Anatomy of the Global Beef Value Chain: A GTAP-Based Value-Added Decomposition

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Abstract: This study provides a value-added decomposition of the global beef value chain using the GTAP Data Base (versions 10 and 11), covering 2014 and 2017. Applying the Wang–Wei–Zhu (WWZ) gross exports decomposition to a GTAP-based multi-region input–output table, the analysis traces how domestic and foreign value added embodied in beef exports is generated, transmitted, and absorbed in final demand. The results reveal that beef exports are predominantly driven by domestic value added (approximately 79–80 percent), substantially exceeding the all-sector average and reflecting the geographically anchored nature of cattle production. The foreign value added component is sourced overwhelmingly from third countries rather than direct importers, with business services and energy consistently ranking as the largest upstream foreign inputs across all major exporters. Major exporting economies display distinct structural archetypes, where resource-abundant exporters such as Brazil and Australia exhibit very high domestic content while European processing hubs and North American integrated producers show elevated foreign value added reflecting regional input networks. Pure double counting is remarkably low compared to manufacturing, confirming that gross beef trade statistics provide a relatively close approximation of genuine value-added flows. Together, these findings carry implications for how competitiveness, structural vulnerability, and policy leverage are assessed in the global beef sector.

Keywords: Global Value Chains, Beef, GTAP Database, Wang–Wei–Zhu Decomposition, Multi-Region Input–Output, Domestic Value Added

JEL Classification: F14, F15, Q17, C67

1. INTRODUCTION

The global beef industry has evolved into one of the most internationally fragmented agri-food systems, spanning feed crop production, livestock rearing, slaughter and processing, cold-chain logistics, and a wide range of distribution and retail services (Hummels, Ishii, & Yi, 2001; Baldwin & Lopez-Gonzalez, 2015). Although beef is traditionally regarded as an agricultural commodity produced primarily within national borders, contemporary beef production increasingly depends on internationally traded inputs—imported feed grains, oilseed meals, veterinary products, energy, and transport services—rendering the sector deeply embedded in global value chains (GVCs) (Greenville, Kawasaki, & Beaujeu, 2017; Santeramo, Lamonaca, & Nardone, 2024). Despite this structural transformation, most empirical analyses of beef trade continue to rely on conventional gross export or production-based statistics, which systematically obscure the underlying distribution of value creation and international specialization along the chain (Koopman, Wang, & Wei, 2014; Johnson & Noguera, 2012).

The limitations of gross trade metrics are well-documented in the broader trade literature. As intermediate inputs cross borders multiple times, gross trade flows double-count value added that has already been registered in earlier stages of production (Hummels et al., 2001; Johnson & Noguera, 2012; Wang, Wei, & Zhu, 2013). This double-counting problem is particularly consequential in sectors where upstream inputs account for a large share of production costs—a condition that applies directly to beef, given the importance of feed crops, energy, and logistics in determining farm-gate and processor-level margins (Greenville et al., 2017; Gereffi, Humphrey, & Sturgeon, 2005). Without decomposing gross exports into their value-added components, it is impossible to determine whether a country's strong performance in beef exports reflects genuine domestic competitiveness or simply the re-processing and re-export of imported inputs.

Multi-region input–output (MRIO) databases have become the standard infrastructure for value-added decomposition in trade research (Timmer, Dietzenbacher, Los, Stehrer, & de Vries, 2015; Los, Timmer, & de Vries, 2015). However, widely used frameworks—including WIOD, OECD ICIO, and the ADB MRIO—aggregate agriculture and food into broad categories that obscure the specific structure of individual agri-food value chains (Owen, Steen-Olsen, Barrett, Wiedmann, & Lenzen, 2016; Timmer et al., 2015). The GTAP Data Base, by contrast, provides a relatively fine disaggregation of agricultural and food sectors, including separate categories for livestock, cattle meat, other meat products, feed crops (grains, oilseeds), and downstream food processing, offering a unique opportunity to analyze the global beef value chain with sectoral precision (Aguiar, Narayanan, & McDougall, 2019; Aguiar, Chepeliev, Corong, & van der Mensbrugghe, 2022).

Despite this analytical potential, systematic value-added decompositions of the global beef value chain using the GTAP Data Base remain scarce. The literature linking MRIO analysis to agri-food sectors has grown considerably in the context of food system sustainability (Pendrill, Persson, Godar, & Kastner, 2019; Henders, Persson, & Kastner, 2015), but economic structural analyses focusing on the distribution of value added along the beef chain—rather than on environmental footprints or policy shocks—have received limited systematic attention.

Against this background, the present study applies the Wang–Wei–Zhu (WWZ) gross exports decomposition to a full multi-region input–output table constructed from GTAP Data Base versions 10 and 11, covering reference years 2014 and 2017. The WWZ framework decomposes gross exports into 16 mutually exclusive and collectively exhaustive terms, providing a comprehensive map of domestic value added (DVA), foreign value added (FVA), returning domestic value added (RDV), and pure double counting (PDC) at the bilateral exporter–importer–sector level (Wang et al., 2013). The analysis addresses four research questions: (1) Is the global beef value chain predominantly driven by domestic value added, or does it exhibit structural dependence on foreign inputs? (2) Which upstream and downstream sectors account for the main foreign value added components, and how does this composition differ across major exporters? (3) Where is the domestic value added generated along the beef value chain ultimately absorbed, and how concentrated are these absorption patterns? (4) How complex is the beef value chain when measured by production length and double-counting indicators, relative to other sectors?

The paper contributes to three strands of literature. First, it extends GVC analysis to an agriculturally disaggregated MRIO framework, complementing broader cross-sectoral decomposition studies (Koopman et al., 2014; Wang, Wei, Yu, & Zhu, 2017). Second, it provides a structural baseline for the beef sector specifically, filling a gap that agri-food GVC research has thus far addressed primarily from sustainability or policy-shock perspectives (Pendrill et al., 2019; Greenville et al., 2017). Third, it demonstrates the comparative utility of the GTAP Data Base for sectoral MRIO analysis, contributing to ongoing discussions about the appropriate granularity of MRIO databases for agri-food applications (Aguiar et al., 2022; Owen et al., 2016).

The remainder of the paper is organized as follows. Section 2 reviews the theoretical and empirical literature on GVC analysis, value-added decomposition, and agri-food value chains. Section 3 describes the GTAP Data Base, the MRIO construction procedure, and the WWZ decomposition framework. Section 4 presents and interprets the empirical results. Section 5 concludes.

2. THEORETICAL BACKGROUND AND LITERATURE REVIEW

2.1 Global Value Chains and Value-Added Trade

The concept of the global value chain emerged from the recognition that international trade increasingly involves the cross-border fragmentation of production processes rather than the exchange of fully finished goods (Gereffi et al., 2005; Hummels et al., 2001). Gereffi et al. (2005) articulated a governance typology distinguishing market, modular, relational, captive, and hierarchical chains, while Hummels et al. (2001) introduced the concept of vertical specialization—the use of imported inputs in the production of exports—as a quantitative measure of the extent to which countries participate in international production networks. These conceptual foundations established the intellectual framework within which subsequent empirical GVC analysis has developed.

The measurement of value-added trade required a fundamental reconceptualization of how trade flows are accounted. Johnson and Noguera (2012) pioneered the estimation of value-added exports—defined as the value added produced in one country and absorbed as final demand in another—and demonstrated that value-added trade flows differ substantially from gross trade flows, particularly for countries deeply embedded in GVCs. Koopman et al. (2014) extended this approach by developing a unified decomposition framework that reconciles gross trade, value-added trade, and double-counted flows within a single accounting identity, establishing the conceptual foundation for subsequent multi-term decompositions.

Building on Koopman et al. (2014), Wang et al. (2013) developed the 16-term WWZ decomposition, which disaggregates gross bilateral exports at the country-sector level into five domestic value added components, three returning domestic value added terms, four foreign value added terms, and four pure double-counting terms. This level of disaggregation enables researchers to distinguish not only between domestic and foreign content, but also between value added absorbed in final versus intermediate uses, and between value added that genuinely enters world trade and value added that is double-counted as a statistical artifact of back-and-forth intermediate flows. Wang et al. (2017) further introduced the concept of production length and upstreamness, providing additional metrics for characterizing the structural complexity of GVCs.

Subsequent methodological refinements have addressed aggregation bias (Los et al., 2016), forward-linkage-based GVC participation (Borin & Mancini, 2019), and the treatment of re-imported value added (Miroudot & Ye, 2021). For the present study, the original WWZ framework remains the appropriate choice because of its direct comparability with the growing body of empirical GVC literature and its comprehensive treatment of double-counting terms, which are particularly relevant for understanding the structural complexity of agri-food chains.

2.2 Agri-Food Global Value Chains and the Beef Sector

Research on agri-food GVCs has expanded rapidly, though it has developed along two largely separate tracks. The first track—rooted in development economics and industrial organization—focuses on upgrading dynamics, power asymmetries, and the governance structures through which lead firms coordinate value chains (Gereffi et al., 2005; Ponte & Gibbon, 2005; Dolan & Humphrey, 2000). In the context of beef, this literature has documented the rise of supermarket-led governance in developed country markets, the role of certification and standards in shaping chain access for developing-country exporters, and the increasing concentration of meatpacking and processing industries (Fold & Larsen, 2011). These insights, however, are primarily qualitative or case-based and do not provide the quantitative value-added accounting required to assess the aggregate structure of international value chains.

The second track—grounded in quantitative MRIO analysis—has primarily engaged with agri-food sectors through the lens of environmental sustainability. Pendrill et al. (2019) quantified the deforestation emissions embodied in agricultural commodity trade, including beef and soy, while Henders et al. (2015) estimated carbon flows associated with forest-risk commodity exports. These contributions demonstrate the analytical power of MRIO-based approaches for agri-food sectors, but their focus on environmental embodiment rather than economic value-added structure limits their relevance for understanding competitive dynamics and value distribution along the chain.

Greenville et al. (2017) represent an important exception, explicitly examining value added in agri-food GVCs using OECD ICIO data and documenting the role of services and upstream inputs in agri-food export competitiveness. Their analysis highlights the growing importance of services value added embodied in agricultural and food exports, a finding that is directly relevant to the present study's treatment of transport, logistics, and distribution services as downstream components of the beef value chain. Similarly, Santeramo et al. (2024) analyze the agri-food value chain through the lens of the global food dollar, decomposing the marketing and farm value shares across commodity groups including beef.

Despite this growing literature, systematic value-added decompositions of the global beef sector specifically—as opposed to agriculture or food industries in aggregate—remain limited. Existing studies that address beef trade tend to focus on bilateral trade flows, tariff structures, or market access barriers rather than on the internal value-added architecture of the chain (Greenville et al., 2017; Santeramo et al., 2024). The present study addresses this gap by providing a comprehensive WWZ decomposition of beef exports using the GTAP Data Base, which offers the sectoral resolution required to isolate the beef value chain from the broader food sector.

2.3 The GTAP Data Base as an MRIO Platform

The GTAP Data Base, maintained by Purdue University's Center for Global Trade Analysis, is one of the most comprehensive and widely used databases in global trade modeling (Aguiar et al., 2019; Aguiar et al., 2022). Unlike general-purpose MRIO databases, which typically treat agriculture and food as two to four aggregate sectors, GTAP provides detailed disaggregation of the agri-food system, including separate sectors for paddy rice, wheat, other grains, oilseeds, sugar, vegetables and fruits, cattle and other livestock, cattle meat, other meat, dairy, and food processing. This sectoral resolution is critical for analyzing the beef value chain, as it enables researchers to trace forward and backward linkages between the core cattle and meat sectors and their upstream feed crop and livestock input suppliers as well as downstream food processing and distribution activities.

The GTAP Data Base has been used as the basis for MRIO construction and GVC analysis in a growing number of studies (Walmsley, Hertel, & Ianchovichina, 2006; Baldwin & Lopez-Gonzalez, 2015). Version 10, covering the reference year 2014, includes 140 countries and 57 sectors (Aguiar et al., 2019), while Version 11, covering

2017, expands coverage to 160 countries and 65 sectors (Aguiar et al., 2022). The construction of an MRIO table from the GTAP Data Base requires Armington-type allocation of imported intermediate and final demand flows to source countries using bilateral trade share matrices, as described in detail in Section 3 of this paper. This approach is methodologically consistent with the literature on MRIO construction from trade-flow data (Tukker et al., 2013; Owen et al., 2016) and ensures that the resulting IOT satisfies standard accounting identities while enabling bilateral decomposition of value-added flows.

The use of two GTAP versions (2014 and 2017) in the present study serves a dual purpose. First, it provides a cross-sectional benchmark for assessing the structural characteristics of the beef value chain at a point in time. Second, comparing the two versions allows for a preliminary assessment of whether the structural patterns identified—DVA share, FVA composition, destination concentration—are stable features of the beef value chain or sensitive to cyclical or structural changes in global commodity and trade conditions over the intervening period (Timmer, Los, Stehrer, & de Vries, 2016; Wang et al., 2022). Identifying such stability is important for establishing whether the results can be interpreted as long-run structural characteristics rather than year-specific artefacts.

3. DATA AND METHODOLOGY

3.1 Constructing a Multi-Region Input–Output Table from the GTAP Data Base

The analytical foundation of this study is a multi-region input–output (MRIO) table constructed directly from the GTAP Data Base. The GTAP Data Base does not store data in MRIO format; rather, it provides bilateral trade matrices, domestic and imported intermediate demand arrays, and final demand vectors organized by commodity, activity, and region. Transforming these into a full MRIO table requires a series of carefully sequenced steps that are described in this section. The same construction protocol is applied to both GTAP version 10 (2014, 140 regions, 57 sectors) and version 11 (2017, 160 regions, 65 sectors), yielding MRIO tables of dimensions 7,980×7,980 and 10,400×10,400 respectively. Table 1 summarizes the key data variables and their roles in the construction process.

Table 1. GTAP Data Variables and MRIO Construction Mapping

Dimension	GTAP v10 (2014)	GTAP v11 (2017)	Source Variable	Notes
Regions (G)	140	160	—	Countries/territories
Sectors (N)	57	65	—	TRAD_COMM + CGDS excluded
IOT dimension (GN×GN)	7,980×7,980	10,400×10,400	—	Bilateral country-sector pairs
Domestic intermediate (Z_d)	VDFM[:N,:N,r]	VDFB[:N,:N,r]	VDFM / VDFB	Producer prices
Imported intermediate (Z_m)	VIFM[:N,:N,r]×share	VMFB[:N,:N,r]×share	VIFM / VMFB	Armington shares via VXMD/VXSB
Household final demand	VDPM + VIPM	VDPB + VMPB	VD/IPM/VD/IPB	Bilateral allocation via shares
Government final demand	VDGM + VIGM	VDGB + VMGB	VD/IGM/B	Bilateral allocation
Investment demand	VDFM[:,57,:] + VIFM[:,57,:]	VDIB + VMIB	CGDS sector / VD/IIB	Capital goods
Value added (V)	X − colSum(Z)	X − colSum(Z)	Residual	Ensures column balance
Output (X)	rowSum(Z) + rowSum(Y)	rowSum(Z) + rowSum(Y)	Derived	Gross output

The MRIO table is indexed by country-sector pairs (r, s) for each of G regions and N traded sectors. The full table has dimensions GN×GN, where each row and column corresponds to a specific country-sector pair. The table is partitioned into an intermediate demand block Z (GN×GN), a final demand block Y (GN×G), a value-added row V (GN×1), and a gross output vector X (GN×1).

The intermediate demand block Z is populated through two distinct components. The domestic component Z_d covers flows of commodity s from region r to production activity j within the same region r, sourced from the GTAP arrays VDFM (version 10) or VDFB (version 11). Each off-diagonal block (r, s) to (r', j) captures imported intermediate flows, constructed by allocating the total imported intermediate demand VIFM[s, j, r_d] (or VMFB[s, j, r_d]) across source regions r_s using Armington bilateral trade shares derived from the export matrix VXMD (version 10) or VXSB (version 11). Formally, the bilateral trade share is defined as:

$$\theta_{s,r_s,r_d} = VXMD_{s,r_s,r_d} \,/\, \Sigma_{r'} VXMD_{s,r',r_d}$$

where θ_{s,r_s,r_d} denotes the share of commodity s imported by region r_d that originates from source r_s. The bilateral imported intermediate flow from r_s to activity j in r_d for commodity s is then:

$$Z_m[r_s*N+s,\ r_d*N+j] = VIFM[s,\ j,\ r_d] \times \theta_{s,r_s,r_d}$$

with the constraint that no country exports to itself through the import channel (self-import flows are set to zero), ensuring that all domestic flows are captured through the VDFM/VDFB arrays. This Armington proportionality assumption—assigning import shares uniformly across all uses within a destination—is standard practice in MRIO construction (Tukker et al., 2013) and is applied consistently for both intermediate and final demand flows.

The final demand block Y captures three components of final expenditure: household consumption (VDPM + VIPM or VDPB + VMPB), government expenditure (VDGM + VIGM or VDGB + VMGB), and investment demand. For GTAP version 10, investment demand is derived from the Capital Goods Delivery Service (CGDS) sector, which constitutes the 58th production activity in the PROD_COMM set. Domestic investment demand by commodity s in region r is extracted as VDFM[s, 57, r] (zero-indexed), while imported investment demand VIFM[s, 57, r] is allocated to source regions using the same trade shares. For version 11, investment demand is directly available as separate VDIB and VMIB arrays. Imported components of all final demand categories are allocated to source regions using the commodity- and destination-specific trade shares, with own-country imports zeroed out.

Gross output X is derived as the row sum of intermediate demand Z plus the row sum of final demand Y: $X = \mathrm{rowSum}(Z) + \mathrm{rowSum}(Y)$. Value added V is computed as the residual $V = X - \mathrm{colSum}(Z)$, which ensures that each column of the technical coefficient matrix $A = Z / \hat{X}$ (where $\hat{X}$ is a diagonal matrix of gross outputs) satisfies the column-sum constraint: $\mathrm{colSum}(A) + V/X = 1$ for all country-sector pairs. In practice, the column balance for the constructed MRIO tables is verified to lie within the range [0.99997, 1.00005] for both GTAP versions, confirming the internal consistency of the constructed tables.

An important technical consideration in GTAP-based MRIO construction is the treatment of transportation and distribution margins. The GTAP Data Base records trade values at both producer and market prices, with the wedge accounted for by international transport margins included in the Trade and Transport services sector (trd, otp, wtp, atp). In the present construction, all intermediate and final demand flows are recorded at purchaser prices (values at which the demander actually pays), consistent with standard MRIO accounting practice. This means that transportation costs are already embedded in the VDFM/VIFM and related arrays, and no separate margin adjustment is required.

The resulting MRIO tables satisfy all standard accounting identities: the total of value added across all sectors equals total final demand, intermediate flows are balanced with gross output, and bilateral trade shares sum to unity across source countries for each commodity-destination combination. These properties ensure that the Leontief inverse $B = (I - A)^{-1}$ is well-defined and that the WWZ decomposition produces results that sum exactly to gross bilateral exports (subject to floating-point rounding). Figure 1 illustrates the schematic structure of the constructed MRIO table and the key data flows from the GTAP Data Base.

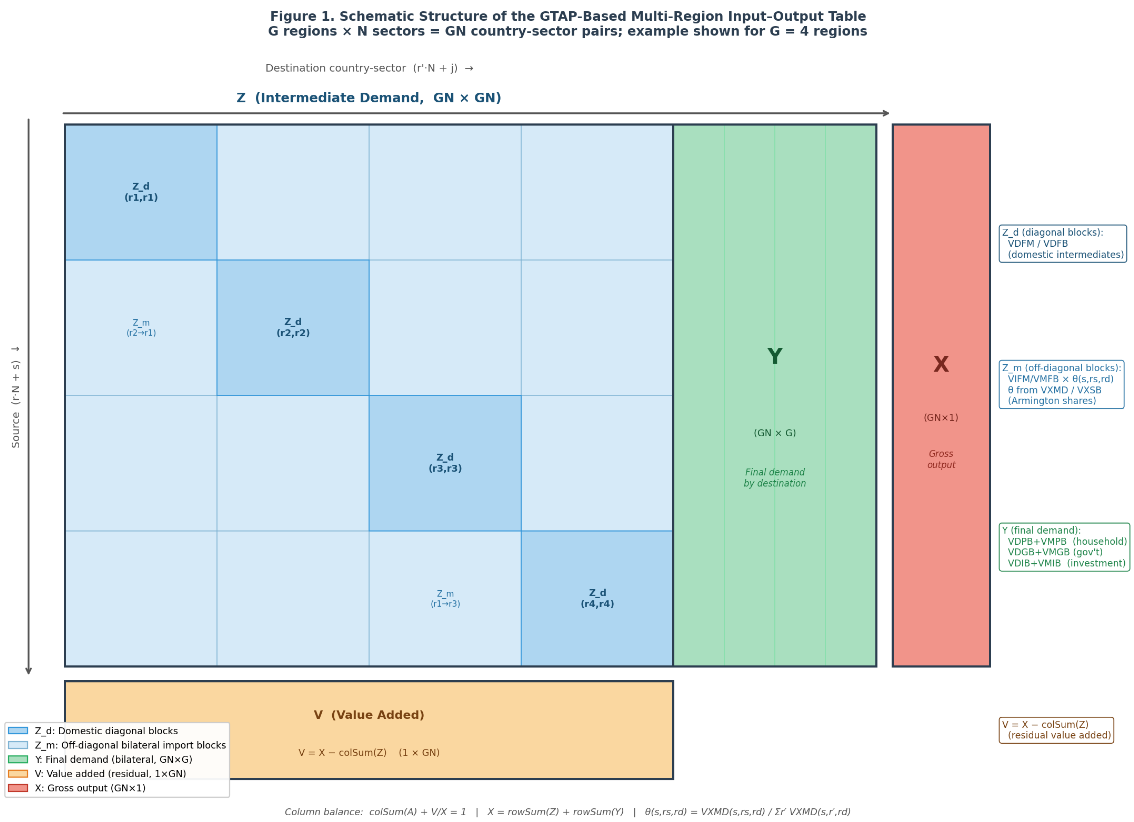

Figure 1. Schematic structure of the GTAP-based MRIO table.

The GN×GN intermediate block Z is decomposed into domestic diagonal blocks Z_d (blue) and off-diagonal imported flow blocks Z_m (light blue). The GN×G final demand block Y (green) captures bilateral final absorption. Value-added row V (orange) and gross output vector X (pink) close the accounting system. Key GTAP arrays used in construction are indicated.

3.2 The Wang–Wei–Zhu Decomposition Framework

The WWZ decomposition (Wang et al., 2013) provides a comprehensive accounting of gross bilateral exports Ē(s, r, r') from exporting country-sector (r, s) to importing country r'. The decomposition produces 16 mutually exclusive and collectively exhaustive terms that partition gross exports according to (i) the ultimate origin of the value added (domestic vs. foreign, and if foreign, third-country vs. direct importer), (ii) the channel through which value added is absorbed (final goods vs. intermediates, direct absorption vs. re-export), and (iii) whether the corresponding value is genuinely traded once or is double-counted due to back-and-forth intermediate trade flows.

The key building blocks of the decomposition are the Leontief inverse $B = (I - A)^{-1}$ and its domestic (B_d) and off-diagonal (B_m) partitions, the block-diagonal domestic Leontief inverse $L = \text{block-diag}\{(I - A\_d)^{-1}\}$, the value-added coefficient vector $\hat{V} = V/X$, and the bilateral export matrices E (intermediate exports) and Y_m (final exports to foreign destinations). Table 2 provides the full taxonomy of WWZ terms as applied in this study.

Table 2. Wang–Wei–Zhu 16-Term Decomposition: Taxonomy and Interpretation

Component	Term	Definition
Domestic Value Added (DVA)	DVA_FIN	DVA directly absorbed in final goods by importing country
	DVA_INT	DVA in intermediates absorbed domestically by direct importer
	DVA_INTrex1	DVA in intermediates re-exported as final goods to third countries
	DVA_INTrex2	DVA in intermediates re-exported as final goods by direct importer
	DVA_INTrex3	DVA in intermediates re-exported to third-country intermediate uses
Returning DVA (RDV)	RDV_INT	DVA returning via importer's intermediate exports
	RDV_FIN1	DVA returning via final goods imports from direct importer
	RDV_FIN2	DVA returning via final goods imports from third countries
Foreign Value Added (FVA)	OVA_FIN	Third-country VA embodied in final goods exports
	MVA_FIN	Direct importer's VA embodied in final goods exports
	OVA_INT	Third-country VA embodied in intermediate exports
	MVA_INT	Direct importer's VA embodied in intermediate exports
Pure Double Counting (PDC)	DDC_FIN	Double-counted DVA in final goods exports
	DDC_INT	Double-counted DVA in intermediate exports
	ODC	Double-counted third-country VA in exporter's production
	MDC	Double-counted direct importer's VA in exporter's production

For each exporting country-sector pair (r, s) and importing country r', the 16 terms are computed following the formulas in Wang et al. (2013), extended to the full GN-dimensional system. The five domestic value added terms (DVA_FIN, DVA_INT, DVA_INTrex1–rex3) together constitute the domestic value added share: DVA_FIN represents domestic value added directly absorbed as final goods by country r'; DVA_INT captures domestic value added in intermediates that r' uses to produce final goods consumed domestically; and the three DVA_INTrex terms trace domestic value added that is re-exported through one or more additional stages. The returning domestic value added terms (RDV_INT, RDV_FIN1, RDV_FIN2) identify domestic value added that eventually returns to the exporting country, either through intermediate or final good imports. The four foreign value added terms (OVA_FIN, MVA_FIN, OVA_INT, MVA_INT) distinguish between value added originating in third countries (OVA) and in the direct importer itself (MVA), across final and intermediate export channels. The four pure double-counting terms (DDC_FIN, DDC_INT, ODC, MDC) capture value that is counted multiple times in gross export statistics due to its repeated crossing of borders.

An important diagnostic property of the WWZ decomposition is that the sum of all 16 terms must equal gross bilateral exports exactly. In the present study, numerical verification confirms that the mean absolute percentage deviation between the term sum and gross exports is 0.0009 percent for GTAP version 10 and 0.0011 percent for version 11, attributable entirely to floating-point rounding in the float32 matrix operations. This confirms the numerical accuracy of the implementation.

In addition to the 16 bilateral terms, this study computes the forward-linkage-based domestic value added in exports (DViX_Fsr), defined following Wang et al. (2017) as the domestic value added generated in exporting country r that is embodied in gross exports from all source sectors to all destinations. This forward-based indicator complements the backward-linkage-based DVA terms and enables a richer characterization of each country's position in the value chain: a country with high DViX relative to DVA_FIN is one whose domestic value added travels through multiple stages before reaching final demand, suggesting a relatively upstream position in the global production network.

3.3 Scope of Analysis and Country-Sector Coverage

The primary analytical focus is on cattle meat (sector code: cmt) and other meat products (omt) as the core beef export sectors in the GTAP classification. Together, these sectors constitute the commercial beef value chain, with cmt capturing slaughtering and primary processing of cattle, and omt covering further-processed and value-added meat products. Upstream sectors explicitly incorporated in the interpretive analysis include cattle and other livestock (ctl, oap), feed grains (gro, wht, pdr), oilseeds (osd), and vegetables and fruits (v_f), which represent the principal intermediate inputs into cattle production and meat processing. Downstream linkages to other food products (ofd), beverages (b_t), trade and distribution (trd), and transport services (otp, wtp, atp) are incorporated through the MRIO structure.

For regional interpretation, major beef-exporting economies are grouped into the following categories: New World resource-abundant exporters (United States, Brazil, Australia, Argentina, New Zealand), European processing-and-export hubs (Germany, Netherlands, France, Denmark, Spain, Poland), and East Asian importing markets (Japan, China, South Korea, Hong Kong, Taiwan). This grouping reflects both the structural characteristics identified in the decomposition analysis and the major regional blocs commonly used in the agricultural trade literature (Greenville et al., 2017). Country-level results are presented for individual economies where data availability and export volume warrant disaggregated analysis.

4. EMPIRICAL RESULTS

4.1 The Domestic Value Added Foundation of the Global Beef Value Chain

The most fundamental finding to emerge from the WWZ decomposition is that the global beef value chain is overwhelmingly driven by domestic value added. Across both reference years, approximately 79 percent (2017) and 80 percent (2014) of global beef gross exports consist of value added generated within the exporting country itself (Table 3). This figure stands substantially above the all-sector average of approximately 71 percent in both years, and well above the manufacturing sector average of approximately 61 percent. It is, however, lower than primary agriculture (90 percent), which is expected given that meat processing involves greater service and energy intensity than raw commodity production.

Table 3. WWZ Decomposition: Sectoral Comparison of Value-Added Shares (%)

	GTAP Version 11 (2017)				**GTAP Version 10 (2014)**			
Sector Group	**DVA**	**FVA**	**RDV**	**PDC**	**DVA**	**FVA**	**RDV**	**PDC**
Beef & Meat	78.9	18.1	0.73	2.24	80.0	17.6	0.71	1.66
All Food Products	75.5	20.2	0.77	3.55	77.3	19.7	0.59	2.42
Agriculture	89.6	6.2	1.24	2.94	90.5	5.6	0.90	2.97
Manufacturing	60.3	23.2	2.65	13.82	61.8	24.1	1.76	12.35
All Sectors	70.9	19.1	1.84	8.19	71.5	19.3	1.33	7.90

The theoretical significance of this finding extends beyond the simple observation that beef is a relatively domestic industry. In the GVC literature, a high domestic value added share is generally associated with what Koopman et al. (2014) term “traditional trade”—exports that embody primarily the exporter’s own factors of production and that generate welfare gains concentrated in the exporting economy. For beef, this structural feature reflects the biological nature of cattle production: the core value-creating activities—feeding, raising, and processing cattle—are geographically anchored to regions with comparative advantage in land and water resources, limiting the scope for the offshore sourcing of primary production inputs that characterizes more footloose manufacturing GVCs (Gereffi et al., 2005; Baldwin, 2016).

Within the DVA components, the decomposition reveals an important structural distinction between value added absorbed directly in final goods (DVA_FIN) and value added transmitted through intermediate export channels (DVA_INT and DVA_INTrex terms). In 2017, approximately 49 percent of gross beef exports consist of DVA_FIN, compared to 29 percent in all-sector DVA_INT-equivalent terms. The DVA_FIN to DVA_INT ratio for beef (1.64 in 2017, 1.47 in 2014) indicates that domestic beef value added reaches foreign consumers primarily through final goods rather than through the re-export of intermediate products by importing countries. This is in contrast to sectors like electronics or automotive components, where domestic value added is more commonly absorbed through multiple rounds of intermediate re-export (Wang et al., 2017). The beef value chain therefore conforms more closely to what the GVC literature describes as a “simple” or “short” chain structure (Los et al., 2015), despite the genuine international fragmentation of its upstream input structure.

Pure double counting (PDC)—the sum of DDC_FIN, DDC_INT, ODC, and MDC—amounts to only 2.24 percent of beef gross exports in 2017 and 1.66 percent in 2014. This is strikingly low compared to manufacturing (13.8 percent) and even to the all-sector average (8.2 percent), and confirms that the circular intermediate flows that generate statistical double counting in complex manufacturing GVCs are largely absent from the beef value chain. The economic interpretation is straightforward: beef exports do not involve extensive back-and-forth processing across multiple countries—a characteristic that has important implications for interpreting gross trade data. For beef, unlike for automobiles or semiconductors, gross export figures are a reasonably close approximation of genuine value added flows, differing primarily by the modest foreign value added content and the negligible double-counting component.

Returning domestic value added (RDV)—domestic value added that is exported as an intermediate input but returns to the exporting country as part of an imported good—is also small, at 0.73 percent in 2017. This contrasts with sectors embedded in deep bilateral production partnerships, where circular intermediate flows generate significant RDV (Miroudot & Ye, 2021). The low RDV in beef reflects the predominantly asymmetric structure of global beef trade: major exporters ship processed or semi-processed beef products to importers who consume them rather than re-exporting them with domestic content added back.

Between 2014 and 2017, the aggregate DVA share declined modestly from 80.0 to 78.9 percent, accompanied by a corresponding increase in FVA from 17.6 to 18.1 percent and in PDC from 1.66 to 2.24 percent. The increase in PDC, while modest in absolute terms, may reflect the gradually deepening integration of the beef sector into broader input networks—particularly in the use of processed feed ingredients, veterinary chemicals, and energy—that create a greater degree of intermediate roundtripping. The shift is consistent with the broader trend of increasing GVC integration documented for the agri-food system as a whole by Greenville et al. (2017) and Santeramo et al. (2024), but the magnitudes remain modest, suggesting that the structural character of the beef value chain is relatively stable over the observation period.

4.2 Heterogeneity Across Major Exporting Economies: Structural Archetypes

While the aggregate figures establish that beef is a domestically anchored value chain, disaggregation by major exporting economy reveals substantial structural heterogeneity that reflects fundamentally different modes of participation in the global beef trade system (Table 4). Three broad structural archetypes are apparent: resource-abundant exporters, trade-hub processors, and intermediate integration economies.

Table 4. WWZ Decomposition by Major Exporting Economy: Value-Added Component Shares (%)

	Share of Total Exports (%) (2017)				Share of Total Exports (%) (2014)			
Country	**DVA_FIN**	**DVA_INT**	**FVA**	**PDC**	**DVA_FIN**	**DVA_INT**	**FVA**	**PDC**
USA	53.4	35.9	7.2	1.1	39.4	46.9	9.0	1.6
Brazil	50.3	41.1	7.5	1.0	55.3	39.3	4.9	0.4
Australia	49.0	41.6	8.2	0.9	41.5	50.5	7.0	0.8
Germany	53.0	20.6	21.5	3.6	56.5	19.1	21.4	2.1
Canada	45.6	38.2	14.8	1.2	38.3	41.2	18.5	1.7
N.Zealand	52.6	36.1	10.1	1.1	49.9	37.0	11.7	1.3
Argentina	53.4	39.6	6.0	0.9	58.7	34.4	6.2	0.6

The first archetype, exemplified by Brazil and Argentina, represents resource-abundant exporters operating primarily at the upstream and primary processing stages of the beef value chain. Brazil's DVA share exceeds 91 percent in both years, while Argentina reaches 93 percent—the highest among all major exporters. The exceptionally high domestic content of these exporters reflects their endowment of extensive pastureland and the predominantly grass-fed nature of Brazilian and Argentine cattle production, which limits dependence on imported feed inputs (Fold & Larsen, 2011). The FVA share for Brazil increased from approximately 4.9 percent in 2014 to 7.5 percent in 2017, possibly reflecting increasing use of imported feed additives, energy inputs, and processing chemicals as Brazilian beef exports shifted toward higher-value processed products. For Argentina, the FVA share was essentially stable, consistent with the country's continued dominance of grassland-based primary beef production.

Australia and New Zealand represent a related but distinct sub-archetype: resource-abundant exporters that are nonetheless more integrated into regional input networks. Australia's FVA share (8.2 percent in 2017) is somewhat higher than Brazil's, reflecting greater use of imported veterinary products, grain supplements, and processing inputs, while its dvix_fsr—the forward-linkage-based measure of domestic value added—is notably high at 49.9 percent in 2017. This indicates that a substantial share of Australian domestic value added in beef is generated upstream and transmitted forward through the processing chain before being absorbed in final demand, suggesting that Australian beef production operates at a relatively upstream position in the global value chain (Wang et al., 2017). New Zealand presents a similar profile with high dvix_fsr (37.8 percent) and concentrated destination structure, consistent with its specialization in high-quality primary beef products destined primarily for East Asian markets. The United States occupies a structurally distinct position reflecting its dual role as both a major beef exporter and a processing hub that imports and re-exports beef products within North American production networks. The US DVA share (89.3 percent in 2017, 86.3 percent in 2014) is high in absolute terms but below the levels of Brazil and Australia. The relatively high RDV for the USA (2.34 percent in 2017)—the highest among all major exporters—indicates that a meaningful share of US domestic beef value added returns home via imports from trading partners, most notably Canada and Mexico, reflecting the deep bilateral integration of North American beef supply chains within the USMCA/NAFTA regional production network. This circular value-added flow has no parallel among South American or Oceanian exporters and is characteristic of what Baldwin (2016) describes as regional factory-economy dynamics within a broader global value chain system. Germany and the Netherlands represent the European trade-hub archetype—exporters with relatively high FVA shares (21.5 and approximately 22 percent respectively in 2017) that reflect their function as processing and re-export platforms within the European single market. Unlike resource-abundant exporters, whose domestic content reflects primary production advantages, European beef exporters draw heavily on intra-EU intermediate inputs—particularly feed grains and livestock from Eastern European producers—as well as on energy-intensive processing technologies. The FVA composition of European exporters is therefore predominantly OVA (third-country value added from EU partner economies) rather than MVA (direct importer value added), consistent with the deeply integrated intra-EU production and trade structure. Germany's dvix_fsr (23.9 percent) is lower than resource-abundant exporters, reflecting the fact that German beef value added is concentrated in the processing and distribution stages rather than in upstream primary production.

Canada serves as an intermediate case: its FVA share (14.8 percent in 2017) is substantially lower than Germany's but higher than Brazil's, reflecting integration into North American feed grain and livestock input networks. The decline in Canada's FVA from 18.5 percent in 2014 to 14.8 percent in 2017 is notable and may reflect adjustments in the North American beef complex following changes in trade flows and feed cost structures over the period, though a definitive attribution would require further disaggregated analysis. Across all exporters, the forward-linkage DVA measure (dvix_fsr) is consistently lower than the backward-linkage domestic DVA share, indicating that most domestic value added in beef is transmitted through direct final demand channels rather than forward through intermediate use by importing economies. This is consistent with the predominantly consumer goods character of beef exports—most exported beef products are final consumption goods rather than intermediate inputs into downstream food processing industries in the destination market—and contrasts with intermediate-goods-dominated sectors such as chemicals or components manufacturing, where dvix_fsr and backward DVA shares tend to be more closely aligned (Wang et al., 2017).

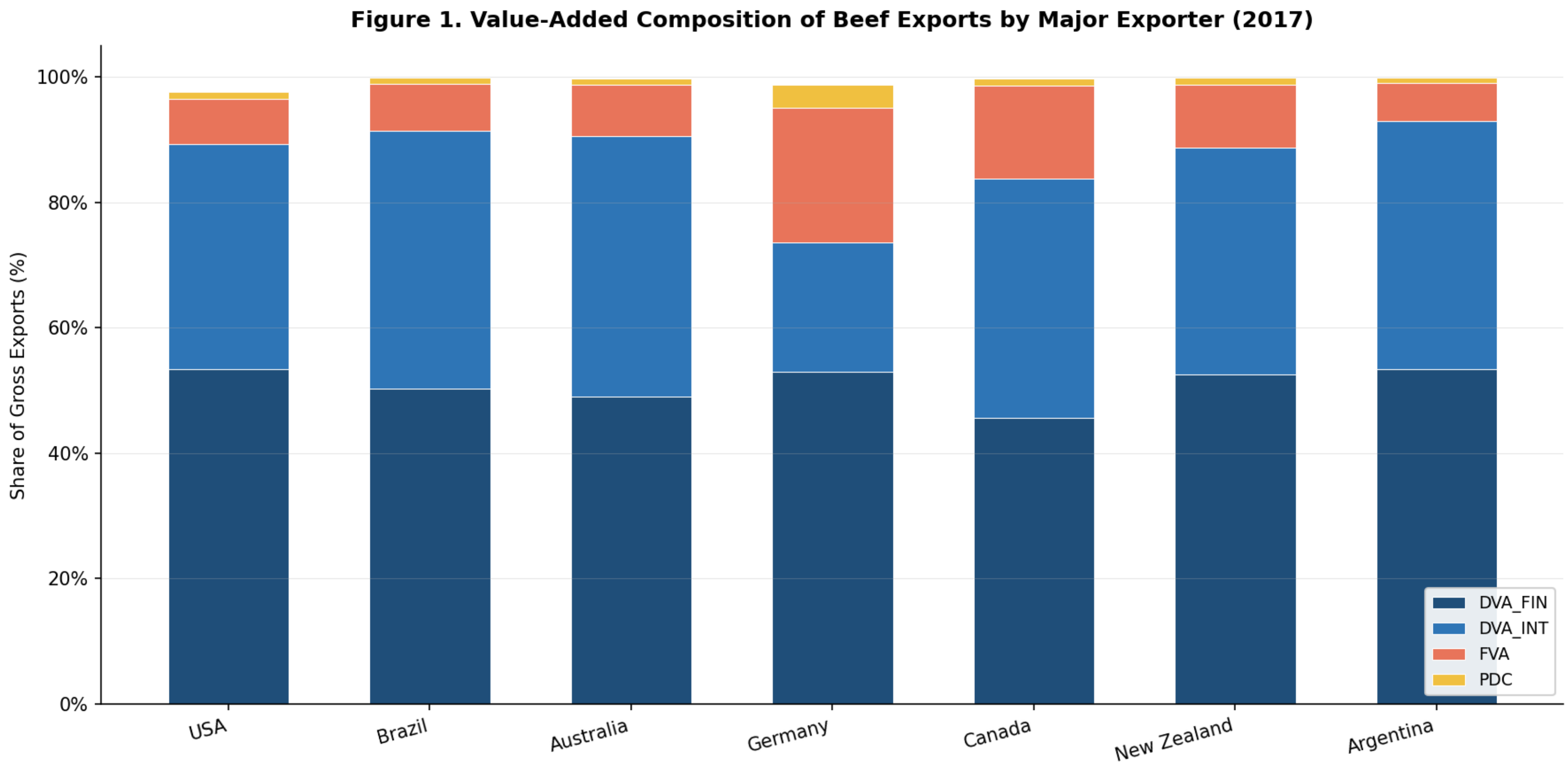

Figure 1. Value-Added Composition of Beef Exports by Major Exporting Economy (2017).

4.3 Destination Concentration and Value Capture Geography

The analysis of where domestic beef value added is ultimately absorbed—rather than where it is shipped—reveals a distinct geography of final value capture that differs substantially from the geography of gross bilateral trade (Table 5). This distinction is theoretically significant because the welfare implications of beef exports for the exporting economy depend on the distribution of final absorption across destination markets: concentration in a small number of destinations implies greater vulnerability to demand shocks, tariff changes, or regulatory barriers in those markets, while diversification provides a buffer against market-specific disruptions (Wang et al., 2022).

Table 5. DVA_FIN Absorption Geography and Destination Concentration (GTAP v11, 2017)

Exporter	Top 5 Absorbing Markets	DVA_FIN (mn)	Top-3 Share (%)	Dominant Destination Type
USA	Mexico, Japan, Korea, Canada, China	12,110	52.3	Regional + East Asia
Brazil	China, Russia, Hong Kong, Japan, UAE	7,923	35.1	Diversified Asia
Australia	USA, Japan, China, Korea, Taiwan	5,468	51.5	East Asia + North America
Germany	Italy, France, UK, Netherlands, Poland	6,183	31.1	Intra-EU concentrated
Canada	USA, Mexico, Japan, China, UK	2,925	-	North America dominant
N.Zealand	China, Japan, USA, Korea, Australia	2,945	52.2	East Asia dominant
Argentina	Chile, China, Russia, EU, Middle East	1,153	50.2	Diversified South-South

Note: DVA_FIN is the domestic value added of the exporting country that is directly absorbed as final goods by the importing country. Top-3 share = share of top three destinations in total DVA_FIN. Values in USD million (GTAP base year prices).

At the global level, the three largest absorbers of beef DVA_FIN in 2017 are Japan (7,123 million USD), China (5,678 million USD), and the United Kingdom (5,024 million USD), followed by the United States, Germany, and Mexico. Between 2014 and 2017, China's absorption rose significantly from a lower base—reflecting the well-documented expansion of Chinese beef import demand driven by urbanization and income growth—while Russia's share declined substantially, likely due to the import bans and trade realignments following geopolitical developments in the post-2014 period. The United Kingdom's position as a major DVA absorber primarily reflects intra-EU trade in beef and processed meat products, particularly from Ireland and

Germany.

The geographic concentration of DVA_FIN absorption varies considerably across major exporting economies in ways that reflect structural features of their respective value chains. Australia and New Zealand exhibit highly concentrated destination structures (HHI of approximately 0.11–0.12), with more than half of their DVA_FIN absorbed by just three markets (USA and Japan for Australia; China, Japan, and the USA for New Zealand). This concentration reflects both geographic proximity to East Asian markets and the preferential market access secured through bilateral and regional free trade agreements. From a structural vulnerability perspective, this concentration implies that shocks to Japanese or Chinese beef import demand—whether from food safety concerns, phytosanitary restrictions, or macroeconomic downturns—would have disproportionate implications for Australian and New Zealand domestic value capture.

Brazil's DVA absorption is markedly more diversified (HHI 0.061), with no single destination absorbing more than 15 percent of total DVA_FIN. This diversification reflects Brazil's strategy of expanding into multiple emerging market destinations—particularly the Middle East, Russia (prior to trade disruptions), and Southeast Asia—alongside its traditional East Asian markets. The diversification of Brazil's value-added absorption base is theoretically consistent with the competitive strategy outlined by Ponte and Gibbon (2005) for developing-country commodity exporters seeking to reduce dependence on individual buyer-led governance structures. Germany, similarly, exhibits low concentration (HHI 0.061), but for a different structural reason: German beef value added is distributed across a large number of European destination markets within the highly integrated intra-EU trade system, where no single market dominates.

The United States presents a highly concentrated absorption pattern (HHI 0.125, top-3 share 52.3 percent), dominated by Mexico, Japan, and Korea. The primacy of Mexico as the leading absorber of US beef DVA_FIN reflects the profound bilateral integration of the US–Mexico beef complex within the USMCA framework: Mexico is the dominant destination for a range of US beef products, including variety meats and secondary cuts that are less demanded in US domestic markets. This structural reliance on a single bilateral partner for more than one quarter of all DVA_FIN absorption represents a meaningful structural exposure, particularly given the potential for regulatory or trade policy changes within the North American market.

The structural contrast between the OVA and MVA components of foreign value added across destination markets also carries theoretical significance. In both 2014 and 2017, OVA (third-country value added embodied in beef exports) is approximately 11 times larger than MVA (direct importer value added), a ratio that indicates the dominant mechanism by which foreign content enters the beef value chain is not through direct bilateral production sharing with the importing country but through the incorporation of inputs from globally dispersed third-country suppliers. This pattern is consistent with the hypothesis that the global beef value chain is predominantly "captive" or "market" in its governance structure (Gereffi et al., 2005)—that is, exporting firms source inputs from competitive global markets rather than entering into deep bilateral production partnerships with their importers—in contrast to the relational or hierarchical governance structures that characterize high-technology GVCs. The implication is that the principal foreign linkages of the beef value chain are on the input side (upstream sourcing from global commodity markets) rather than on the production-sharing side (bilateral intermediate processing), a structural feature that distinguishes beef from most manufactured good value chains.

Comparing the two GTAP versions reveals a general shift in the geography of value absorption from developed-economy importers (particularly Russia and some European markets) toward East and Southeast Asian importers (China, Japan, Korea, ASEAN). This temporal pattern is consistent with the structural transformation of global beef demand documented in the trade literature—driven by income growth, urbanization, and dietary convergence in emerging economies—and has direct implications for how the strategic positioning of major exporting economies in the global beef value chain should be assessed (Greenville et al., 2017; Santeramo et al., 2024)

Figure 2. Top 5 DVA_FIN Absorption Markets by Major Beef Exporter (2017)

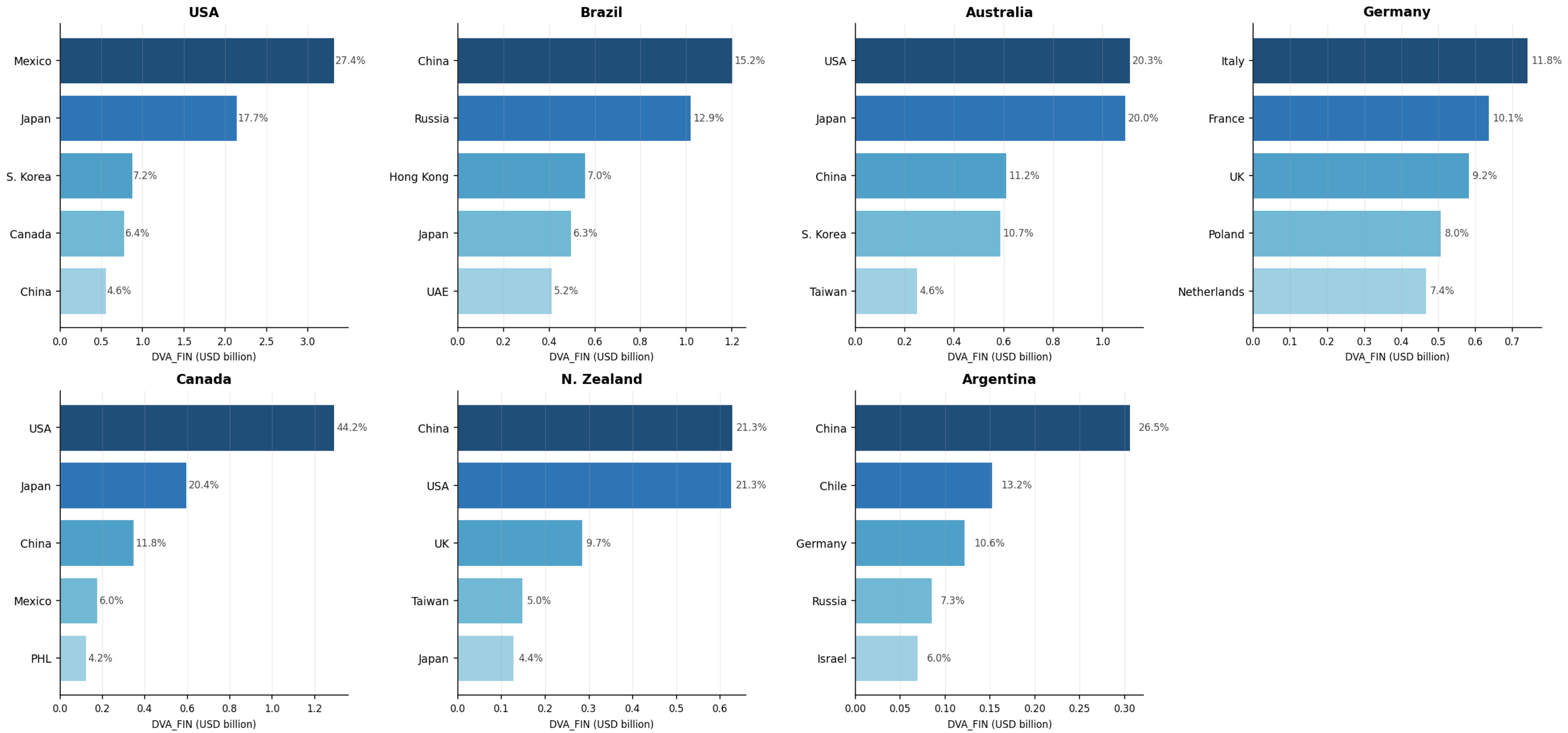

Figure 2. Top Five DVA_FIN Absorption Markets by Major Beef Exporter (2017). Bars show DVA_FIN in USD billion; percentage labels indicate each destination's share of total DVA_FIN. Source: Author computation from GTAP v11 WWZ decomposition.

4.4 Upstream Sources of Foreign Value Added: Country and Sector Origins

The preceding sections have established that between 6 and 22 percent of major beef exporters' gross export value consists of foreign value added, and that this range reflects fundamentally different structural positions in the global value chain. To understand the economic content of this foreign value, the MRIO-based source decomposition developed in Section 3.4 traces each unit of FVA back to its originating country and sector by combining the off-diagonal Leontief inverse (B^M) with value-added coefficients and bilateral export flows. The resulting breakdown, summarised in Table 6, reveals that the foreign content in beef does not primarily reflect cross-border fragmentation of agricultural production activities but originates instead from a concentrated set of upstream service- and energy-supplying economies whose role in the beef value chain is largely invisible from gross trade data alone.

The most consistent structural finding across all major exporters is the dominant position of globally traded services as a source of foreign value added. Business services (GTAP sector obs, comprising legal, accounting, consulting, research and development, and financial services) and trade and distribution services (trd) together account for approximately 20 to 25 percent of total FVA across most countries. The primacy of these sectors reflects a structural feature of modern agri-food systems: even resource-abundant commodity exporters depend on a range of professional, logistical, and financial intermediation services that are sourced globally and are ultimately embodied in the exported product without being physically visible in it. Petroleum and petrochemical products (oil) constitute a second consistently large FVA source, reflecting the energy-intensive nature of feedlot-based production, refrigerated processing, and long-distance cold-chain shipping. Saudi Arabia and Russia emerge as FVA sources for multiple exporters specifically through this energy channel, with no direct agricultural linkage to the beef supply chain itself.

The geographic origin of FVA follows each country's regional integration architecture with considerable fidelity, and this correspondence is most strikingly illustrated by the Canada-United States-Mexico Agreement (USMCA) complex. Canada accounts for 23.3 percent of US beef FVA while the United States accounts for 67.7 percent of Canadian beef FVA, a structural interdependence that reflects the deep bilateral integration of the North American beef complex. The largest individual source-country by sector combination for the United States is Canadian petroleum (3.3 percent of FVA), followed by Mexican cattle inputs (2.9 percent) and Canadian cattle inputs (2.7 percent), a configuration that directly mirrors the documented pattern of live cattle cross-border flows and integrated feedlot-to-packer supply chains within North America. For Canada, whose FVA sourcing is the most concentrated of any major exporter with nearly 68 percent of all foreign content originating from the United States, this dependence extends across business services, chemicals, trade services, paper and printing inputs, and processed food ingredients, reflecting the comprehensive depth of US-Canada bilateral economic integration across all intermediate input categories.

Germany's FVA sourcing pattern corresponds to a qualitatively distinct configuration reflecting its role as an intra-EU processing hub. The Netherlands (14.9 percent), France (7.2 percent), Denmark (6.6 percent), and Poland (6.0 percent) collectively supply approximately 35 percent of German beef FVA, and the two largest individual source-country by sector combinations are Danish animal products (3.4 percent) and Dutch animal products (2.9 percent), both representing live cattle, poultry, and processed animal feed from Germany's EU neighbours. This pattern is consistent with Germany's structural position as the hub of an EU-wide meat processing network in which raw livestock inputs are sourced from adjacent specialised production regions and processed for distribution across the European single market. The high overall FVA share of German beef exports (21.5 percent) thus reflects regional agricultural specialisation within an economically integrated supranational bloc rather than global fragmentation in the conventional GVC sense.

Australia and New Zealand exhibit a bilateral sourcing structure that mirrors their geographic and economic proximity. New Zealand sources 24.5 percent of its beef FVA from Australia, primarily through business services (4.5 percent of FVA) and communication infrastructure services (2.0 percent), while Australian beef FVA in turn includes New Zealand cattle inputs (2.3 percent). China appears as a significant FVA source for both Oceanian exporters, supplying 16.5 percent of Australian and 13.4 percent of New Zealand beef FVA across a highly dispersed range of sectors. For Australia, trade and distribution services (9.1 percent of China's contribution), chemicals (8.2 percent), business services (5.6 percent), textiles and apparel (5.5 percent), and electronics (4.6 percent) each contribute broadly comparable shares, with no single sector dominating (Figure 3). This finding implies that the growing bilateral export dependence of Oceanian beef exporters on Chinese final demand is accompanied by a corresponding, if less visible, reliance on Chinese manufactured inputs on the production side, creating a structural linkage to China on both the upstream and the downstream dimensions of the value chain simultaneously.

For South American exporters, the United States functions as the dominant source of business and professional services regardless of geographic distance. The USA accounts for 26.1 percent of Brazil's and 26.4 percent of Argentina's beef FVA, primarily through business services and chemicals. Regional neighbours also feature prominently in the South American context: Argentina supplies 8.2 percent of Brazilian beef FVA across a broadly distributed set of sectors, with wheat inputs for intermediate feed (2.1 percent), processed food intermediates (1.0 percent), chemicals (0.9 percent), and vegetable and oilseed products (0.7 percent) each contributing modest individual shares, while Bolivia contributes 1.9 percent of Brazilian FVA through natural gas exports that power Brazilian agri-food processing facilities. These intra-South American FVA flows illustrate the extent to which South American beef production networks are embedded in regional commodity and energy supply chains that are structurally distinct from the livestock-integration patterns of North America and Europe (Figure 4).

The aggregate pattern across all exporters supports a reinterpretation of the low foreign value added finding from Section 4.1. The fact that business services consistently rank as the single largest FVA sector for most exporters implies that the competitive efficiency of even resource-abundant beef exporters depends in part on access to globally traded professional and financial services supplied predominantly by developed-economy service hubs including the United States, the United Kingdom, Germany, and Australia. This service-sector FVA dimension has received little attention in the agricultural GVC literature, yet its policy implications are potentially significant: as service liberalisation becomes an increasingly important dimension of international agricultural trade negotiations, the upstream service content of beef exports may become as policy-relevant as the more visible barriers affecting final goods trade itself.

Table 6. Foreign Value Added in Beef Exports: Top Source Countries and Sectors by Major Exporter (GTAP v11, 2017)

Exporter	FVA (USD mn)	FVA Share (%)	Top-3 Source Countries (% of FVA)	Top-3 Source Sectors (% of FVA)	Regional Integration Pattern
USA	1,539	7.2	Canada (23.3%), Mexico (12.0%), China (11.4%)	Petroleum (13.4%), Business services (8.3%), Trade services (7.9%)	North American (USMCA)
Germany	2,551	21.5	Netherlands (14.9%), France (7.2%), Denmark (6.6%)	Animal products (13.4%), Business services (12.5%), Trade services (8.0%)	Intra-EU production network
Brazil	1,075	7.5	USA (26.1%), China (10.6%), Argentina (8.2%)	Chemicals (14.6%), Trade services (12.8%), Business services (12.4%)	Global services + regional
Canada	924	14.8	USA (67.7%), China (6.5%), Germany (2.1%)	Business services (11.5%), Chemicals (8.8%), Trade services (8.1%)	US-dominated (USMCA)
Australia	851	8.2	USA (17.8%), China (16.5%), New Zealand (7.0%)	Business services (12.7%), Trade services (10.8%), Petroleum (8.4%)	Asia-Pacific bilateral
New Zealand	487	10.1	Australia (24.5%), USA (14.1%), China (13.4%)	Business services (13.6%), Petroleum (11.2%), Chemicals (9.0%)	Australia-centred regional
Argentina	90	6.0	USA (26.4%), Brazil (21.9%), China (12.7%)	Business services (12.8%), Trade services (8.4%), Chemicals (7.8%)	S. American + USA services

Note: FVA total (USD million) and FVA share (%) are from the bilateral WWZ decomposition of beef exports (cmt + omt). Top-3 source country and sector shares are computed from the full 5-dimensional FVA source breakdown using the Leontief inverse off-diagonal B^M and value-added coefficient vector $\hat{V}$. Sector abbreviations: Animal products = oap; Business services = obs; Trade services = trd; Chemicals = chm; Petroleum = oil.

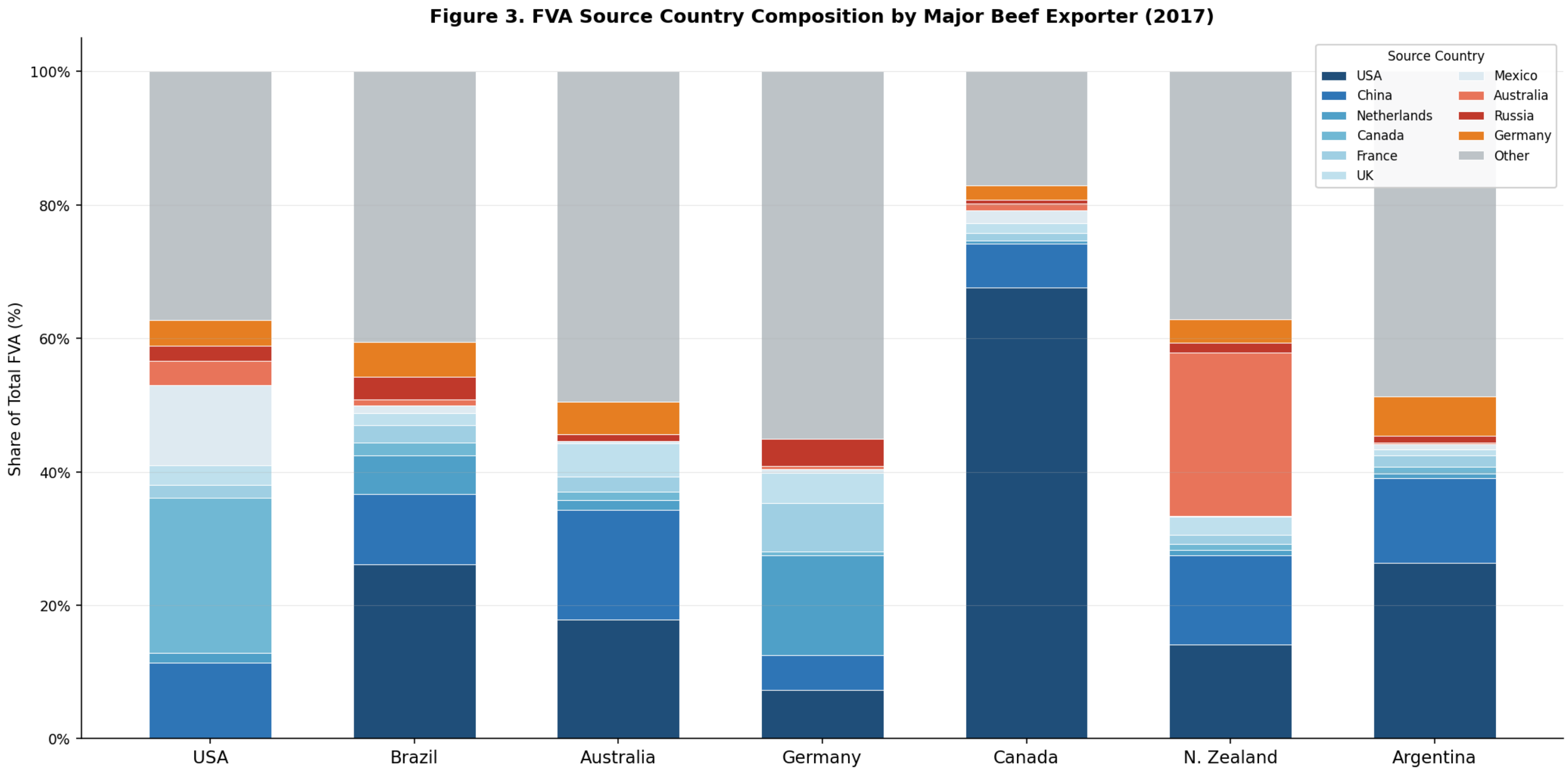

Figure 3. FVA Source Country Composition by Major Beef Exporter (2017).

Each stacked bar segment shows the share of total FVA attributable to each source country; "Other" aggregates all remaining source countries.

Source: Author computation from GTAP v11 FVA_YL decomposition.

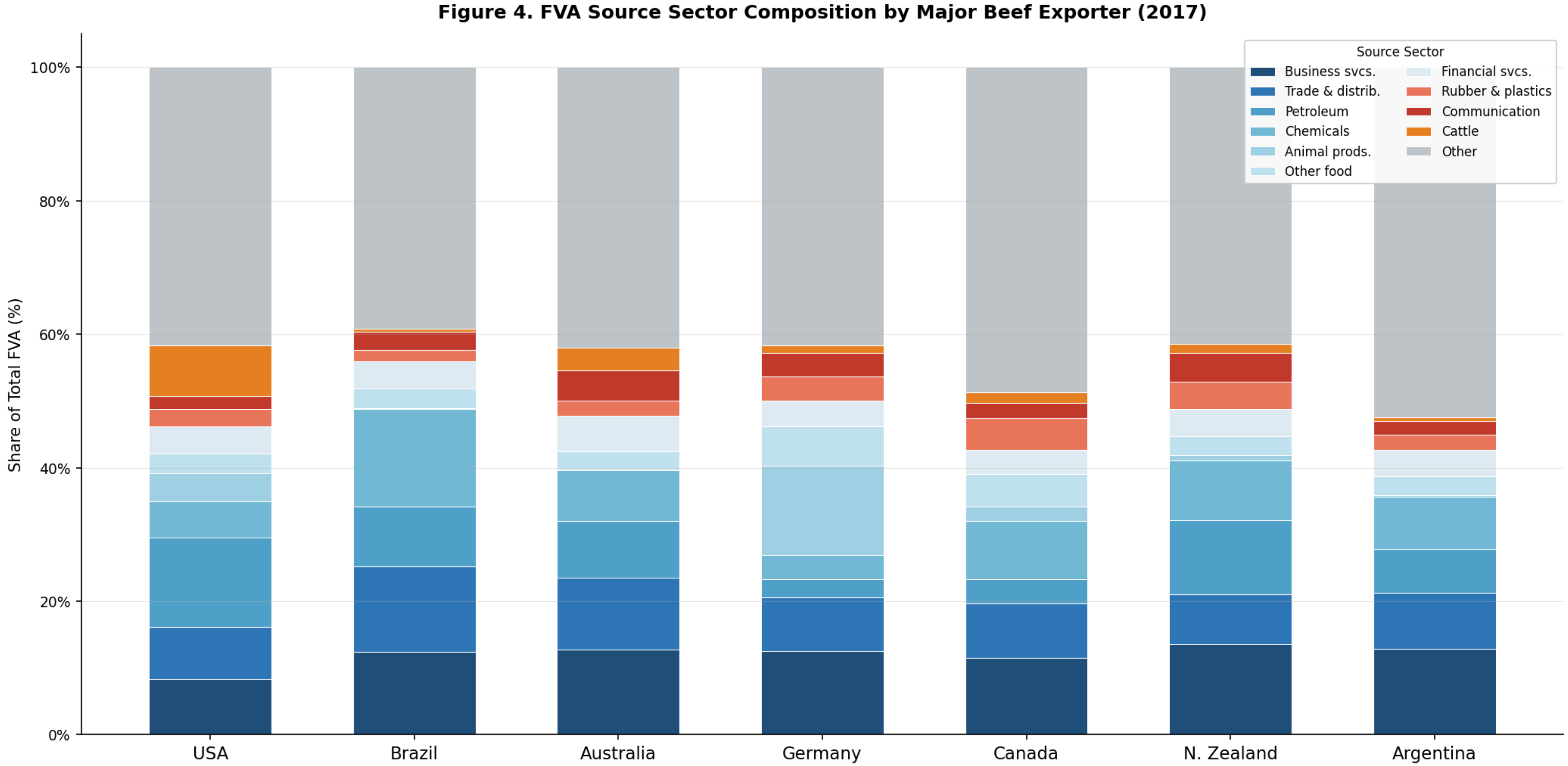

Figure 4. FVA Source Sector Composition by Major Beef Exporter (2017).

Sectors shown are the top 10 by aggregate FVA contribution across all exporters.

Source: Author computation from GTAP v11 FVA_YL decomposition

5. DISCUSSION AND CONCLUSION

This study has applied the Wang–Wei–Zhu gross exports decomposition to a multi-region input–output table constructed from the GTAP Data Base (versions 10 and 11) to provide the first systematic value-added structural analysis of the global beef value chain. Four principal findings are highlighted. First, the global beef value chain is characterized by a high and relatively stable domestic value added share of approximately 79–80 percent, substantially above the all-sector manufacturing average. This confirms that, despite global input sourcing, the beef value chain retains a structurally domestic character: the primary drivers of competitive advantage in beef exports are domestic endowments of land, labor, and livestock production technology rather than the assembly of globally fragmented intermediate inputs. The theoretical implication is that conventional analytical frameworks that treat beef as a globalized commodity with dispersed value-added sourcing need to be qualified: international fragmentation in beef is primarily an input-side phenomenon, not a production-sharing phenomenon. Second, pure double counting is remarkably low (around 2 percent) compared to manufacturing, confirming that the beef value chain does not exhibit the complex circular intermediate flows that characterize modern electronics, automotive, or chemical GVCs. This finding is important for empirical trade analysis: gross beef export statistics, while imperfect, provide a relatively close approximation of genuine value-added flows, and the statistical distortions associated with global value chain participation are modest in the beef context.

Third, major exporting economies exhibit distinct structural archetypes that cannot be revealed by gross trade statistics alone. Resource-abundant South American and Oceanian exporters show very high domestic content, while European processing hubs exhibit elevated foreign value added reflecting their role in assembling inputs from multiple EU partner economies. The United States occupies a distinctive position due to its deep bilateral integration with Canada and Mexico within regional production networks, reflected in unusually high returning domestic value added. These structural differences have implications for how "competitiveness" in beef trade is conceptualized: for resource-abundant exporters, competitiveness is primarily a function of domestic factor endowments, while for processing hubs, it is increasingly determined by the ability to efficiently source and integrate foreign intermediate inputs.

Fourth, the geography of domestic value added absorption is more concentrated than gross trade data would suggest, with East Asia—particularly Japan and China—emerging as the dominant final value absorbers across most major exporting economies. Between 2014 and 2017, the shift toward Asian absorption accelerated, suggesting a structural realignment of the global beef value chain around Asian demand rather than the European and North American markets that historically dominated. This concentration creates meaningful structural exposures: exporters whose domestic value added is heavily concentrated in one or two Asian markets face non-trivial risks from demand shocks, regulatory disruptions, or geopolitical events affecting those markets.

Several limitations should be noted. The analysis is based on a single benchmark year per GTAP version, and therefore cannot distinguish cyclical from structural variation within each period. The Armington proportionality assumption used in constructing bilateral intermediate flows is a recognized simplification that may introduce bias in countries where import sourcing differs systematically across uses. The GTAP sectoral aggregation, while more disaggregated than most MRIO databases for agri-food, still combines cattle meat and other meat within the cmt and omt categories, obscuring potential differences in the value chain structure of, for example, grass-fed versus grain-fed beef or fresh versus frozen and further-processed products. Future research could address these limitations through the use of multi-year panel MRIO analysis, the development of use-table disaggregations of the GTAP intermediate demand arrays, and the integration of value-chain length metrics (Wang et al., 2017) to provide a more complete characterization of the global beef GVC structure. From a policy perspective, the findings suggest that measures aimed at strengthening value capture in beef-exporting economies should focus on the domestic value-added segments of the chain—particularly processing, cold-chain logistics, and distribution services—rather than on limiting foreign input sourcing, which remains modest. The high destination concentration identified for several major exporters underscores the strategic importance of market diversification as a risk management tool. Finally, the emergence of China as the single most dynamic absorber of beef value added between 2014 and 2017 points to the critical importance of understanding Chinese import demand dynamics—including food safety standards, bilateral trade relationships, and dietary transition trajectories—for the long-run structural positioning of major beef-exporting economies in the global value chain.

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