBTSL	0.332	0.158	0.269	0.269	
	Overidentification (Sargan) test: $p = 0.280$				

[13] As our application does not look at an intervention, or a dichotomous treatment that turns on, we cannot construct pretrends

A.3.2 Test of Overidentification

Another way to test the validity of multiple IVs is by conducting a Sargan test of overidentification. While our research design consists of only one Bartik IV, our shares-driven identification strategy requires the industry shares to be exogenous. We estimate a model with individual industry shares as separate IVs by two-staged least squares to assess the exogeneity of industry shares. The test results are detailed at the bottom of Table A.2.

A.3.3 The Relationship between Sector Shares and Observable Correlates

We argue that the sector distribution is mainly dependent on exogenous natural circumstances such as fertile land endowment. One way to assess the validity of the exclusion restriction is to examine how sector composition correlates with observable covariates that could be linked to participation in GAVCs, just like potential unobservable confounders. The relationships between observable location characteristics and industry shares offers suggestive evidence on mechanisms that could compromise the exclusion restriction. It is worth highlighting that the empirical strategy is still valid if the covariates of the shares and outcomes are correlated in levels, but not if the levels of share covariates predict *changes* in the outcome variable.

Table A.3 provides OLS regression results for individual sector shares and our SSIV for baseline year 2001 on all control variables used in the analysis. The R^2 of models predicting sector shares is moderately high. Importantly the sector shares are strongly associated with arable land, land under cereal production and land area supporting our identifying assumption that natural endowments drive GAVC sector shares in the past. Other variables relating to demography, economy and trade are not significantly correlated with sector shares, aside from having an economic integration agreement, which implies that if anything, trade policy may drive GVAC activity which is exactly one of the mechanisms we are interested in investigating. The R^2 in the SSIV regression drops substantially and with the exception of customs unions, we find no statistically significant correlate. Altogether, we find no potential pathways for other demand or supply-side drivers of sector shares other than natural endowments given the observables tested in table A.3 providing further evidence for the exclusion restriction to hold for our SSIV.

A.3.4 Alternative shares assumptions

Depending on the identification problem and data, a variety of SSIVs can be constructed. The SSIV in our baseline model interacts pre-analysis period or historic time-invariant industry shares ($t = 1999$) with time varying GAVC sectors. We argue that natural endowments are exogenous drivers of sector participation and past sector distributions is exoge-

TABLE A.3: Relationship between industry shares and country characteristics

Dependent Variable	Agriculture (1)	Food and Beverages (2)	Δ SSIV (3)
Agricultural land (sq. km)	-3.31×10^{-9} (3.48×10^{-9})	-6.16×10^{-11} (2.6×10^{-9})	-1.74×10^{-9} (6.34×10^{-9})
Arable land (hectares)	$-1.57 \times 10^{-9**}$ (6.33×10^{-10})	$-1.43 \times 10^{-9**}$ (6.78×10^{-10})	-2.12×10^{-10} (9.3×10^{-10})
Land under cereal production (hectares)	$2.95 \times 10^{-9***}$ (1.11×10^{-9})	$2.26 \times 10^{-9**}$ (9.49×10^{-10})	1.71×10^{-9} (3.15×10^{-9})
Land area (sq. km)	$4.93 \times 10^{-9**}$ (2.24×10^{-9})	$3.75 \times 10^{-9**}$ (1.58×10^{-9})	-8.78×10^{-10} (3.93×10^{-9})
Cereal production (metric tons)	4.09×10^{-10} (2.96×10^{-10})	3.06×10^{-10} (3.75×10^{-10})	-3.75×10^{-10} (4.99×10^{-10})
Food production index (2004-2006 = 100)	-6.54×10^{-5} (7.32×10^{-5})	-9.97×10^{-5} (7.42×10^{-5})	-0.0011 (0.0007)
Livestock production index (2004-2006 = 100)	4.63×10^{-5} (7.68×10^{-5})	8.84×10^{-5} (9.17×10^{-5})	0.0009 (0.0007)
Population density (people per sq. km of land area)	1.64×10^{-6} (1.39×10^{-6})	2.43×10^{-6} (1.97×10^{-6})	1.74×10^{-5} (2.1×10^{-5})
Capture fisheries production (metric tons)	-4.05×10^{-10} (2.68×10^{-9})	9.22×10^{-10} (2.51×10^{-9})	2.67×10^{-11} (1.14×10^{-8})
Total fisheries production (metric tons)	8.11×10^{-11} (2.53×10^{-9})	-1.65×10^{-9} (2.45×10^{-9})	1.45×10^{-10} (1.02×10^{-8})
Agriculture forestry and fishing value added (% of GDP)	-8.78×10^{-6} (6.43×10^{-5})	1.39×10^{-5} (8.78×10^{-5})	9.67×10^{-5} (0.0008)
Exports of goods and services (% of GDP)	1.8×10^{-5} (8.01×10^{-5})	3.94×10^{-5} (0.0001)	0.0003 (0.0005)
Imports of goods and services (% of GDP)	-6.53×10^{-6} (4.44×10^{-5})	5.09×10^{-7} (5.5×10^{-5})	-0.0006 (0.0004)
Inflation GDP deflator (annual %)	-9.69×10^{-6} (4.04×10^{-5})	-3.42×10^{-5} (3.62×10^{-5})	0.0003 (0.0004)
GDP (constant 2010 US$)	3.44×10^{-15} (7.3×10^{-15})	3.32×10^{-15} (9.3×10^{-15})	1.36×10^{-14} (1.13×10^{-14})
GDP growth (annual %)	-4.42×10^{-5} (0.0002)	-4.18×10^{-5} (0.0002)	-0.0014 (0.0009)
Population ages 0-14 total	-1.57×10^{-6} (4.36×10^{-5})	-3.38×10^{-5} (5.74×10^{-5})	0.0001 (0.0004)
Population ages 15-64 total	-1.57×10^{-6} (4.36×10^{-5})	-3.38×10^{-5} (5.74×10^{-5})	0.0001 (0.0004)
Population ages 65 and above total	-1.57×10^{-6} (4.36×10^{-5})	-3.38×10^{-5} (5.74×10^{-5})	0.0001 (0.0004)
Population growth (annual %)	0.0003 (0.0006)	0.0003 (0.0007)	0.0039 (0.0034)
Population female	3.51×10^{-5} (3.39×10^{-5})	1.27×10^{-5} (1.78×10^{-5})	-0.0001 (0.0004)
Population male	3.51×10^{-5} (3.39×10^{-5})	1.27×10^{-5} (1.78×10^{-5})	-0.0001 (0.0004)
Rural population	-3.36×10^{-5} (6.72×10^{-5})	2.1×10^{-5} (6.85×10^{-5})	2.3×10^{-10} (6.18×10^{-10})
Urban population	-3.36×10^{-5} (6.72×10^{-5})	2.1×10^{-5} (6.85×10^{-5})	
Regional Trade Agreements (RTA)	0.0001 (0.0002)	-8.2×10^{-5} (0.0002)	-0.0004 (0.0006)
Customs Unions (CU)	-0.0001 (0.0002)	6.5×10^{-6} (0.0002)	0.0017* (0.0010)
Free Trade Agreements (FTA)	-0.0002 (0.0002)	6.23×10^{-5} (0.0002)	0.0005 (0.0007)
Partial Scope Agreements (PSA)	-0.0001 (0.0002)	6.34×10^{-5} (0.0002)	-0.0002 (0.0009)
Economic Integration Agreements (EIA)	0.0075** (0.0030)	0.0127*** (0.0039)	0.0097 (0.0073)
Regional Trade Agreements (RTA) (i)	0.0042 (0.0040)	0.0080 (0.0050)	0.0220 (0.0145)
Customs Unions (CU) i	-0.0007 (0.0021)	-0.0002 (0.0018)	-0.0182 (0.0111)
Free Trade Agreements (FTA) i	0.0026 (0.0027)	0.0005 (0.0028)	-0.0214 (0.0162)
Partial Scope Agreements (PSA) i	0.0012 (0.0019)	0.0005 (0.0017)	0.0160 (0.0246)
Economic Integration Agreements (EIA) i	-0.1138** (0.0490)	-0.1947*** (0.0635)	-0.1544 (0.1194)
Observations	138	138	126
R^2	0.68494	0.60184	0.17051
Within R^2	0.64404	0.51956	0.03969
Region fixed effects	✓	✓	✓

Standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1.

nous to prices, price volatility and unobservables today. Two other ways of constructing SSIVs are thinkable in our scenario. First, we might allow the sector shares to vary over time and thus relax out assumption to have industry shares to be exogenous even in the previous time period. This approach uses time-varying $t-1$ sector shares instead of time-invariant $t_0 - 1$ sector shares. Second, instread of using one year pre-analysis period, we might instead use two years, or other time periods dating further back to calculate sector exposure.

A convenient feature of our data is that the EORA GVC data dates back to 1991 for some countries. Thus, we can construct the instruments also for previous time periods at the expense of less cross sections. Table A.4 juxtaposes SSIV variables that rely on the sector distributions from 1991, 1995, 1999, 2000, 2001, the averages of 1991-1995, 1991-1999 and 1995-1999, as well from $t-1$ in columns 1-9, respectively. We observe a peak in relevance of the SSIV in 1999 and while the estimates vary slightly in the different models, they are not substantially different providing strong evidence that sector distributions are indeed constant over time and exogenously driven by natural endowments.

TABLE A.4: Alternative sector-share years for FD-SSIV models

Dependent Variable:	Δ log food price								
Model	IV_{1991} (1)	IV_{1995} (2)	IV_{1999} (3)	IV_{2000} (4)	IV_{2001} (5)	$IV_{1991-1995}$ (6)	$IV_{1991-1999}$ (7)	$IV_{1995-1999}$ (8)	IV_{t-1} (9)
I: Δ log food price									
Δ GAVC share	-0.0722***	-0.0706***	-0.0695***	-0.0599***	-0.0654***	-0.0747***	-0.0748***	-0.0716***	-0.0509**
	(0.0207)	(0.0182)	(0.0147)	(0.0146)	(0.0157)	(0.0190)	(0.0169)	(0.0159)	(0.0221)
Agriculture	✓	✓	✓	✓	✓	✓	✓	✓	✓
Demography	✓	✓	✓	✓	✓	✓	✓	✓	✓
Trade policy	✓	✓	✓	✓	✓	✓	✓	✓	✓
F-test (1st stage)	97.166	164.12	215.58	275.05	242.36	147.95	182.21	199.49	97.179
Observations	1,270	1,720	1,885	1,960	2,002	1,735	1,885	1,885	1,994
R^2	0.15411	0.23670	0.26691	0.30156	0.28049	0.21196	0.23501	0.25496	0.35108
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
II: Δ food price volatility									
Δ GAVC share	0.4878**	0.3045	0.3500**	0.1592	0.1792	0.3418	0.3426*	0.3299*	0.3356
	(0.2363)	(0.2081)	(0.1649)	(0.1650)	(0.1806)	(0.2145)	(0.1861)	(0.1809)	(0.2890)
Agriculture	✓	✓	✓	✓	✓	✓	✓	✓	✓
Demography	✓	✓	✓	✓	✓	✓	✓	✓	✓
Trade policy	✓	✓	✓	✓	✓	✓	✓	✓	✓
F-test (1st stage)	97.647	164.79	216.42	276.00	243.20	148.56	182.90	200.28	97.428
Observations	1,273	1,723	1,888	1,963	2,005	1,738	1,888	1,888	1,997
Year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: Standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. Appendix A.2 provides a full list of controls.

A.4 Further Results

In this section, we present further results for our analysis of treatment heterogeneity. In particular, we split the sample by sector, i.e. *Agriculture* and *Food & Beverages*, GAVC participation type, i.e. downstream and upstream participation, region, and by income group and GAVC participation type.

A.4.1 GAVC Participation by Sector

Table A.5 shows OLS estimates of the relationship between participation in GAVCs and food price volatility where the sample is split by the agriculture and food and beverages sectors. With regards to ffod price levels, the results show that neither sector seems to be driving the results individually. Instead, the main results in the paper are driven by both sectors jointly. However, wuith regards to food price volatility, the *Food & Beverages* sector exhibits a larger and statistically stronger coefficient than the coefficient in the *Agriculture* sector.

TABLE A.5: Participation in GAVCs and food prices by sector

Dependent variable	Δ log food price		Δ food price volatility	
Sector	Agriculture	Food & Beverages	Agriculture	Food & Beverages
	(1)	(2)	(3)	(4)
Δ GAVC share	-0.0215***	-0.0224***	0.0292	0.1169**
	(0.0046)	(0.0049)	(0.0928)	(0.0562)
Agriculture	✓	✓	✓	✓
Demography	✓	✓	✓	✓
Trade policy	✓	✓	✓	✓
Observations	1,885	1,885	1,885	1,885
Year fixed effects	✓	✓	✓	✓

Notes: Standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. Appendix A.2 provides a full list of controls.

A.4.2 By type of GAVC

Here, we provide results from models in which the variable of interest is constructed such that it contains only downstream or upstream linkages of participation in GAVCs.

Table A.6 estimates the effects of downstream-type GAVC participation and upstream-type participation separately, where for each type of GAVC participation the SSIVs are constructed, respectively. Noting low relevance in the upstream-type models, the estimates suggest that it is predominantly downstream-type GAVC participation that drives down prices and increases price uncertainty. separately

TABLE A.6: Upstream and downstream participation in GAVCs and food prices

Dependent variable	Δ log food price		Δ food price volatility	
	(1)	(2)	(3)	(4)
Δ upstream GAVC share	-0.3410		1.521	
	(0.3206)		(2.064)	
Δ downstream GAVC share		-0.0742***		0.3499**
		(0.0184)		(0.1351)
Agriculture	✓	✓	✓	✓
Demography	✓	✓	✓	✓
Trade policy	✓	✓	✓	✓
F-test (1st stage)	17.686	170.62	17.686	170.62
Observations	1,885	1,885	1,885	1,885
R^2	-1.8818	0.20200	-0.09838	0.05200
Year fixed effects	✓	✓	✓	✓

Notes: Standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. Appendix A.2 provides a full list of controls.

A.4.3 By Region

In Table A.7 we report results of models where we split the sample into East Asia and Pacific (EA &P), Europe & Central Asia (E & CA), Latin America & Caribbean (LA & C), Middle East & North Africa (ME & NA) and sub-Saharan Africa (SSA). We make reference to these results in the main text. While the statistical power of the coefficients is limited, probably owing to the relatively low number of observations with a large number of independent variables in the sample split models, the magnitude of the coefficients is in line with results from previous models and we observe a similar progression of trade-offs along income levels of economies. Namely, the uncertainty increasing GAVCs and participation is stronger in low-income regions, particularly in Asia and the Pacific as well as in Latin America and the Caribbean, and weaker in high-income countries. Notably, we find consistently statistically significant negative effects on real food prices throughout almost all regions.

A.4.4 By Income-group and Type

Table A.8 details the effects of downstream-type GAVC participation of sample split models by income-group. The estimates suggest that in all income groups food prices decrease as backwards GAVC participation increases and this effect is strongest in upper-middle income countries and weakest in lower-middle income countries. Moreover, the coefficients indicate that upper-middle income countries and, albeit not statistically significant from zero, low income countries associate strongest price volatility increases when downstream participation increases.

Table A.9 details the effects of upstream-type GAVC participation of sample split models by income-group. The estimates suggest that only in high-income and upper-middle income countries food prices decrease as upstream GAVC participation increases and this effect is strongest in high-income countries. Moreover, the coefficients indicate that high-income countries associate strongest price volatility increases when upstream participation increases.

TABLE A.7: Participation in GAVCs and food prices by region

Region	Full sample (1)	EA & P (2)	E & CA (3)	LA & C (4)	ME & NA (5)	SSA (6)
			Δ log food price			
Δ GAVC share	-0.0695***	-0.0574	-0.1235***	-0.0642***	-0.0729**	-0.0396
	(0.0175)	(0.0492)	(0.0343)	(0.0224)	(0.0261)	(0.0365)
Agriculture	✓	✓	✓	✓	✓	✓
Demography	✓	✓	✓	✓	✓	✓
Trade policy	✓	✓	✓	✓	✓	✓
F-test (1st stage)	215.58	21.664	34.812	61.779	16.220	29.320
Observations	1,885	239	585	326	210	405
R^2	0.26691	0.47926	0.19634	0.43203	0.52358	0.29338
Year fixed effects	✓	✓	✓	✓	✓	✓
			Δ food price volatility			
Δ GAVC share	0.3292**	0.4871	0.3845	0.4222	-0.0336	-0.0975
	(0.1594)	(0.3930)	(0.4011)	(0.3408)	(0.2001)	(0.7033)
Agriculture	✓	✓	✓	✓	✓	✓
Demography	✓	✓	✓	✓	✓	✓
Trade policy	✓	✓	✓	✓	✓	✓
F-test (1st stage)	215.58	21.664	34.812	61.779	16.220	29.320
Observations	1,885	239	585	326	210	405
R^2	0.05079	0.18542	0.08788	0.21758	0.21773	0.14674
Year fixed effects	✓	✓	✓	✓	✓	✓

Notes: Standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. Appendix A.2 provides a full list of controls.

TABLE A.8: Downstream GAVC participation and food prices

Income group	Full sample (1)	Low (2)	Lower-middle (3)	Upper-middle (4)	High (5)
Δ log food price					
Δ downstream GAVC share	-0.0742***	-0.0215	-0.0441**	-0.1174***	-0.1196***
	(0.0184)	(0.0860)	(0.0203)	(0.0394)	(0.0339)
Agriculture	✓	✓	✓	✓	✓
Demography	✓	✓	✓	✓	✓
Trade policy	✓	✓	✓	✓	✓
F-test (1st stage)	170.62	4.4160	109.48	21.677	29.568
Observations	1,885	300	494	551	540
R^2	0.20200	0.31049	0.27260	0.26471	-0.03243
Year fixed effects	✓	✓	✓	✓	✓
Δ food price volatility					
Δ downstream GAVC share	0.3499**	1.271	0.3359**	0.9282*	0.3100
	(0.1556)	(2.125)	(0.1597)	(0.5273)	(0.2231)
Agriculture	✓	✓	✓	✓	✓
Demography	✓	✓	✓	✓	✓
Trade policy	✓	✓	✓	✓	✓
F-test (1st stage)	170.62	4.4160	109.48	21.677	29.568
Observations	1,885	300	494	551	540
R^2	0.05200	0.10169	0.12713	0.08277	0.00462
Year fixed effects	✓	✓	✓	✓	✓

Notes: Standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. Appendix A.2 provides a full list of controls.

TABLE A.9: Upstream GAVC participation and food prices

Income group	Full sample (1)	Low (2)	Lower-middle (3)	Upper-middle (4)	High (5)
			Δ log food price		
ΔupstreamGAVCshare	-0.3410	-0.0083	0.6465	-0.4462	-0.5388*
	(0.3206)	(0.1483)	(2.715)	(0.3039)	(0.2927)
Agriculture	✓	✓	✓	✓	✓
Demography	✓	✓	✓	✓	✓
Trade policy	✓	✓	✓	✓	✓
F-test (1st stage)	17.686	3.7061	1.1742	5.8020	15.510
Observations	1,885	300	494	551	540
R^2	-1.8818	0.31848	-13.282	-2.1102	-2.1961
Year fixed effects	✓	✓	✓	✓	✓
			Δ food price volatility		
Δ upstream GAVC share	1.521	-1.969	-3.651	4.347	1.278
	(2.064)	(2.414)	(15.02)	(3.639)	(0.8900)
Agriculture	✓	✓	✓	✓	✓
Demography	✓	✓	✓	✓	✓
Trade policy	✓	✓	✓	✓	✓
F-test (1st stage)	17.686	3.7061	1.1742	5.8020	15.510
Observations	1,885	300	494	551	540
R^2	-0.09838	0.09910	-1.4980	-0.81101	0.00181
Year fixed effects	✓	✓	✓	✓	✓

Notes: Standard errors in parentheses. ***: 0.01, **: 0.05, *: 0.1. Appendix A.2 provides a full list of controls.