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Decomposition of Changes in Gross Value Added in Indian Agriculture: An Index Number Approach using National Accounts Statistics

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SUMMARY

The present study examines the structural composition and decomposition of Gross Value Added (GVA) in Indian agriculture using the National Accounts Statistics framework. A mathematical decomposition methodology based on index number theory is employed to separate the changes in agricultural GVA into output effect, input intensity effect, and price-relativity effect over the period 2011-12 to 2022-23. The analysis utilizes data from National Accounts Statistics published by the National Statistical Office (NSO), Government of India, with 2011-12 as the base year. The results indicate that the output effect has been the dominant contributor to GVA growth, accounting for approximately 62.4 per cent of the total change, followed by price-relativity effect at 24.1 per cent and input intensity effect at 13.5 per cent. The input-output ratio in agriculture has shown a rising trend from 0.423 in 2011-12 to 0.440 in 2022-23 at current prices, suggesting increasing intermediation in the agricultural production process. A Törnqvist-type decomposition index has been constructed to measure the year-on-year contribution of each factor, revealing significant inter-year variability linked to monsoon performance and policy interventions. The findings have implications for agricultural policy formulation and for improving the methodology of GVA estimation in the agricultural sector.

JEL Classification: C43, E01, E31, O13, Q10

Keywords: Gross Value Added; National Accounts Statistics; Index Number; Decomposition Analysis; Input-Output Ratio; Indian Agriculture.

1. INTRODUCTION

The measurement of agricultural income through the national accounts framework constitutes a fundamental exercise in economic statistics. In India, the National Statistical Office (NSO) compiles estimates of Gross Value Added (GVA) for the agriculture, forestry, and fishing sector as part of the National Accounts Statistics (NAS). The GVA is derived as the difference between the value of output and intermediate consumption, and this apparently simple accounting identity conceals within it a rich structure amenable to analytical decomposition.

While considerable research attention has been directed toward the analysis of growth rates in agricultural GDP or GVA (Bhalla, 2007; Chand *et al.*, 2015), relatively less attention has been devoted to the structural decomposition of changes in GVA into its constituent components. Such decomposition is valuable because it reveals whether increases in agricultural income arise primarily from expansion of output volumes, from favourable movements in relative prices of outputs vis-à-vis inputs, or from changes in the technical structure of production as reflected in input intensity.

The national accounts identity for GVA at current prices can be expressed as:

$$GVA_t = O_t - IC_t$$

where O_t denotes the value of output and IC_t denotes intermediate consumption at time t. This

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identity, when expressed in terms of the input-output ratio $\lambda_t = IC_t / O_t$), yields:

$$GVA_t = O_t(1 - \lambda_t)$$

Changes in GVA can therefore be traced to changes in O_t and changes in λ_t, and further decomposition into price and quantity components is possible using index number methods.

The objective of the present paper is to develop a mathematically rigorous yet computationally tractable decomposition framework for analysing changes in agricultural GVA using published NAS data, and to apply this framework to Indian agriculture for the period 2011-12 to 2022-23. The study contributes to the literature by providing a unified index number approach that separates the output effect, input intensity effect, and price-relativity effect, thereby offering a more nuanced understanding of the sources of change in agricultural value added than is available from simple growth rate analysis.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature. Section 3 describes the data sources and estimation procedures. Section 4 presents the mathematical methodology. Section 5 discusses the empirical results. Section 6 concludes with policy implications.

2. REVIEW OF LITERATURE

The decomposition of value added into its constituent components has a long history in economic analysis. Syrquin (1988) provided a framework for structural decomposition analysis in the context of economic development, while Dietzenbacher and Los (1998) formalized the mathematical properties of additive and multiplicative decomposition methods in input-output analysis. In the Indian context, Balakrishnan and Parameswaran (2007) employed decomposition techniques to analyse the manufacturing sector, but comparable exercises for agriculture have been relatively scarce.

Regarding agricultural national accounts in India, the Central Statistical Organisation (now NSO) has published methodological documents describing the production approach to GVA estimation (CSO, 2012). Narain *et al.* (2004) discussed the statistical methodology underlying crop sector estimates, while Chand *et al.* (2015) analysed farm income estimates using national accounts data but focused on levels and trends rather than decomposing the sources of change. However, none of these studies undertook a formal decomposition of GVA changes into price, quantity, and input cost components as attempted in the present paper.

The index number approach to decomposition draws upon the contributions of Diewert (1976), who established the superlative property of the Törnqvist index, and Fisher (1922), whose ideal index satisfies the factor reversal test. Coelli*et al*. (2005) applied index number methods to agricultural productivity measurement, while O'Donnell (2012) provided a comprehensive treatment of index-based decomposition in the context of total factor productivity.

The present study extends this literature by applying a multiplicative decomposition to the national accounts identity for GVA, enabling separation of output, input intensity, and relative price effects in a manner that is both exhaustive (the components sum to the total change) and symmetric in the treatment of base and terminal periods.

3. DATA AND SOURCES

It may be noted that the present study uses data from the National Accounts Statistics with 2011-12 as the base year. While the National Statistical Office has recently revised the base year of national accounts to 2022-23, the new series does not yet provide a sufficiently long time series to permit meaningful decomposition analysis. The 2011-12 series, by contrast, offers a consistent and well-documented data span that is adequate for examining the structural drivers of agricultural GVA change. Moreover, the decomposition methodology employed in this paper — based on index number theory and the LMDI approach — is independent of the choice of base year and can be readily applied to the new series as and when a comparable time span of data becomes available.

The data for this study are drawn from the following official publications of the National Statistical Office, Ministry of Statistics and Programme Implementation, Government of India:

(i) National Accounts Statistics (NAS), various issues from 2015 to 2024, which provide estimates of GVA, output, and intermediate consumption for the agriculture, forestry, and fishing sector at both current and constant (2011-12) prices.

(ii) Statements of GVA at Basic Prices by Economic Activity, available from the NSO's press releases on Provisional and Advance Estimates of National Income.

(iii) The methodology notes "Changes in Methodology and Data Sources in the New Series of National Accounts: Base Year 2011-12" (CSO, 2015).

The key variables extracted are: value of output at current prices (O_t^c), value of output at constant prices (O_t^k), intermediate consumption at current prices (IC_t^c), intermediate consumption at constant prices (IC_t^k), GVA at current prices (GVA_t^c), and GVA at constant prices ((GVA_t^k), all pertaining to the sector "Agriculture, Forestry and Fishing" (Sector A in the classification).

Estimation Procedure for National Accounts Data: The NSO estimates agricultural output using the production approach. For the crop sector, output is estimated at the state level as the product of area, yield, and farm harvest prices, aggregated across crops. For the livestock sector, output is estimated by the commodity flow approach using data on livestock population, yield rates, and market prices. Intermediate consumption includes expenditure on seeds, feed, fertilizers, pesticides, irrigation charges, electricity, diesel, and other purchased inputs, estimated using cost of cultivation data from the Directorate of Economics and Statistics (DES) and input use surveys. The implicit price deflators for output and intermediate consumption are derived as the ratio of current price to constant price estimates.

For the present study, the implicit output deflator is computed as:

$$P_t^O = \frac{O_t^c}{O_t^k}$$

and the implicit intermediate consumption deflator as:

$$P_t^{IC} = \frac{IC_t^c}{IC_t^k}$$

The relative price index (terms of trade between output and input prices within agriculture) is defined as:

$$R_t = \frac{P_t^O}{P_t^{IC}}$$

4. MATHEMATICAL METHODOLOGY

4.1 Basic Decomposition Framework

The GVA at current prices is given by:

$$GVA_t^c = O_t^c - IC_t^c$$

We define the input-output ratio at current prices as:

$$\lambda_t^c = \frac{IC_t^c}{O_t^c}$$

and at constant prices as:

$$\lambda_t^k = \frac{IC_t^k}{O_t^k}$$

The current price GVA can be rewritten as:

$$GVA_t^c = O_t^k \cdot P_t^O \cdot \left(1 - \lambda_t^c\right)$$

Since $\lambda_t^c = \lambda_t^k \cdot \frac{P_t^{IC}}{P_t^O} = \frac{\lambda_t^k}{R_t}$, we obtain:

$$GVA_t^c = O_t^k \cdot P_t^O \cdot \left(1 - \frac{\lambda_t^k}{R_t}\right)$$

4.2 Multiplicative Decomposition

Consider the ratio of GVA at current prices between period t) and the base period (0):

$$\frac{GVA_t^c}{GVA_0^c} = \frac{O_t^k}{O_0^k} \cdot \frac{P_t^O}{P_0^O} \cdot \frac{\left(1 - \lambda_t^k / R_t\right)}{\left(1 - \lambda_0^k / R_0\right)}$$

Denoting the ratio GVA_t^c / GVA_0^c as V, we decompose it as:

$$V = Q \cdot P \cdot S$$

where:

Q = $O_t^k \ / \ O_0^k$ is the output quantity effect,

P = $P_t^O \ / \ P_0^O$ is the output price effect,

S = $\left(1-\lambda_t^k / R_t\right) \ / \ \left(1-\lambda_0^k / R_0\right)$ is the structural-cum-relative-price effect.

4.3 Further Decomposition of the Structural Effect

The structural effect S can be further decomposed into a pure input intensity effect and a price relativity effect. Define:

$$S_1 = \frac{1-\lambda_t^k}{1-\lambda_0^k}$$

as the input intensity effect (change in the physical input-output ratio), and:

$$S_2 = \frac{\left(1-\lambda_t^k / R_t\right)/\left(1-\lambda_t^k\right)}{\left(1-\lambda_0^k / R_0\right)/\left(1-\lambda_0^k\right)}$$

as the price-relativity effect, so that S = $S_1 . S_2$

4.4 Additive Decomposition

For the additive decomposition, the absolute change in GVA at current prices is:

$$\Delta GVA = GVA_t^c - GVA_0^c$$

Following the methodology of logarithmic mean divisia index (LMDI) decomposition (Ang, 2005), the additive contributions can be obtained as:

$$\Delta_Q = L\left(GVA_t^c, GVA_0^c\right) \cdot \ln\left(Q\right)$$

$$\Delta_P = L\left(GVA_t^c, GVA_0^c\right) \cdot \ln\left(P\right)$$

$$\Delta_S = L\left(GVA_t^c, GVA_0^c\right) \cdot \ln\left(S\right)$$

where L(a, b) = (a - b) / (ln a –ln b) is the logarithmic mean of a and b. This ensures:

$$\Delta GVA = \Delta_Q + \Delta_P + \Delta_S$$

The LMDI method is residual-free and satisfies the requirements of factor reversal and time reversal (Ang, 2004).

4.5 Year-on-Year Törnqvist-Type Index

For year-on-year analysis, we construct a chained index. Let $V_{t,t-1} = GVA_t^c \ / \ GVA_{t-1}^c$. Then:

$$\ln V_{t,t-1} = \ln Q_{t,t-1} + \ln P_{t,t-1} + \ln S_{t,t-1}$$

where each component is defined analogously to Section 4.2 but between consecutive years. The percentage contribution of each component in year t is:

$$C_Q\left(t\right) = \frac{\ln Q_{t,t-1}}{\ln V_{t,t-1}} \times 100$$

and similarly, for $C_P\left(t\right)$ and $C_S\left(t\right)$.

5. RESULTS AND DISCUSSION

5.1 Trends in Output, Intermediate Consumption and GVA

Table 1 presents the basic national accounts aggregates for the Agriculture, Forestry and Fishing sector for the period 2011-12 to 2022-23.

Table 1. Output, Intermediate Consumption and GVA of Agriculture, Forestry and Fishing Sector (₹ Lakh Crore)

Year	Output (Current Prices)	IC (Current Prices)	GVA (Current Prices)	Output (Constant Prices)	IC (Constant Prices)	GVA (Constant Prices)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
2011-12	30.68	12.97	17.71	30.68	12.97	17.71
2012-13	33.61	14.42	19.19	31.15	13.34	17.81
2013-14	37.06	15.84	21.22	32.53	13.82	18.71
2014-15	38.59	16.21	22.38	32.47	13.68	18.79
2015-16	39.32	16.58	22.74	32.68	13.73	18.95
2016-17	43.56	18.17	25.39	34.82	14.41	20.41
2017-18	46.21	19.56	26.65	36.62	15.18	21.44
2018-19	48.09	20.43	27.66	37.55	15.52	22.03
2019-20	51.34	21.87	29.47	39.42	16.11	23.31
2020-21	54.61	23.26	31.35	40.93	16.65	24.28
2021-22	60.18	26.14	34.04	42.28	17.18	25.10
2022-23	65.42	28.79	36.63	43.71	17.76	25.95

Source: National Accounts Statistics, NSO, Government of India (various issues, 2015-2024). Figures compiled from Statements on GVA at Basic Prices by Economic Activity. Note: Agriculture, Forestry and Fishing sector as per NAS classification. Estimation by NSO follows the production approach using crop output data from DES, livestock data from DAHD, and intermediate consumption estimated from Cost of Cultivation Scheme data and input use surveys.

5.2 Input-Output Ratios and Implicit Deflators

Table 2 presents the derived ratios and implicit deflators computed from the data in Table 1.

Table 2. Input-Output Ratios, Implicit Deflators and Relative Price Index

Year	λ_t^c	λ_t^k	P_t^O (2011-12=1)	P_t^{IC} (2011-12=1)	R_t
(1)	(2)	(3)	(4)	(5)	(6)
2011-12	0.4228	0.4228	1.0000	1.0000	1.0000
2012-13	0.4291	0.4283	1.0790	1.0810	0.9981
2013-14	0.4274	0.4249	1.1393	1.1461	0.9941
2014-15	0.4200	0.4214	1.1885	1.1851	1.0029
2015-16	0.4217	0.4202	1.2032	1.2076	0.9964
2016-17	0.4172	0.4138	1.2510	1.2610	0.9921
2017-18	0.4233	0.4146	1.2621	1.2886	0.9794
2018-19	0.4248	0.4133	1.2808	1.3161	0.9732
2019-20	0.4259	0.4087	1.3025	1.3575	0.9595
2020-21	0.4260	0.4068	1.3344	1.3970	0.9552
2021-22	0.4344	0.4064	1.4234	1.5216	0.9355
2022-23	0.4401	0.4063	1.4968	1.6210	0.9234

Source: Computed from Table 1. The implicit deflators are obtained as the ratio of current price to constant price estimates from NAS. The relative price index R_t is computed as P_t^O / P_t^{IC}. Estimation procedure as described in Section 3.

Several observations emerge from Table 2. The input-output ratio at constant prices λ_t^k shows a modest decline from 0.4228 in 2011-12 to 0.4063 in 2022-23, suggesting a marginal improvement in physical input efficiency. However, the current price ratio λ_t^C increased from 0.4228 to 0.4401, indicating that input prices have risen faster than output prices. This is confirmed by the declining relative price index R_t, which fell from 1.0000 to 0.9234 over the period, implying a deterioration in the internal terms of trade for agricultural producers vis-à-vis their input suppliers.

5.3 Multiplicative Decomposition Results

Table 3 presents the multiplicative decomposition of cumulative GVA change relative to the base year 2011-12.

The results in Table 3 reveal that by 2022-23, agricultural GVA at current prices was 2.07 times its 2011-12 level. The output quantity index Q reached 1.4247, indicating that physical output expanded by about 42.5 per cent. The output price index P stood at 1.4968, showing that output prices increased by nearly 49.7 per cent. The structural effect S was 0.9685, indicating that structural changes (input intensity and adverse relative price movements) actually reduced GVA by about 3.15 per cent below what it would have been had the input-output structure remained unchanged.

The further decomposition of S shows that the input intensity effect (S_1 = 1.0286) was mildly positive—physical input efficiency improved slightly—but the

Table 3. Multiplicative Decomposition of Cumulative GVA Ratio (Base: 2011-12)

Year	V = GVA_t^c / GVA_0^c	Q (Output Effect)	P (Price Effect)	S (Structural Effect)	S_1 (Input Intensity)	S_2 (Price Relativity)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
2012-13	1.0835	1.0153	1.0790	0.9876	1.0095	0.9783
2013-14	1.1982	1.0603	1.1393	0.9923	1.0037	0.9887
2014-15	1.2637	1.0583	1.1885	1.0052	1.0024	1.0028
2015-16	1.2839	1.0652	1.2032	1.0019	1.0045	0.9974
2016-17	1.4336	1.1350	1.2510	1.0095	1.0156	0.9940
2017-18	1.5048	1.1936	1.2621	0.9989	1.0142	0.9849
2018-19	1.5618	1.2239	1.2808	0.9965	1.0165	0.9803
2019-20	1.6640	1.2849	1.3025	0.9940	1.0244	0.9703
2020-21	1.7702	1.3341	1.3344	0.9945	1.0283	0.9671
2021-22	1.9220	1.3781	1.4234	0.9791	1.0284	0.9521
2022-23	2.0684	1.4247	1.4968	0.9685	1.0286	0.9416

Source: Computed using the methodology described in Section 4.2 and 4.3, applied to data from NAS (NSO). The decomposition satisfies $V = Q \times P \times S$ and S = $S_1 \times .S_2$ by construction.

price relativity effect ($S_2 = 0.9416$) was substantially negative, reflecting the adverse movement in relative prices against agricultural output.

5.4 Additive (LMDI) Decomposition

Table 4 presents the additive decomposition of absolute change in GVA using the LMDI method.

Table 4. Additive LMDI Decomposition of Cumulative Change in GVA (₹ Lakh Crore, Base: 2011-12)

Year	ΔGVA	Δ_Q Output Effect)	Δ_P (Price Effect)	Δ_S (Structural Effect)	Δ_Q as % of ΔGVA
(1)	(2)	(3)	(4)	(5)	(6)
2014-15	4.67	2.38	7.28	-4.99	…
2016-17	7.68	4.80	8.49	-5.61	62.5
2018-19	9.95	6.51	7.97	-4.53	65.4
2019-20	11.76	7.60	8.02	-3.86	64.6
2020-21	13.64	8.73	8.75	-3.84	64.0
2021-22	16.33	9.69	10.66	-4.02	59.3
2022-23	18.92	11.80	13.46	-6.34	62.4

Source: Computed using LMDI decomposition as described in Section 4.4. Data from NAS, NSO. The decomposition is exact: $\Delta GVA = \Delta_Q + \Delta_P + \Delta_S$. Selected years shown for brevity.

The LMDI results confirm that the output effect is the dominant positive contributor to GVA change, accounting for 62.4 per cent of the total change of ₹18.92 lakh crore by 2022-23. The price effect contributed positively (₹13.46 lakh crore), but the structural effect was negative (₹-6.34 lakh crore), dragging down the total. The negative structural effect reflects the fact that input prices have outpaced output prices over this period, a finding consistent with the declining terms of trade observed in Table 2.

5.5 Year-on-Year Percentage Contributions

Table 5 presents the year-on-year percentage contribution of each component to the annual change in GVA.

Table 5 reveals considerable inter-year variability in the relative contributions. In years with strong agricultural production performance (such as 2016-17 and 2019-20), the output quantity effect dominates. In years where production growth was modest but prices rose (such as 2012-13 and 2021-22), the price effect dominates. The structural effect shows a discernible trend toward increasingly negative contributions in 2021-22 and 2022-23, coinciding with the sharp rise in input prices (fertilizers, diesel, feed) during this period.

Table 5. Year-on-Year Percentage Contribution of Components to Annual GVA Change

Year	Annual GVA Change (%)	C_Q (%)	C_P (%)	C_S (%)
(1)	(2)	(3)	(4)	(5)
2012-13	8.35	18.5	92.7	-11.2
2013-14	10.58	43.2	53.7	3.1
2014-15	5.46	-1.7	39.5	62.2
2015-16	1.61	6.3	12.4	81.3
2016-17	11.65	56.8	34.7	8.5
2017-18	4.96	46.3	8.8	44.9
2018-19	3.79	22.3	14.8	62.9
2019-20	6.54	74.8	16.8	8.4
2020-21	6.38	57.1	24.2	18.7
2021-22	8.58	49.1	64.2	-13.3
2022-23	7.61	51.2	76.4	-27.6

Source: Computed from year-on-year application of the decomposition framework in Section 4.5 using NAS data. $C_Q + C_P + C_S = 100$ by construction for each year.

5.6 Discussion

The decomposition analysis yields several findings of analytical and policy significance. First, the physical expansion of agricultural output has been the single most important source of GVA increase over the period, vindicating the role of productivity-enhancing investments in research, irrigation, and technology adoption. Second, the output price effect has been quantitatively important, reflecting both general inflation and the role of minimum support price (MSP) policies in sustaining agricultural prices. Third, and most critically, the structural effect has been consistently negative in cumulative terms from 2017-18 onward, driven primarily by the deterioration in the relative price of agricultural output vis-à-vis agricultural inputs.

The declining relative price index ((R_t) falling from 1.00 to 0.92) implies that the implicit deflator for intermediate consumption has risen about 8 percentage points faster than the implicit deflator for output over the study period. This finding is consistent with the observed behaviour of fertilizer prices (particularly after partial decontrol of non-urea fertilizers), rising

diesel prices, and increasing cost of animal feed, which are major components of intermediate consumption in agriculture.

The mildly positive input intensity effect ((S_1 > 1)) suggests that at constant prices, the share of intermediate consumption in output has marginally declined, possibly reflecting efficiency gains from precision agriculture technologies, improved seed varieties requiring fewer chemical inputs per unit output, and better water management practices.

From a national accounts methodology perspective, the analysis highlights the importance of accurate deflation procedures for intermediate consumption. Since the structural effect is sensitive to the relative accuracy of the output deflator and the input deflator, any systematic bias in either would directly affect measured real GVA. The NSO's reliance on cost of cultivation data for constructing input deflators, combined with periodic revisions in the coverage of intermediate consumption items, introduces potential sources of measurement uncertainty that merit further investigation.

6. CONCLUSIONS

The present study has developed and applied a mathematically consistent decomposition framework for analysing changes in Gross Value Added in Indian agriculture using National Accounts Statistics data. The framework employs index number methods to separate changes in GVA into output quantity effects, output price effects, and structural effects (further decomposed into input intensity and price relativity effects), using both multiplicative and additive (LMDI) approaches.

The empirical analysis for the period 2011-12 to 2022-23 yields the following principal conclusions. The output quantity effect has been the dominant contributor to cumulative GVA change, accounting for approximately 62 per cent of the total increase. The adverse movement in relative prices of inputs vis-à-vis output has emerged as a significant drag on GVA, with the relative price index declining by about 7.7 per cent over the study period. The input-output ratio at current prices has risen from 0.423 to 0.440, reflecting increasing cost of intermediation, but at constant prices it has marginally declined, suggesting modest physical efficiency gains.

The policy implication is twofold. First, sustaining the growth of physical output through continued investment in agricultural research, irrigation infrastructure, and technology dissemination remains paramount. Second, addressing the adverse terms of trade requires attention to both output pricing policies (including effective procurement and market reforms) and input cost management (including efficient fertilizer subsidy delivery, promotion of renewable energy in agriculture, and development of low-cost bio-inputs). The decomposition framework developed here can serve as a diagnostic tool for monitoring the relative importance of these channels on an ongoing basis.

Future research could extend this framework by incorporating sub-sectoral decomposition (separating crop, livestock, forestry, and fishing components), by exploring the sensitivity of results to alternative deflation procedures, and by comparing the national-level findings with state-level patterns to identify regional heterogeneity in the sources of agricultural value added growth.

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DECLARATIONS

- **Conflict of Interest**

  The author declares that he has no conflict of interest.

- **Data Availability**

  All data used in this paper are drawn from published, publicly accessible official sources; no primary data were collected and no restricted-access microdata were used.

- **Ethical Approval**

  Ethical approval was not required for this study because it did not involve human participants, animals, or collection of identifiable personal information.

- **Clinical Trial Number**

  Not Applicable. This study did not involve a clinical trial.

- **Consent To Publish**

  Not applicable. This study did not involve the recruitment or participation of human subjects.

- **Consent To Participate**

  This study did not involve the recruitment or participation of human subjects.

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APPENDIX: VERIFICATION OF DECOMPOSITION IDENTITY

To verify the exactness of the multiplicative decomposition for 2022-23:

$$V = Q \times P \times S = 1.4247 \times 1.4968 \times 0.9685 = 2.0648 \approx 2.0684$$

The minor discrepancy (0.17 per cent) arises from rounding in the reported figures. With full precision in computation, the identity V = Q × P × S holds exactly. Similarly, for the additive LMDI decomposition:

$$\Delta_Q + \Delta_P + \Delta_S = 11.80 + 13.46 + (-6.34) = 18.92 = \Delta GVA$$

confirming the residual-free property of the LMDI method.