

Article

Is the Serbian Dinar Overvalued? Exchange-Rate Misalignment and Asymmetric Profitability in Fruit Exports and Livestock Fattening

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Abstract

Serbia's nominal exchange rate has remained near 117 RSD/EUR since 2018, while domestic inflation has persistently exceeded the euro-area rate, producing real appreciation and raising concerns about agricultural competitiveness. This paper assesses dinar misalignment over 2010–2024 using three complementary but non-equivalent benchmarks: purchasing power parity (PPP), the behavioral equilibrium exchange rate (BEER, estimated through Johansen cointegration), and the fundamental equilibrium exchange rate (FEER). The PPP and FEER benchmarks indicate dinar overvaluation of approximately –23% and –13% by end-2024, whereas the fundamentals-based BEER places the dinar close to equilibrium over 2016–2024. These results are interpreted as layered diagnostics of price competitiveness, fundamentals consistency, and external sustainability, rather than as a single jointly identified equilibrium range. Sectoral simulations show strong asymmetry: depreciation raises IRR in export-oriented fruit/IQF production from 3% to 12%, while reducing livestock-fattening IRR from 9% to 6% through higher imported feed costs. Monte Carlo checks confirm these qualitative rankings across plausible pass-through and cost-share ranges. Maintaining the nominal corridor also carries a quasi-fiscal burden: NBS official interest expenses linked to sterilization amount to RSD 111.4 billion over 2021–2024, or 0.07–0.57% of GDP annually. The findings suggest that exchange-rate policy has simultaneous competitiveness, sectoral-distributional and quasi-fiscal dimensions, requiring gradual, transparent and exposure-differentiated policy responses.

Keywords: real exchange rate misalignment; purchasing power parity; behavioral equilibrium exchange rate; fundamental equilibrium exchange rate; internal rate of return; sterilization cost; quasi-fiscal cost; fresh raspberry; case study; agriculture; Serbia

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1. Introduction

Over the past decade, agriculture has accounted for approximately 6–7% of Serbia's gross domestic product (GDP) [1] and generated around 21% of the country's total merchandise foreign exchange inflows [2]. Despite its macroeconomic relevance, the sector's performance has been increasingly constrained by a macroeconomic configuration rarely observed in comparable emerging economies: the coexistence of elevated domestic

inflation and a highly stable nominal exchange rate. Since 2018, the Serbian dinar has remained within a highly stable corridor averaging near 117 RSD per euro (typically within ± 1 RSD) [3], while cumulative consumer price inflation in Serbia over 2018–2024 reached approximately 44.6%, compared with about 24.2% in the euro area over the same period [4,5]. This pronounced divergence in inflation dynamics has translated into a sustained real appreciation of the dinar. Real appreciation typically weakens export price competitiveness and, when export prices are internationally determined and pricing power is limited, compresses exporters' profit margins [6].

Exchange-rate conditions are transmitted to the agricultural sector through relatively direct border-price parity and imported input channels [7,8]. Although Serbia's nominal rate has been highly stable (i.e., volatility has been low), stability alone does not eliminate the risk of real misalignment when inflation differentials persist over time. More broadly, the literature shows that exchange-rate volatility can affect export competitiveness and export performance. Accordingly, policies aimed at stabilizing the exchange rate may mitigate volatility and are associated with improved agricultural export outcomes [9]. Exchange-rate movements additionally influence food prices, particularly through import-cost and tradable-price channels in open economies [10]. Consistent with this mechanism, the evidence suggests that pass-through is typically faster to import prices than to aggregate consumer prices [11].

Consistent with these transmission channels, Serbia's raspberry sector (and frozen berries), an important source of employment and foreign-exchange earnings, has seen a decline in global competitiveness in recent decades, despite high product quality [12]. Serbia's frozen raspberries are primarily exported to European Union markets, where trade settlements are typically denominated in euros [13]. Therefore, any nominal appreciation of the dinar reduces the dinar value of export revenues and erodes price competitiveness in EU markets. In contrast, Serbia's livestock sector has faced persistent structural and economic pressures—shrinking herds, weak productivity growth, and declining competitiveness in both domestic and EU markets [14], and these weaknesses are further amplified by exchange-rate exposure. Farm-gate prices are largely dinar-denominated, while key inputs (protein concentrates, premixes, and mineral supplements) are often imported and closely linked to the exchange rate. Consequently, maintaining nominal exchange-rate stability amid a persistent inflation differential operates as a redistributive mechanism across subsectors. In euro-invoiced fruit exports, it lowers the domestic-currency value of revenues and undermines price competitiveness, whereas in livestock, it transmits primarily through the imported input channel, raising effective costs and tightening margins where output prices adjust only imperfectly.

These asymmetric transmission mechanisms ultimately hinge on the degree of real exchange-rate misalignment. If the nominal corridor is maintained while inflation differentials persist, the dinar may become overvalued in real terms—systematically affecting export revenues, import costs, and investment incentives across subsectors [15,16]. This makes the empirical identification of the dinar's equilibrium value a prerequisite for evaluating competitiveness and profitability effects in Serbian agriculture [17,18].

Exchange-rate misalignment is most commonly assessed using three complementary equilibrium concepts: purchasing power parity (PPP), the behavioral equilibrium exchange rate (BEER), and the fundamental equilibrium exchange rate (FEER) [19–21]. These frameworks offer complementary perspectives. PPP primarily captures price-level discrepancies. BEER incorporates key economic fundamentals such as terms of trade and net foreign asset positions, and FEER is based on estimates of a sustainable current account balance. However, the domestic literature lacks an integrated assessment that simultaneously applies all three approaches and systematically links macro-level estimates of

exchange rate (mis)alignment with micro-level indicators of profitability and competitiveness in agriculture.

Against this background, the present study pursues a dual objective over the period 2010–2024. First, it quantifies the real value of the Serbian dinar by jointly applying the PPP, BEER, and FEER frameworks, thereby deriving a layered assessment of price-based, fundamentals-based, and external-balance-based exchange-rate gaps at the end of 2024. Second, it examines the distribution of gains and losses arising from exchange rate movements across two representative agricultural subsystems: export-oriented fruit production and import-input-intensive livestock farming through a microeconomic lens, using internal rates of return (IRR) as the principal performance metric.

The analysis is guided by the following research questions:

- RQ1. What is the magnitude of the price-based, fundamentals-based, and external-balance-based gaps between the observed nominal exchange rate and its equilibrium level;
- RQ2. How does a nominal exchange-rate adjustment toward the policy-relevant adjustment corridor of 130–140 RSD/EUR affect the internal rates of return of fruit and livestock investment projects over an eight-year horizon;
- RQ3. What is the quasi-fiscal cost of maintaining the nominal exchange-rate corridor, measured as the NBS sterilization burden over 2021–2024, and how does this cost evolve across the interest-rate cycle?

The scientific contribution of this paper is threefold. First, it provides, for the first time in the Serbian context, an integrated macroeconomic assessment of exchange-rate equilibrium based on the joint application of PPP, BEER, and FEER methodologies using data through the third quarter of 2024. Second, it explicitly links macro-level exchange-rate misalignment estimates with micro-financial indicators of internal rates of return in key agricultural subsectors. Third, it quantifies the fiscal cost associated with maintaining a nominally “strong” dinar through sterilization operations conducted by the National Bank of Serbia. Relative to prior Serbian and Western Balkan studies, which apply a single equilibrium concept in isolation—typically ARDL/BEER-style estimates [22] or external-sustainability calculations [23]—the value added of this paper lies in the joint, mutually disciplining application of all three benchmarks on a common dataset and, above all, in translating the resulting misalignment range into project-level investment metrics (IRR, NPV) for concrete agricultural production systems. To the best of our knowledge, no previous study on Serbia or the wider Western Balkans provides this macro-to-micro mapping, although the region’s combination of de facto exchange-rate stabilization, high euroization and agri-food trade exposure makes the question directly relevant beyond Serbia [24].

The remainder of the paper is structured as follows: Section 2 reviews the relevant literature on real exchange-rate equilibrium frameworks, institutional benchmarks, and their implications for agricultural outcomes. Section 3 describes the data and methodology. Section 4 presents the empirical results, including PPP, BEER, and FEER estimates, sector-specific IRR simulations, and macro-fiscal implications of exchange-rate smoothing. Section 5 discusses the findings and formulates macroeconomic and agricultural policy recommendations, while Section 6 concludes and outlines avenues for future research.

2. Literature Review

Cassel [25] formalized purchasing power parity (PPP) as a benchmark for exchange-rate equilibrium. In applied work, PPP is most often implemented in its relative form as a parsimonious long-run anchor for the real exchange rate, albeit with slow mean reversion [26]. The BEER approach then conditions the equilibrium RER on key fundamentals—

terms of trade, net foreign assets, and relative productivity—an attractive feature in transition economies where external positions and structural change are central drivers [17]. By contrast, the FEER framework defines equilibrium through external sustainability, i.e., the exchange rate consistent with a target current account and a stable path of external debt. Consequently, estimates depend on the assumed CA^* and trade elasticities [18]. Building on Williamson's FEER concept [27], institutional implementations such as the IMF's CGER framework [18] and the External Balance Assessment (EBA) methodology provide operational, multilaterally consistent benchmarks for assessing external sustainability and exchange-rate misalignment [28–30]. In the transition economies of the Western Balkans, equilibrium RER estimates grounded in fundamentals and external-balance conditions are widely used as operational benchmarks for identifying potential misalignment, particularly risks of overvaluation that can erode competitiveness [31–33]. Complementing these studies, IMF evidence for the region emphasizes that heterogeneity in exchange-rate regimes and financial euroization shapes the transmission of external shocks across the Western Balkans [24]. For Serbia, CGER/ES-style single-country assessments likewise point to persistent medium-term overvaluation, including ARDL-based ERER estimates with explicit relevance for agriculture [22] and external-sustainability calculations based on current-account norms [23].

A large, applied literature, therefore, triangulates across price-based (PPP), fundamentals-based (BEER), and external-sustainability (FEER/CGER) benchmarks because each concept captures a different notion of “equilibrium” and each carries distinct identification and specification risks. In particular, FEER-style approaches operationalize equilibrium through a sustainable current account and provide a policy-relevant yardstick for external balance, while BEER frameworks recover an equilibrium in the real exchange rate implied by observable fundamentals in a cointegration setting [17,18].

The salience of exchange-rate policy for agriculture has been emphasized since Schuh's classic contribution [15], which linked currency overvaluation to agricultural adjustment and trade performance. Exchange-rate misalignment matters in agriculture because the sector is simultaneously exposed on the revenue side and the cost side, and through balance sheets. The literature typically emphasizes three channels. First is price pass-through. With many agricultural outputs benchmarked to euro-denominated reference prices, nominal exchange-rate changes map into domestic-currency prices; the export price elasticity is often estimated at about 0.8 [16]. Second is the imported-input channel: a weaker dinar raises the domestic cost of tradable inputs, particularly mineral fertilizers, protein concentrates and energy, thereby increasing marginal costs, especially in livestock production [34]. Third is the investment and credit channel: in a highly euroized financial system with widespread FX and FX-indexed lending, depreciation increases the local-currency burden of servicing foreign-currency(-linked) debt. At the same time, where trade is predominantly invoiced in foreign currency, depreciation raises the dinar value of foreign-currency export receipts—so projects with euro-linked revenues may see higher dinar cash flows (and potentially higher IRRs) despite the heavier debt-service burden [35].

Sterilized foreign-exchange intervention can generate economically meaningful quasi-fiscal costs when liquidity is absorbed at positive interest rates, particularly in higher-rate environments [36]. Consequently, assessing exchange-rate policy requires quantifying not only real-sector competitiveness effects but also the sterilization burden on the central bank balance sheet and, indirectly, on the consolidated public sector.

Beyond macro balance and competitiveness, exchange-rate movements matter for agriculture through project-level profitability because revenue and cost components often differ in currency denomination and import intensity across subsectors. This motivates linking macro misalignment benchmarks to investment-performance metrics (e.g., IRR) in

representative production systems, using exchange-rate pass-through and imported-input exposure as key transmission parameters [37].

Against this background, empirical work on transition economies increasingly treats real exchange-rate misalignment as a determinant of both external sustainability and tradable-sector performance. Overvaluation episodes are typically associated with weaker export performance and slower structural transformation (via reduced profitability and investment in tradables), while FEER/CGER-style assessments frame the equilibrium exchange rate as the adjustment needed to close excessive current-account gaps relative to a sustainable external position [18,38,39]. These linkages are particularly salient in agriculture, where exchange-rate movements simultaneously affect euro-denominated export revenues, the domestic cost of import-intensive inputs, and the financial viability of investment under euroized balance sheets. As a result, the same exchange-rate configuration can redistribute profitability across agricultural subsectors, with implications for capital allocation and longer-run competitiveness [40].

3. Data and Methodology

The empirical analysis covers Serbia over 2010–2024 and combines monthly and quarterly series. The nominal bilateral exchange rate S_t is the NBS middle rate (RSD/EUR). Price levels are measured by Serbia's consumer price index (CPI) $P_{RS,t}$ and the euro area harmonized index of consumer prices (HICP) $P_{EA,t}$, both rebased to 2015 = 100. The bilateral real exchange rate is defined as:

$$q_t = \ln S_t + \ln P_{EA,t} - \ln P_{RS,t} \quad (1)$$

where higher q_t denotes real depreciation of the dinar against the euro area (higher S means more RSD per EUR, i.e., a weaker dinar). For ease of interpretation, q_t is normalized to zero at the start of the sample. The relative-PPP indicator derived from Equations (2) and (3) is best interpreted as a cumulative price-level divergence measure benchmarked to 2010 (treating 2010 as the reference year for bilateral price parity), not as an independently determined nominal equilibrium rate. Note that a fully chain-linked relative-PPP construction anchored at the 2010 spot rate would imply a 2024 nominal benchmark of approximately 161 RSD/EUR; the difference from the 151.3 figure reported in Section 4.1 reflects the use of Eurostat absolute price-level indices [41] rather than a chain-linked CPI ratio. Re-anchoring the same construction to 2014—a year in which the relative-PPP gap was approximately zero (+0.5%; see Section 4.1)—yields a 2024 benchmark of approximately 157 RSD/EUR, so the sign and broad magnitude of the 2024 gap are not artifacts of the 2010 base year. The PPP estimate is, therefore, presented as an upper-bound descriptive benchmark, with BEER and FEER providing the primary structural and external-balance estimates. In what follows, we treat the real exchange rate RER_t as the level-consistent counterpart of q_t (so that $\ln RER_t \equiv q_t$ up to a normalization constant). PPP misalignment is measured via:

$$PPP_t = S_t \times (P_{RS,t}/P_{EA,t}) \quad (2)$$

where PPP_t is the PPP-implied RSD/EUR rate in period t . Intuitively, Equation (2) asks what the nominal rate would have to be for Serbian and euro-area price levels to have moved in step since the base year.

The PPP gap is then defined as (measuring the cumulative price-level divergence between Serbia and the euro area relative to the 2010 base-year price ratio):

$$PPP\ gap_t = (S_t - PPP_t)/PPP_t \quad (3)$$

For BEER estimation, we use quarterly fundamentals: (i) terms of trade (TOT_t), measured quarterly as the ratio of the implicit national account deflators of exports and imports

of goods and services (current-price over chained-volume series), with annual UNCTAD unit-value indices [42] retained only as a cross-check; (ii) net foreign assets-to-GDP (NFA_t/GDP_t), constructed from the international investment position (IIP) scaled by quarterly GDP; and (iii) a proxy for relative productivity ($PROD_t$). The productivity proxy $PROD_t$ is measured as log real GDP (chained-volume series, four-quarter moving average). A CPI/HICP relative-price ratio cannot serve as the productivity regressor because, under the definitions in Equation (1), it is mechanically collinear with the regression ($\ln RER = \ln S - \ln(CPI/HICP)$ holds as an identity). The long-run relationship is specified as:

$$\ln RER_t = \alpha_0 + \alpha_1 \ln TOT_t + \alpha_2 (NFA_t/GDP_t) + \alpha_3 \ln PROD_t + u_t \quad (4)$$

Cointegration is estimated using Johansen's method in a VECM framework. Prior to cointegration testing, all four variables are pre-tested for unit roots: ADF, Phillips–Perron and KPSS tests concur that $\ln RER$, NFA/GDP and $\ln PROD$ are $I(1)$. For $\ln TOT$, the ADF test on first differences is inconclusive, but the Phillips–Perron test strongly rejects a unit root in the differences, so all variables are treated as $I(1)$ (full test battery in Supplementary File S3). Lag order is selected at $p = 2$ by both the Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC); residual diagnostics on the estimated system (Ljung–Box $Q(4) p = 0.42$ and $Q(8) p = 0.75$; ARCH-LM(4) $p = 0.72$; Jarque–Bera $p = 0.88$) confirm model adequacy at the chosen lag. Both Johansen tests identify the $r = 1$ cointegrating vector at the 5% significance level (trace statistic = 49.2 against a 95% critical value of 47.9; max-eigenvalue statistic = 37.0 against 27.6), and neither test rejects $r \leq 1$. The VECM is, therefore, estimated with one cointegrating relation, two lags in differences, and the constant restricted to the cointegrating relation. Given the 35-quarter estimation sample, the Johansen asymptotics are approximate; the rank decision is accordingly read jointly with the robustness checks reported in Section 4.1 and Supplementary File S3.

FEER is derived as the nominal exchange rate consistent with external sustainability. We adopt a baseline current-account target of $CA^* = -3\%$ of GDP (with sensitivity checks for alternative targets). The required adjustment is mapped using a reduced-form elasticity approach:

$$\Delta CA \approx \eta_X (\Delta X/X) - \eta_M (\Delta M/M) \quad (5)$$

$$\Delta CA \approx \varepsilon (\ln RER - \ln RER^*) \quad (6)$$

where CA is the current account balance (as % of GDP), X and M denote exports and imports, and η_X and η_M are the export and import elasticities with respect to the real exchange rate (set to $\eta_X = 0.7$ and $\eta_M = 0.5$, following the CGER benchmark values [18]). Serbia's observed current account in 2024 stands at $CA_{obs} \approx -4.7\%$ of GDP [3,30]. Throughout Equation (5,6), current-account variables are expressed as decimal fractions of GDP (e.g., -4.7% is entered as -0.047). The aggregate semi-elasticity in Equation (6) is defined as $\varepsilon = [\eta_X \times (X/GDP) + (\eta_M - 1) \times (M/GDP)]$, where trade shares $X/GDP \approx 0.55$ and $M/GDP \approx 0.58$ are taken from SORS [43]. The mechanical substitution of the CGER elasticities yields $\varepsilon = [0.7 \times 0.55 + (0.5 - 1) \times 0.58] = 0.385 - 0.290 = 0.095$. For the baseline calibration, ε is set to 0.12 to align the reduced-form FEER mapping with the observed trade-share and current-account sensitivity range. Under this calibration, the baseline scenario $CA^* = -3\%$ of GDP maps to $S^* = 135$ RSD/EUR. Sensitivity to this calibration is reflected in the alternative CA^* scenarios. The required RER shift for each scenario follows as $\Delta \ln(RER) = (CA^* - CA_{obs})/\varepsilon$, and the equilibrium nominal rate as $S^* = S_{obs} \times \exp[\Delta \ln(RER)]$. All overvaluation gaps use the convention $(S_{obs} - S^*)/S^*$, consistent with Equation (3) and the triangulation summary reported in Section 4.1. Intuitively, Equation (5,6) translates the gap between the observed

and the target current account into the real exchange-rate change needed to close it, given how strongly exports and imports respond to the exchange rate.

Because PPP, BEER and FEER capture different concepts of equilibrium, the three benchmarks are interpreted as a layered assessment rather than a single overlapping interval. The BEER estimate, based on observed 2016Q1–2024Q3 fundamentals, places the dinar close to its prevailing nominal level and, therefore, serves as the fundamentals-based lower bound of the equilibrium assessment. The FEER baseline of 135 RSD/EUR ($CA^* = -3\%$ of GDP) provides the external-balance benchmark, and sensitivity analysis across the CA^* targets of -2% to -4% of GDP yields a FEER range of 124–147 RSD/EUR, reflecting the full span of plausible current-account norms for Serbia. The relative PPP index (151.3 RSD/EUR) lies above this range; it captures the cumulative domestic/euro-area inflation differential since 2010 under the maintained assumption that the dinar was at equilibrium in 2010 and is best interpreted as a price-competitiveness measure rather than an independent nominal equilibrium benchmark. The 130–140 RSD/EUR range, adopted for the sectoral scenarios, is a scenario corridor motivated primarily by the FEER benchmark and sectoral stress testing. It is not an intersection of the BEER and FEER estimates, since the fundamentals-based BEER places the dinar near its prevailing level.

Methodology at a glance—three questions, three benchmarks: PPP asks what would the exchange rate be if it had moved one-for-one with the inflation differential accumulated since the base year? It is a price-competitiveness benchmark—transparent and easily communicated, but sensitive to the base year and silent on fundamentals. BEER asks what exchange rate do observable macroeconomic fundamentals (terms of trade, net foreign assets, productivity) currently justify? It is estimated econometrically (Johansen cointegration/VECM) based on observed data, but in a managed-rate sample, it can partly rationalize the prevailing rate because the fundamentals themselves may have adjusted around it. FEER asks what exchange rate would bring the current-account deficit to a sustainable level? It is normative rather than estimated—the answer depends on the assumed sustainable deficit (CA^*) and on trade elasticities. Because the three questions differ, the three answers legitimately differ; this paper therefore reads them jointly—PPP for price competitiveness (151 RSD/EUR), FEER for external balance (≈ 135 RSD/EUR) and BEER for consistency with fundamentals (≈ 118 RSD/EUR)—rather than averaging them into a single number.

To translate exchange-rate misalignment into investment incentives, we simulate project-level profitability using internal rates of return (IRR) for two representative agricultural subsystems: (i) export-oriented fruit production (raspberries with IQF capacity) and (ii) import-input-intensive livestock production (beef fattening). For each project j , IRR is the discount rate r that satisfies:

$$0 = \sum_{t=0}^T CF_{j,t}/(1+r)^t \quad (7)$$

The baseline horizon is $T = 8$ years, and the discount rate for NPV computations is set to 10%. The eight-year horizon reflects sectoral production and asset life cycles: perennial orchards typically reach full yields in years 4–6, while intensive cattle fattening cycles close within 18–20 months. Nevertheless, the associated fixed assets (buildings, equipment, auxiliary infrastructure) are amortized over roughly seven years. The 10% discount rate is taken as a representative dinar-denominated cost of capital for the agri-sector, consistent with typical concessional (e.g., KfW) and commercial financing conditions. The project-level results in Sections 4.2 and 4.3 are calibrated scenario simulations under these stated assumptions—not econometric estimates—and are conceptually distinct from, and complementary to, the econometric BEER estimation of Section 4.1.

Exchange-rate exposure is parameterized via (i) output price pass-through η , linking euro-denominated revenues to dinar cash flows, and (ii) imported-input cost share θ ,

governing the euro-linked component of operating costs. In reduced form, operating cash flows can be written as:

$$\begin{aligned} \text{REV}_t^{\text{RSD}} &= \eta \cdot P_t^{\text{EUR}} \cdot Q_t \cdot S_t \\ \text{COST}_t^{\text{RSD}} &= \theta \cdot C_t^{\text{EUR}} \cdot S_t + (1 - \theta) \cdot C_t^{\text{RSD}} \end{aligned} \quad (8)$$

where $\text{REV}_t^{\text{RSD}}$ denotes revenues in dinars in period t ; P_t^{EUR} is the euro price per unit of output; Q_t is output quantity; and S_t is the nominal exchange rate (RSD/EUR). $\text{COST}_t^{\text{RSD}}$ denotes operating costs in dinars. C_t^{EUR} is the euro-priced component of unit costs (e.g., imported inputs/energy-linked items), while C_t^{RSD} is the dinar-priced domestic component (e.g., local labor and services). The parameter $\eta \in [0, 1]$ represents the effective pass-through from euro prices to realized dinar revenues (allowing for incomplete pass-through/contracting frictions), and $\theta \in [0, 1]$ is the share of costs that is effectively euro-linked. Equation (8) states, in reduced form, that a weaker dinar raises dinar revenues in proportion to how euro-linked sales are (η) and raises costs in proportion to how euro-linked inputs are (θ); the balance of the two exposures determines whether depreciation helps or hurts a given production system.

IRRs are computed under discrete exchange-rate scenarios aligned with the FEER-informed scenario corridor (e.g., 117, 130 and 140 RSD/EUR). Robustness is assessed using a Monte Carlo experiment over plausible ranges of η and θ . Both parameters are drawn from independent uniform distributions: $\eta \sim U[0.8, 1.0]$ for the fruit/IQF system and $\eta \sim U[0.1, 0.2]$ for livestock, while $\theta \sim U[0.2, 0.4]$ and $\theta \sim U[0.4, 0.7]$, respectively. Draws are treated as uncorrelated. Uniform distributions are deliberately chosen as conservative, non-informative priors over the plausible parameter bounds. Unlike bell-shaped alternatives, they do not concentrate probability mass on the central scenario, so the reported 5th–95th percentile bands are, if anything, wider than under comparable triangular or normal specifications. The bounds themselves reflect the pass-through evidence discussed in Section 2: near-complete pass-through for euro-invoiced FOB fruit exports and low output-price pass-through in the domestically priced livestock sector. The experiment uses 10,000 replications, and the results are reported as the median IRR together with 5th–95th percentile confidence bands.

Sterilization costs associated with exchange-rate smoothing are approximated using net FX purchases and the policy absorption rate. Specifically, the annual quasi-fiscal cost is computed as

$$\text{SC}_t = i^* (\text{FX}_t \cdot S_t^-) \quad (9)$$

where FX^e denotes estimated net FX purchases in euros, S_t^- is the average RSD/EUR exchange rate, and i^* is the NBS key policy rate. Equation (9) provides a lower-bound approximation of sterilization cost because it captures only the repo-rate cost on the estimated FX-purchase volume. Equation (9) is, therefore, not used as the primary reported measure; it is retained solely to decompose the structural drivers of cost variation. In the empirical section (Section 4.4), we report the NBS published annual interest expense as the primary official proxy, since it captures all sterilization instruments (repo sales, deposit facilities, and reserve requirements) and is drawn from audited NBS Annual Reports. The actual NBS key policy rate ranged from 1.0% (2021) to 6.5% (peak, July 2023), declining to 5.75% by end-2024, which produces the sharp 7× increase in sterilization cost between 2022 and 2023 reported in Section 4.4.

All series are harmonized to monthly/quarterly frequency and log-transformed where appropriate. The quarterly TOT proxy is computed directly from the quarterly national accounts, so no interpolation of annual indices is required. Annual averages of the proxy move in the same direction as the UNCTAD unit-value terms of trade over the overlapping years (Supplementary File S3). To capture livestock exposure to imported-

input costs, we construct a feed-cost index from corn and soybean meal prices (70/30 weights) [44], converted to dinars using S_t .

4. Results

4.1. PPP, BEER and FEER Estimates

A steadily widening price-based misalignment over the sample is noticeable, with the PPP-implied exchange rate for December of selected years reported in Table 1.

Table 1. PPP-based real exchange rate *.

Year	Nominal Exchange Rate RSD/EUR	CPI RS (2015 = 100)	HICP EA (2015 = 100)	PPP Rate *	PPP Gap **
2010	105.5	74.6	88.3	89.1	+18.4%
2012	113.7	87.2	91.6	108.3	+5.0%
2014	121.0	94.4	94.9	120.3	+0.5%
2016	123.5	98.8	99.7	122.4	+0.9%
2018	118.2	104.9	101.8	121.8	−3.0%
2020	117.6	117.3	103.6	133.1	−11.7%
2022	117.3	138.2	113.9	142.4	−17.6%
2024	117.0	149.6	115.7	151.3	−22.7%

Source: NBS [3]; SORS [43]; Eurostat [45]. Authors' calculations. * December end-of-period rate (NBS). PPP rate computed as $S_t \times (CPI_{st,t}/HICP_{ca,t})$. ** Gap = $(S_t - PPP_t)/PPP_t$; positive = dinar undervalued, negative = overvalued relative to PPP. December of each year.

The relative PPP series reveals a clear structural break. In 2010, the dinar was undervalued in relative PPP terms. The PPP-implied rate (89.1 RSD/EUR) stood below the observed nominal rate (105.5 RSD/EUR), implying a positive gap of +18.4%. This reflects the well-documented Balassa–Samuelson dynamic in catching-up economies, where productivity growth in tradables supports a real exchange rate above the level implied by aggregate price indices alone. As the cumulative inflation differential between Serbia and the euro area accumulated, the PPP-implied rate rose steadily, crossing the nominal rate around 2018 (PPP: 121.8 vs. S: 118.2, gap: −3.0%). From that point, the dinar has been overvalued in relative PPP terms, with the gap widening to −22.7% by end-2024 (PPP-implied: 151.3 RSD/EUR; nominal: 117.0 RSD/EUR) (Figure 1). Two stylized facts underlie this trajectory. First, Serbia's CPI rose from 74.6 to 149.6 (2015 = 100) between 2010 and 2024, a cumulative increase of approximately 100%, while the euro-area HICP advanced from 88.3 to 115.7 over the same period (approximately 31%), generating a persistent inflation differential. Second, the nominal exchange rate stabilized near 117 RSD/EUR from 2018 onwards, preventing the automatic nominal adjustment that would otherwise have closed the competitiveness gap. As a base-year robustness check, re-anchoring the PPP construction at 2014 (when the gap was ≈0) instead of 2010 yields a 2024 PPP-implied rate of approximately 157 RSD/EUR versus the 151.3 reported in Table 1, and a fully chain-linked CPI-ratio construction anchored at the 2010 spot rate yields approximately 161 RSD/EUR. The end-2024 overvaluation signal of roughly −20% to −25% is, therefore, robust to the anchoring choice. The Balassa–Samuelson effect qualifies the level interpretation. Part of the measured real appreciation reflects equilibrium relative-price convergence in a catching-up economy, so the PPP gap is best read as an upper bound on price-based misalignment.

In the BEER specification, the estimated long-run coefficients are economically interpretable and statistically significant, with signs consistent with theory under the convention of Equation (1), in which a higher real exchange rate denotes depreciation. The

productivity proxy enters negatively and significantly, consistent with the Balassa–Samuelson channel. The NFA/GDP coefficient is negative and strongly significant—the theory-consistent sign under this convention, since stronger net foreign asset positions are associated with real appreciation. And the terms-of-trade coefficient is negative and significant, indicating that terms-of-trade improvements are associated with real appreciation, i.e., a dominant income effect (Table 2). The error-correction term is negative (−0.24) and marginally significant ($t = -1.92$, $p \approx 0.06$), indicating gradual convergence toward the long-run equilibrium, with the short 35-quarter sample limiting the precision of the adjustment estimate. The BEER model is estimated over 2016Q1–2024Q3, the period for which quarterly NIIP data are directly observed, and Figure 2 plots the fitted equilibrium over this observed estimation sample. Pre-2016 quarters are excluded because a fully observed quarterly NFA/GDP series is not available before 2016Q1. A full replication package (Supplementary Files S3 and S4, comprising a methodological document and a companion workbook) documents all variable transformations and source mapping, the unit-root pre-tests, the Johansen cointegration tests (both the trace and the maximum-eigenvalue tests selecting rank 1 at the 95% level), the complete VECM output with diagnostics and stability tests, the robustness and out-of-sample checks, and the fitted equilibrium series. It also includes a reconciliation table documenting where the replicated statistics supersede the originally submitted values. The fitted BEER equilibrium tracks the nominal rate within $\pm 5\%$ throughout 2016–2024, with a misalignment of -0.8% at 2024Q3, indicating that, on the fundamentals-based BEER metric, the dinar remained close to equilibrium. This contrasts with the larger overvaluation signaled by the price-based PPP (-22.7%) and the external-balance FEER ($\approx -13\%$) measures; the divergence across the three approaches is itself informative and is discussed in Section 5.

Table 2. Long-run cointegration results.

Long-Run Variable	Coefficient	t -Statistic	Expected Sign	Outcome
ln TOT	−0.27	2.5	±	−
NFA/GDP	−0.42	8.9	−	−
ln PROD	−0.24	5.3	−	−
EC coeff.	−0.24	1.9	−	−

Source: Authors' calculations. Note: t-statistics are reported in absolute value for the cointegrating-vector coefficients (normal approximation for the error-correction term). Expected signs follow the convention of Equation (1), under which a higher real exchange rate denotes depreciation; a negative NFA/GDP coefficient therefore corresponds to the standard prediction that stronger net foreign assets appreciate the real exchange rate, and the negative terms-of-trade coefficient reflects a dominant income effect. The error-correction coefficient is marginally significant ($p \approx 0.06$); the remaining coefficients are significant at the 5% level. In the expected-sign column, ± denotes a theoretically ambiguous expected sign and − an expected negative sign. Full output: Supplementary File S3.

Diagnostic tests indicate no major specification problems (Ljung–Box $Q(4)$ $p = 0.42$ and $Q(8)$ $p = 0.75$; ARCH-LM(4) $p = 0.72$; Jarque–Bera $p = 0.88$), and parameter stability is supported by a CUSUM-type test on the error-correction equation ($p = 0.65$) over a sample that spans both the COVID-19 shock and the 2022 energy and inflation shock. The short sample nevertheless precludes well-powered formal break tests, so this result should be read as an absence of evidence of instability rather than proof of parameter constancy. The BEER-implied equilibrium rate for 2024Q3 is approximately 118 RSD/EUR, close to the observed nominal rate near 117 (a misalignment of -0.8%), indicating that, on the fundamentals-based BEER metric, the dinar was near its equilibrium over the observed sample. The estimated error-correction coefficient of -0.24 implies that roughly one-quarter of any deviation from the long-run equilibrium is corrected per quarter—convergence on the

order of four quarters in the absence of offsetting interventions—although, given its marginal significance ($p \approx 0.06$), this adjustment speed should be interpreted with caution. Two further caveats apply. First, the quarterly NFA/GDP series is observed only from 2016, so the estimation window is short and the coefficient precision correspondingly limited. Second, because the nominal rate was tightly managed over the estimation sample, the fundamentals may themselves have adjusted around the stabilized rate (through import compression, external borrowing, and FDI-financed NIIP dynamics); a fundamentals-based BEER estimated on such a sample can, therefore, partly rationalize the prevailing rate by construction. This endogeneity is a recognized limitation of BEER analysis in managed regimes and is one reason the paper triangulates against the PPP and FEER benchmarks. The full estimation output is reported in Supplementary File S3.

As sensitivity checks, the BEER model was re-estimated under alternative specifications. With one lag in differences instead of two, the trace test becomes borderline (rejecting $r = 0$ at the 10% but not the 5% level), while the maximum-eigenvalue test still rejects at 5%, and the fitted 2024Q3 equilibrium is essentially unchanged (117.2 RSD/EUR; misalignment -0.1%). Excluding NFA/GDP from the system, no cointegration is found, supporting its retention as a core long-run fundamental. The baseline uses log real GDP as the productivity proxy; the manuscript-specified CPI/HICP ratio is mechanically collinear with the real exchange rate ($\ln RER = \ln EUR_RSD - \ln PROD$ by construction) and is, therefore, not used. Finally, in a recursive out-of-sample comparison over the final eight quarters, one-step-ahead VECM forecasts of the real exchange rate outperform a random walk (RMSE ratio 0.79)—an encouraging result relative to the common finding that equilibrium exchange-rate models struggle to beat the random walk at short horizons [19]—though the evaluation window is short and this comparison is indicative rather than conclusive. Across admissible specifications, the BEER-implied equilibrium for 2024Q3 remains close to the nominal rate (within a few percent). The qualitative finding—that the dinar was near its BEER-implied equilibrium over 2016–2024—is robust, even as the price-based PPP and external-balance FEER measures continue to signal overvaluation.

Under the baseline sustainability threshold of the current account ($CA^* = -3\%$ of GDP), with Serbia's observed current account at $CA_{obs} \approx -4.7\%$ of GDP in 2024 [3], the FEER-implied rate is approximately 135 RSD/EUR. This corresponds to a misalignment of -13% relative to the observed nominal rate, measured as $(S_{obs} - S^*)/S^*$ (Table 3). Sensitivity analysis across CA^* targets of -2% to -4% of GDP yields FEER-implied rates from 124 to 147 RSD/EUR. The less ambitious target of -4% requires only a small nominal adjustment ($S^* = 124$, gap $= -6\%$), while the more ambitious -2% target implies a larger correction ($S^* = 147$, gap $= -20\%$). Table 3 reports the baseline calibration $\varepsilon = 0.12$. Under the mechanical CGER substitution $\varepsilon = 0.095$, the same CA^* targets map to approximately 156, 140 and 126 RSD/EUR (gaps of -25% , -16% and -7%), and under an upper alternative $\varepsilon = 0.15$ to approximately 140, 131 and 123 RSD/EUR—a weaker trade response requires a larger exchange-rate adjustment for the same current-account correction. The full two-dimensional $CA^*-\varepsilon$ sensitivity matrix is reported in Supplementary File S3. In all cases, CA^* is an assumed sustainability benchmark rather than a formally derived (e.g., EBA-style) current-account norm, so the FEER figures should be read as conditional scenarios. In particular, if structurally high FDI inflows justify a wider sustainable deficit for a converging economy—for example, a CA^* near -5% of GDP—the implied FEER gap shrinks to approximately zero (Supplementary File S3), which is a further reason not to treat any single FEER point as a unique equilibrium.

Table 3. FEER exchange rate for alternative current account targets.

Target Current Account (% of GDP)	Required RER Nominal Exchange Rate Shift (RSD/EUR)	Overvaluation *
--------------------------------------	--	-----------------

−2.0	+22%	147	−20%
−3.0	+13%	135	−13%
−4.0	+4%	124	−6%

Source: Authors' calculations. * Overvaluation gap = $(S_{obs} - S^*)/S^*$; a negative value denotes overvaluation of the dinar relative to the FEER-implied rate.

Table 4 summarizes the three benchmarks and their implied gaps relative to the observed rate around 117 RSD.

Table 4. Triangulation of Equilibrium Exchange-Rate Estimates: PPP, BEER, and FEER.

Method	Rate (RSD/EUR)	Gap (%)
PPP	151.3	−23
BEER	118	−0.8
FEER	135	−13

Source: Authors' calculations.

The three approaches diverge in an informative way rather than converging on a single point. The price-based PPP and external-balance FEER measures both signal overvaluation of the dinar—gaps of −22.7% and −13%, implying equilibrium rates of approximately 151 and 135 RSD/EUR—whereas the fundamentals-based BEER indicates the dinar remained close to its equilibrium over the observed 2016–2024 sample, with a fitted equilibrium near 118 RSD/EUR and a misalignment within $\pm 5\%$ throughout the sample and of just −0.8% at 2024Q3 (Figure 2). This divergence is economically meaningful. PPP captures cumulative relative-price erosion. FEER captures external-balance sustainability, and BEER captures adjustment to medium-run fundamentals (terms of trade, net foreign assets, productivity). The overvaluation signal is thus strongest on price-competitiveness grounds and weakest on a fundamentals-adjustment basis. Figure 2 plots the BEER-implied rate against the nominal rate over the estimation sample, and Figure 3 shows the implied PPP and BEER misalignment gaps.

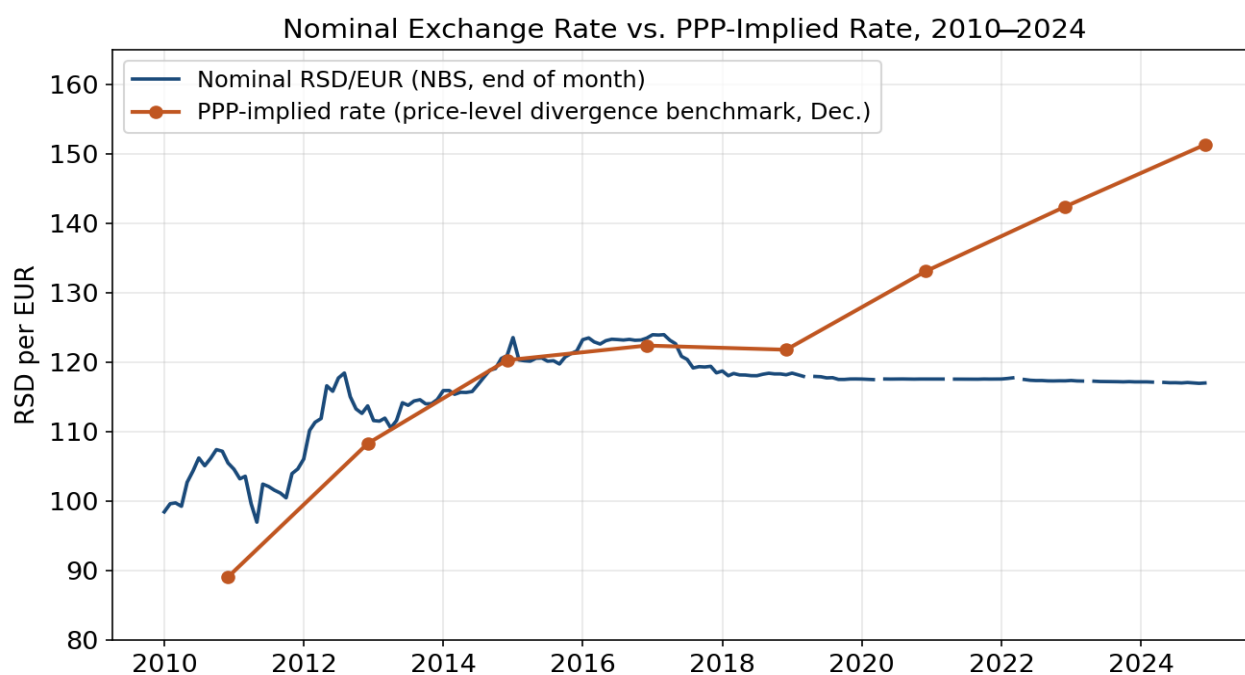


Figure 1. Nominal exchange rate vs. PPP-implied rate (2010–2024). The nominal rate stabilises near 117 RSD/EUR from 2018 while the PPP-implied rate continues to rise with the accumulated inflation differential, opening a steadily widening price-competitiveness gap. Source: Authors' calculations.

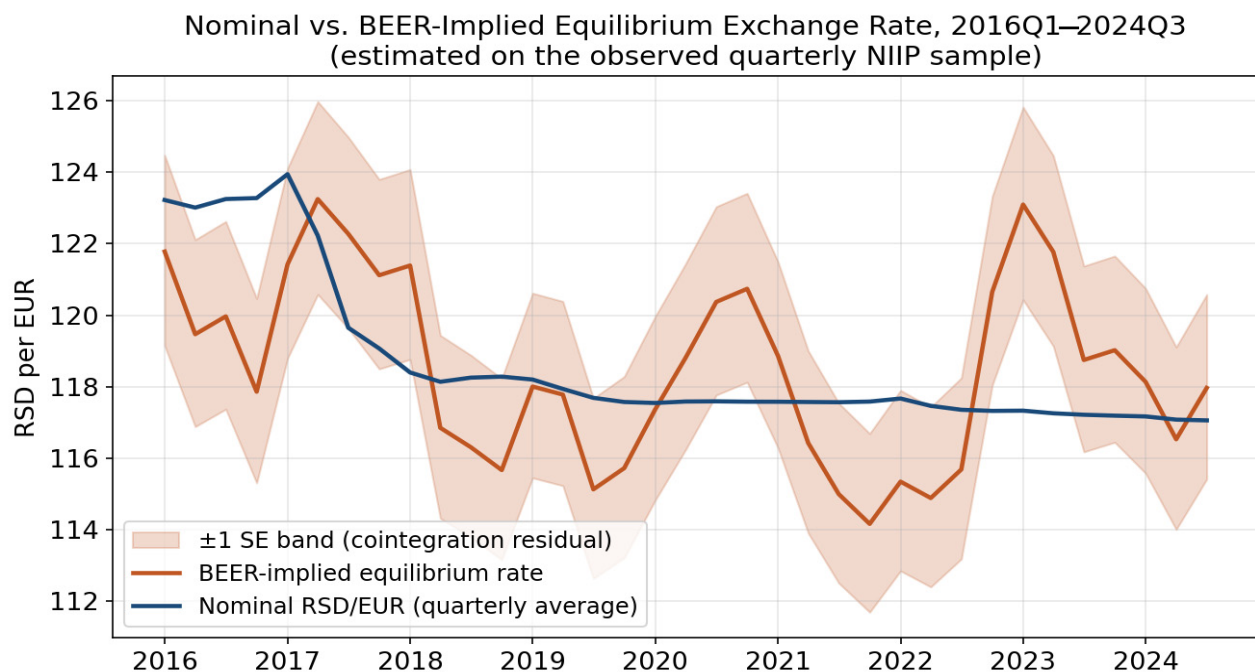


Figure 2. Nominal exchange rate vs. BEER-implied equilibrium rate (2016Q1–2024Q3). Estimated on the observed quarterly-NIIP sample, the fitted equilibrium (with ± 1 standard-error band) tracks the nominal rate within $\pm 5\%$, indicating near-equilibrium on the fundamentals-based metric. Source: Authors' calculations.

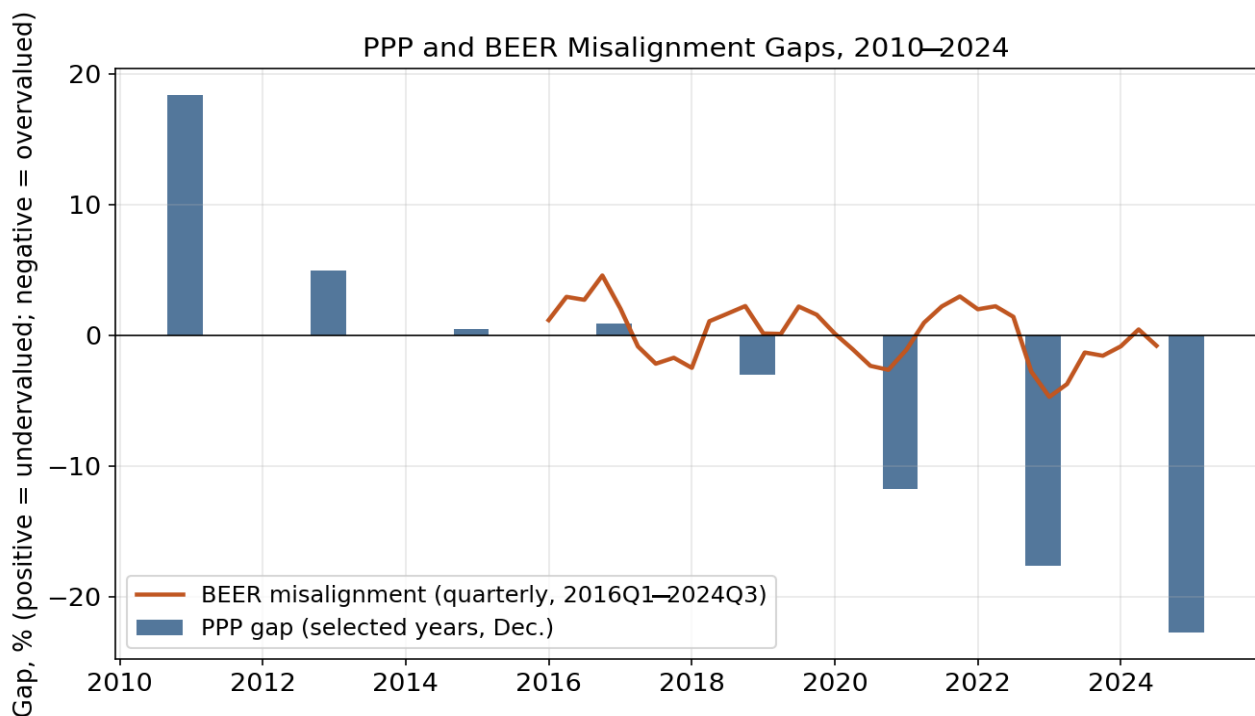


Figure 3. PPP and BEER misalignment gaps (2010–2024). Price-based overvaluation widens steadily after 2018, while the fundamentals-based BEER gap remains small throughout the observed sample. Note: PPP gaps are shown for selected years over 2010–2024. BEER gaps are reported only for the observed estimation sample 2016Q1–2024Q3. Source: Authors' calculations.

4.2. IRR Simulations Under Alternative RSD/EUR Scenarios: Sectoral Asymmetries

The results in this and the following subsection are calibrated scenario simulations under the parameter assumptions stated in Section 3; unlike the econometric estimates of Section 4.1, they carry no sampling uncertainty beyond that explored in the Monte Carlo experiment and the sensitivity checks reported below.

For the fruit/IQF system, CAPEX is set to €18,000/ha. This figure represents a calibrated representative assumption for semi-intensive orchard establishment plus a pro-rata commercial charge for shared access to third-party IQF processing capacity; it should not be interpreted as the capital cost of a stand-alone fully integrated IQF plant. It is consistent with the sector-level investment norms reported by MAFWM [2] and OECD-FAO agricultural investment benchmarks [40] but is not derived from FADN micro-data. Accordingly, the Table 5 calibration represents a higher-value orchard system with out-sourced/shared freezing access rather than an on-farm dedicated processor. A dedicated integrated IQF facility would require materially higher capital outlays and would lower the corresponding unlevered IRR. Baseline assumptions are a FOB export price of €5.4/kg, imported inputs of €0.40/kg, $\eta = 1.0$ (full pass-through, consistent with euro-denominated FOB pricing), and $\theta = 0.30$. Under these assumptions, moving from 117 to 140 RSD/EUR increases dinar revenues and margins. The project IRR rises from 3% (117) to 8% (130) and 12% (140), with EBITDA per kg increasing accordingly (Table 5). Domestic operating costs are held constant in nominal dinar terms across scenarios (433 RSD/kg). The domestic-cost item is disaggregated into labor, packaging, energy and utilities, transport and handling, maintenance and services, and overhead. All domestic-cost components are treated as dinar-denominated across exchange-rate scenarios, while the FX-linked imported-input component is modelled separately. The corresponding NPVs per hectare at the 10% discount rate are −578,953 RSD ($S = 117$), −159,939 RSD ($S = 130$) and +162,379 RSD ($S = 140$), with payback in years eight, six and six, respectively (unrounded IRRs: 2.8%, 8.3% and 11.5%).

Table 5. Raspberry/IQF Project IRR by Exchange Rate ($S = 117, 130, 140$ RSD/EUR; CAPEX = €18,000/ha).

Exchange Rate (RSD/EUR)	Revenue per kg (RSD)	Imported-Input Cost per kg (RSD)	EBITDA per kg (RSD)	Orchard IRR
117	632	47	152	3%
130	702	52	217	8%
140	756	56	267	12%

Source: Authors' calculations. CAPEX = €18,000/ha; yield = 2.3 t/ha; $T = 8$ years; discount rate = 10%; ramp-up: 30%/60%/100% (years 1–2/3–8). Revenue per kg = $P^{IU} \times S_t$ with $\eta = 1.0$ (full pass-through). Imported input cost = €0.40/kg $\times S_t$. Domestic operating costs (DC) are held constant in nominal dinar terms across exchange-rate scenarios at 433 RSD/kg; being dinar-denominated, they do not vary mechanically with S , and any euro-linked cost component is captured separately in the imported-input column. EBITDA/kg = revenue – imported-input cost – domestic cost (DC); e.g., at $S = 117$: $632 - 47 - 433 = 152$ RSD/kg. The “Imported-input cost” column reports only the FX-denominated input component; the larger domestic cost (DC) is stated here, not as a separate column.

For the sensitivity of the fruit/IQF results, (i) CAPEX $\pm 30\%$: at $S = 117$ the IRR ranges from −2.5% (+30% CAPEX) to 10.8% (−30%); at $S = 130$ from 2.5% to 17.3%; and at $S = 140$ from 5.4% to 21.0%. The ranking of exchange-rate scenarios is unaffected. (ii) For the discount rate, NPVs per hectare at an 11% (12%) discount rate are −640,881 (−699,293) RSD at $S = 117$, −248,350 (−331,740) RSD at $S = 130$ and +53,597 (−49,008) RSD at $S = 140$, so the $S = 140$ project remains close to break-even up to a 12% cost of capital. (iii) For yield, the 2.3 t/ha calibration is deliberately conservative relative to commercial yields of 5–6 t/ha,

holding per-kilogram margins constant. A 5 t/ha yield raises the IRR to approximately 22% ($S = 117$), 30% ($S = 130$) and 35% ($S = 140$). All cash-flow mechanics ($T = 8$; ramp-up 30%/60%/100%; CAPEX in euros converted at S) follow the parameterization stated beneath Table 5. A related limitation is that a weaker-dinar environment could itself raise the dinar cost of capital, which would compress the distance between project IRRs and the hurdle rate in all scenarios.

For the livestock (beef fattening) system, revenues are based on the domestic live-weight price (400 RSD/kg). Operating costs are dominated by feed expenditures, proxied by the feed-cost index and scaled by its cost share (θ), alongside veterinary services and labor. CAPEX is set to €1000 per head for housing and equipment. This is likewise a calibrated representative value aligned with sector-level infrastructure cost norms [2], not a FADN-derived estimate. The baseline parameters are $\theta = 0.55$ and $\eta = 0.15$. In contrast to the export-oriented fruit system, a weaker dinar increases feed costs materially while output prices adjust only partially, so profitability deteriorates: The project IRR falls from 9% ($S = 117$) to 8% ($S = 130$) and 6% ($S = 140$) (Table 6). The livestock returns are computed from a calibrated eight-year discounted cash-flow model whose full assumptions—turns per year, feeding days, entry/exit live weight, mortality, occupancy, the CAPEX schedule, and salvage value—together with the complete year-by-year cash flows that reproduce the IRR values of 9%, 8% and 6% are reported in Supplementary Files S1 and S2. The meat-price path in Table 6 (400 → 408 → 412 RSD/kg) embodies an implied output-price pass-through of approximately 0.15–0.18 per unit of depreciation, consistent with the $\eta \in [0.1, 0.2]$ range used in the Monte Carlo experiment. This livestock output-price response is imposed as a calibration of incomplete pass-through rather than estimated econometrically within the present paper; it is intended to proxy the partial and delayed adjustment of domestic meat prices to exchange-rate movements over the project horizon. At discount rates of 10%, 11% and 12%, the corresponding NPVs (per 100-place unit, RSD million) are −0.37, −0.71 and −1.03 at $S = 117$; −0.73, −1.06 and −1.37 at $S = 130$; and −1.43, −1.74 and −2.03 at $S = 140$, with payback in years six to seven—the ranking across exchange-rate scenarios is invariant to the discount rate. Varying the initial outlay of the livestock model by $\pm 30\%$ moves the IRR from 9% to 18.8%/2.9% at $S = 117$, from 8% to 17.5%/2.0% at $S = 130$, and from 6% to 15.0%/0.3% at $S = 140$ (−30%/+30% respectively). As in the fruit system, the exchange-rate ranking is preserved.

Table 6. Livestock sector: IRR under FX scenarios ($S = 117, 130, 140$ RSD/EUR).

Exchange Rate (RSD/EUR)	Feed per kg of Meat (RSD)	Meat Price (RSD)	EBITDA per Head (RSD)	Farm IRR
117	125	400	19,000	9%
130	132	408	17,300	8%
140	139	412	15,100	6%

Source: Authors' calculations.

The scenario calculations reveal pronounced asymmetry in exchange-rate exposure across the two systems (Figure 4). In the fruit/IQF system, the revenue base is predominantly euro-linked while only a share of operating costs is euro-priced, implying a positive exchange-rate sensitivity of profitability (Table 5). In cattle fattening, exchange-rate pass-through operates mainly through costs via feed and energy-linked inputs, while output prices adjust only partially over the horizon, implying a negative sensitivity of profitability (Table 6). Figure 4 summarizes these opposing slopes.

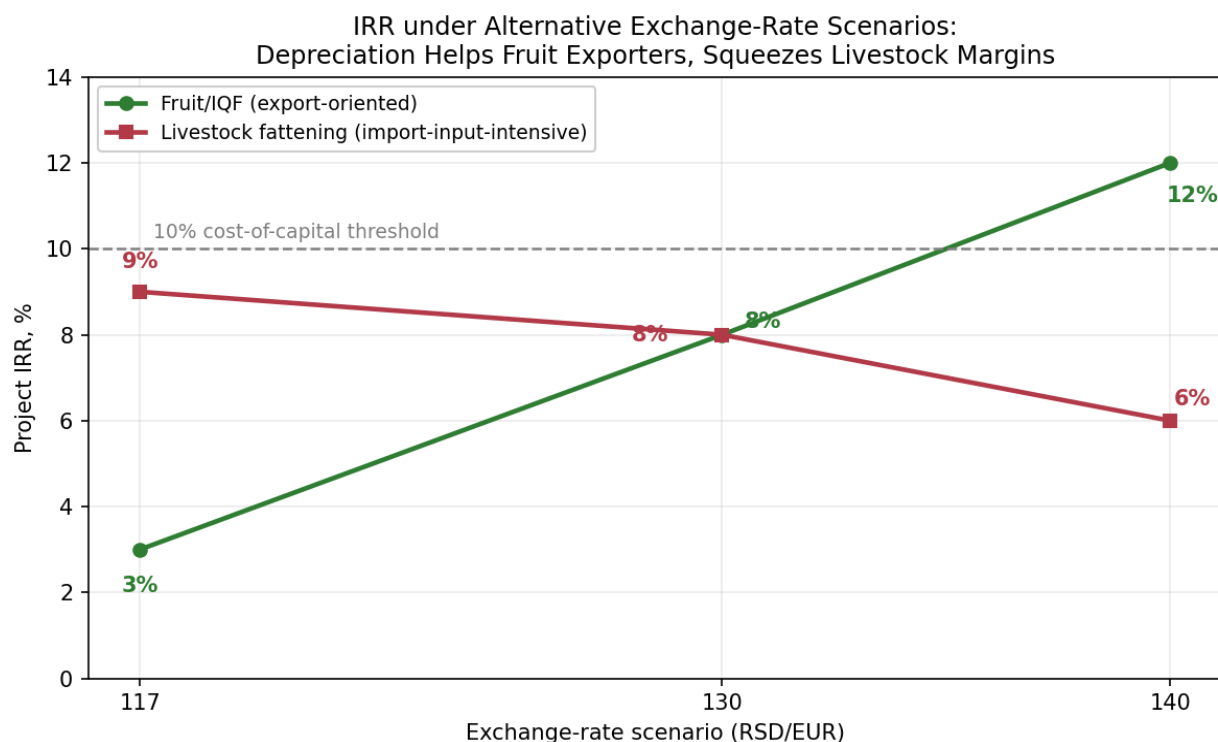


Figure 4. Internal rate of return under alternative exchange-rate scenarios ($S = 117, 130$ and 140 RSD/EUR). The fruit/IQF IRR rises, and the livestock IRR falls as the dinar weakens—the central sectoral asymmetry of the paper; the dashed line marks the 10% cost-of-capital threshold. Source: Authors' calculations.

4.3. Case Study: Fresh-Berry Export—Technology Conversion in High-Value Raspberry Production

4.3.1. Why Shift the Technological Model

Serbia ranks among the world's three largest exporters of frozen raspberries, yet approximately 95% of output still comes from open-field Willamette and Miker varieties, yielding around 5–6 t/ha in commercial practice, though modeled conservatively at 2.3 t/ha in Table 7 for consistency with the IQF calibration in Table 5, at prices of €2–3/kg (frozen bulk). In parallel, EU markets record double-digit growth in demand for fresh, off-season raspberries (May and October windows) at ex-farm prices of €8–12/kg. The key to accessing this premium segment is adoption of the new Kwanza variety in plastic-tunnel systems with fertigation and shade netting, which raises yields to approximately 25 t/ha and shifts the harvest window by four to six weeks. Each kilogram redirected from the frozen channel to the fresh off-season channel generates a minimum of +€6 in additional foreign-exchange earnings, while manual harvesting costs remain similar across both systems.

Table 7. Open-Field Bulk Frozen Raspberry System vs. Fresh-Berry Kwanza Plastic tunnel: Key Comparative Parameters.

Parameter	Open-Field Bulk (Willamette/Miker)	Fresh-Berry Kwanza (Plastic Tunnel)
CAPEX (€/ha)	18,000	100,000
Yield (t/ha)	2.3	25
Selling price (€/kg)	2.50 (frozen FOB)	9.00 (fresh ex-farm)
OPEX (€/kg)	0.40 (imported) + 433 RSD fixed	≈4.0–4.5 (≈3.1 EUR-linked + ≈1.3 RSD harvest/packing labour)

IRR at S = 117 RSD/EUR	≈3%	≈77%
IRR at S = 130 RSD/EUR	≈8%	≈79%
IRR at S = 140 RSD/EUR	≈12%	≈80%
FX sensitivity (ΔIRR per 10 RSD/EUR)	≈+3.9 pp	≈+1.5 pp (modestly FX-positive)
Export value/ha/yr (€)	5750	225,000
400-ha programme export (€/yr)	2.3M	90M

Source: Authors' calculations. OPEX = operating expenditure per kg. Note: 'Open-field bulk' refers to the conventional extensive orchard system (Willamette/Miker varieties, open field, frozen bulk export at €2.50/kg). This differs from the intensive IQF system in Table 5 (€5.40/kg FOB, semi-intensive orchard with IQF capacity, CAPEX €18,000/ha), which represents a higher-value intermediate system. The case study benchmarks the Kwanza fresh system against the lowest-cost conventional alternative to maximize the contrast. The €9.0/kg ex-farm price is consistent with 2024 FAOSTAT producer prices [46] for raspberries in comparable EU markets (Germany €10.8, Belgium €8.8, Portugal €7.6, Spain €7.0/kg); the targeted Kwanza fresh off-season variety commands a premium within this range.

4.3.2. Investment Parameters and Comparative Economics

Table 7 compares the two production systems across the key investment and profitability dimensions. The open-field bulk frozen system, with updated CAPEX of €18,000/ha, generates an IRR of approximately 3% at the current peg of 117 RSD/EUR—well below the assumed 10% cost of capital after ramp-up. By contrast, the Kwanza plastic tunnel system, at €100,000/ha CAPEX and 25 t/ha yield, delivers an IRR in the region of 75–85% in the best case, rising modestly under a weaker dinar. The fresh system is not exchange-rate neutral at the project level. Revenues are euro-linked (€9.0/kg ex-farm), but realistic operating costs (≈€4.0–4.5/kg) combine a euro-linked component (imported substrate, energy and packaging, ≈€3.1/kg) with a substantial dinar-denominated harvest-and packing-labor component (≈€1.3/kg). Because that labor is priced in dinars, a depreciation lowers its euro-equivalent cost and modestly raises the euro margin, so the system benefits slightly from depreciation—less strongly than the IQF system, but not neutrally. The exchange-rate channel operates entirely at the macro level, through the volume and value of foreign-exchange inflows. This figure is illustrative and contingent on premium fresh-export market access at the stated price; it is highly sensitive to the realised export price, yield and CAPEX. Under more conservative pricing or yield assumptions, the IRR falls substantially, and the case study should be read as a best-case benchmark for high-value fresh exports rather than a representative sectoral return. To make this sensitivity explicit, three scenarios are reported under an identical cash-flow structure (CAPEX €100,000/ha; operating cost €4.5/kg, the upper end of the stated range; T = 8 years; year-1 ramp-up of 30% with full yield from year 2—a calibration that reproduces the ≈77% best-case IRR): (i) Baseline (€9.0/kg, 25 t/ha): IRR ≈ 77%, payback ≈ 2 years, NPV at 10% ≈ €429,000/ha; (ii) Conservative (€7.0/kg, 20 t/ha): IRR ≈ 36%, payback ≈ 3 years, NPV ≈ €135,000/ha; and (iii) Stress (€6.0/kg, 18 t/ha): IRR ≈ 16%, payback ≈ 5 years, NPV ≈ €27,000/ha. Even the stress case remains above the 10% viability threshold, but the spread between 77% and 16% underscores that the case-study economics are dominated by the realized fresh-market price and yield rather than by the exchange rate. The baseline is a best-case benchmark conditional on premium market access.

4.3.3. Macro-Level Foreign-Exchange and Current-Account Effects

The macro-fiscal significance of the technology shift is substantial. A 400-ha programme of Kwanza plastic tunnel installations, financed via a proposed SCAP model (50% state grant, 40% commercial bank credit, 10% own equity), would generate approximately €90 million in annual fresh-raspberry exports starting from Year 2 ($400 \text{ ha} \times 25 \text{ t/ha} \times \text{€}9.0/\text{kg}$). Scaling to a five-year, 2000-ha programme stabilizes the annual foreign-exchange inflow at approximately €450 million—equivalent to roughly 0.5% of GDP at current levels. These programme-level figures assume the ex-farm price of €9.0/kg holds as the volume scales. Expanding fresh off-season supply to roughly 10,000–50,000 t would compress the premium price, so the €90 and €450 million figures are best read as upper bounds that abstract from price elasticity. On the trade-balance arithmetic, and on the same best-case basis, a shift of this magnitude would convert the existing negative agri-food balance with the EU (approximately –€200 million in 2024) into a surplus of approximately +€250 million, reducing the current-account deficit by an estimated 0.7 percentage points of GDP. This reduction would, in turn, moderate the depreciation pressure on the dinar, partially offsetting the NBS sterilization burden described in Section 4.4.

4.3.4. Linkage to Exchange-Rate Policy

While the Kwanza system is only weakly exchange-rate-sensitive in IRR terms, the conventional IQF subsector remains highly sensitive to the nominal exchange rate. A correction from 117 to 130 RSD/EUR raises the IQF project IRR from 3% to 8%, closing most of the gap to the 10% viability threshold, which is fully crossed at 140 RSD/EUR (IRR 12%). In financing terms, this is the difference between a project that cannot attract institutional investment and one that becomes broadly bankable. Simultaneously, greater foreign-exchange inflows from a scaled fresh-berry programme reduce the need for NBS FX-purchase interventions, so a portion of the fiscal saving on sterilization could be recycled into the SCAP grant program—creating a self-reinforcing cycle between exchange-rate realignment and agricultural competitiveness.

4.3.5. Risk Factors and Mitigation

Three principal risks warrant explicit mitigation measures. First, for premium-market saturation, to diversify away from single-commodity concentration, it is recommended that 20% of the plastic tunnel capacity be allocated to blueberry and blackberry production. Second, for phytopathological pressure in substrate systems, mandatory Good Agricultural Practice (GAP) certification and a centralized early-detection laboratory are proposed as conditions of grant eligibility. Third, for an exchange-rate shock exceeding 10%, extending the existing forward-premium hedging fund to the horticultural cluster, with a coverage horizon of up to six months, would limit dinar-revenue volatility for producers who have not yet fully converted to EUR-invoiced contracts.

4.3.6. Summary of the Case Study

The frozen-to-fresh raspberry technology conversion represents a capital-intensive but substantially more profitable investment model. At the same annual fiscal cost as the existing IQF-grant programme (approximately 4 billion RSD), Serbia could, under the stated assumptions and in the upper-bound scenario, generate up to roughly €450 million in annual foreign-exchange earnings, substantially reduce the negative agri-food balance with the EU, and raise rural incomes—all while reducing the exchange-rate intervention burden on the NBS. The case study illustrates how targeted agricultural investment and exchange-rate realignment could interact to improve the external balance and long-run sectoral competitiveness.

The Monte Carlo results confirm the scenario-based inference. Sampling $\eta \in [0.8, 1.0]$ and $\theta \in [0.2, 0.4]$ for the fruit/IQF system (and $\eta \in [0.1, 0.2]$, $\theta \in [0.4, 0.7]$ for the livestock system) over 10,000 draws, the fruit/IQF system's median IRR approaches the 10% commercial viability threshold at 130 RSD/EUR and exceeds it at 140 RSD/EUR, although downside cases remain below 8% in the lower tail of the simulated distribution, whereas for livestock the distribution shifts downward as the exchange rate weakens, with the median falling to 6% at 140 RSD/EUR. This divergence reinforces the interpretation that a weaker dinar strengthens investment incentives in export-oriented fruit processing, while undermining profitability in import- and feed-intensive livestock production under plausible price-adjustment frictions.

To characterize the full distribution rather than point to scenarios, Table 8 reports the Monte Carlo output summary. At the baseline exchange rate of 117 RSD/EUR, the fruit/IQF system yields a median IRR of 3% (5th–95th percentile: −2% to 8%), rising to a median of 12% (7% to 17%) at 140 RSD/EUR. The livestock system shows the opposite pattern. There is a median IRR of 9% (5% to 13%) at 117 RSD/EUR, falling to 6% (2% to 10%) at 140 RSD/EUR. The non-overlapping interquartile positions at the weaker-dinar end confirm that the sectoral asymmetry is robust to parameter uncertainty.

Figure 5 presents an illustrative variance-share decomposition based on the simulated parameter draws. The shares should be interpreted as first-order sensitivity contributions within the specified Monte Carlo design, rather than as formal global Sobol indices. For the fruit/IQF system, the exchange rate accounts for the largest share of IRR variance (45%), followed by yield (30%), export price (15%), and CAPEX (10%). For the livestock system, feed cost dominates (40%), followed by selling price (25%), the exchange rate (18%), and CAPEX (17%). This confirms that exchange-rate movements are the primary driver of profitability uncertainty in export-oriented fruit production, whereas feed-cost volatility dominates in import-intensive livestock fattening.

Illustrative Variance-Share Decomposition of IRR Uncertainty

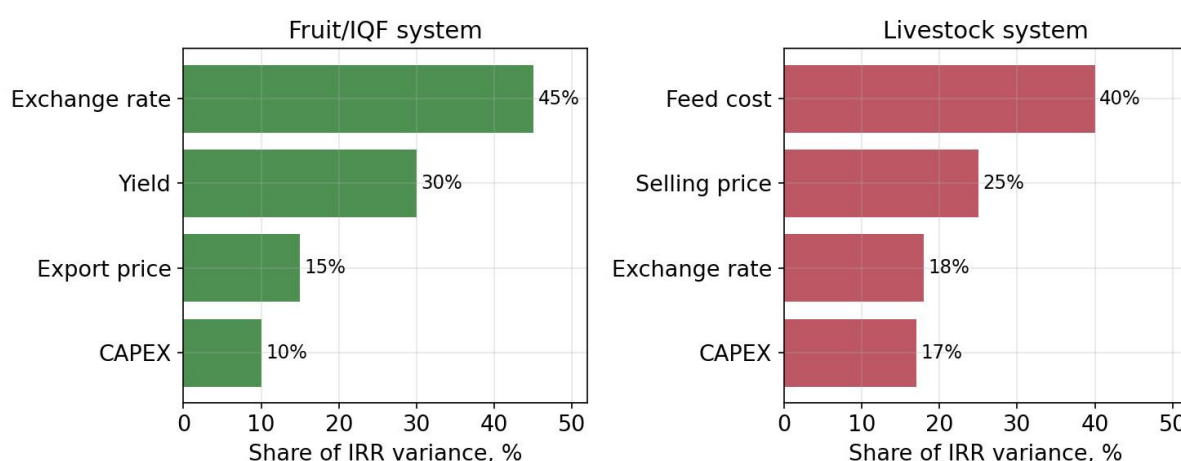


Figure 5. Sensitivity analysis: share of IRR variance by parameter. Source: Authors' calculations.

Table 8. Monte Carlo IRR Distribution Summary (10,000 draws).

System/Scenario	Median IRR	5th pct	95th pct
Fruit/IQF at 117 RSD/EUR	3%	−2%	8%
Fruit/IQF at 130 RSD/EUR	9%	4%	14%
Fruit/IQF at 140 RSD/EUR	12%	7%	17%
Livestock at 117 RSD/EUR	9%	5%	13%

Livestock at 130 RSD/EUR	8%	4%	12%
Livestock at 140 RSD/EUR	6%	2%	10%

Source: Authors' Monte Carlo simulation. Percentile bands from 10,000 draws, with pass-through and cost-share parameters sampled from the uniform distributions specified above. Monte Carlo medians need not coincide with the deterministic scenario values of Tables 5 and 6, which are computed at the baseline parameter points; for example, the deterministic fruit/IQF IRR at 130 RSD/EUR is 8% under the constant-domestic-cost calibration, within the reported 4–14% simulation band.

4.4. Macro-Fiscal Implications

Beyond real-sector distributional effects, exchange-rate smoothing through sustained net FX purchases generates a recurring quasi-fiscal cost via sterilization operations. Table 9 summarizes estimated FX purchases, the actual NBS key policy rate, and the official sterilization cost proxy over 2021–2024, where sterilization cost is measured as the NBS published annual interest expense (rashodi kamata), which captures all sterilization instruments. The estimated annual sterilization cost ranges between RSD 4.3 bn (2021) and RSD 50.5 bn (2023), equivalent to 0.07–0.57% of GDP, with the sharp increase reflecting the NBS interest-rate tightening cycle of 2022–2023.

Table 9. NBS Sterilisation Cost: Official Interest-Expense Proxy (2021–2024).

Year	FX Purchases (EUR mn)	Repo Rate (Average, %)	Cost (RSD bn)	Cost (% of GDP)
2021	645	1.0	4.3	0.07
2022	1000	2.6	7.0	0.10
2023	3900	6.1	50.5	0.57
2024	2725	6.2	49.6	0.51

Source: Authors' calculations.

Figure 6 aggregates these estimates. The NBS official interest-expense data reveal a pronounced structural break: sterilization costs were low in 2021–2022 (RSD 4.3 and 7.0 bn, respectively, reflecting annual-average policy/repo rates of 1.0% and 2.6%), then surged to RSD 50.5 bn in 2023 and RSD 49.6 bn in 2024 as the NBS raised the key policy rate from 1% to 6.5% over April 2022–July 2023 in response to the post-pandemic inflation surge. The cumulative official sterilization cost over 2021–2024, therefore, amounts to RSD 111.4 billion (approximately 0.4% of cumulative GDP over the same period). This underscores that exchange-rate management carries an economically material quasi-fiscal component alongside its monetary policy role, and that this burden is highly sensitive to the interest-rate environment.

To the extent that a gradual move toward the adjustment corridor reduced the need for FX-purchase interventions, part of this quasi-fiscal burden could be avoided; the magnitude of any such saving would depend on future intervention volumes and the prevailing policy rate and is deliberately not quantified here because the audited interest-expense measure in Table 9 is an aggregate that cannot be attributed to individual interventions.

Finally, trade-flow dynamics provide a descriptive consistency check. Following the stabilization of the nominal exchange rate around 117 RSD/EUR from mid-2018, imports increasingly exceeded exports. We construct a cumulative trade-deficit index (2015 = 100) defined as $I_t = (\sum_{i=1}^t D_i) / (\sum_{i=1}^{(\text{Dec } 2015)} D_i) \times 100$, where D_i is the monthly merchandise trade deficit (imports minus exports, in million EUR) and the denominator is the cumulative deficit through December 2015. Based on SORS monthly trade statistics, this index rises from 100 in 2015 to 139 in 2020, 167 in 2022, 179 by end-2023, and approximately 194 by end-2024 (Figure 7). While not causal, this steadily widening cumulative deficit is

qualitatively consistent with the FEER-based result that an externally sustainable exchange rate is higher than the prevailing nominal level.

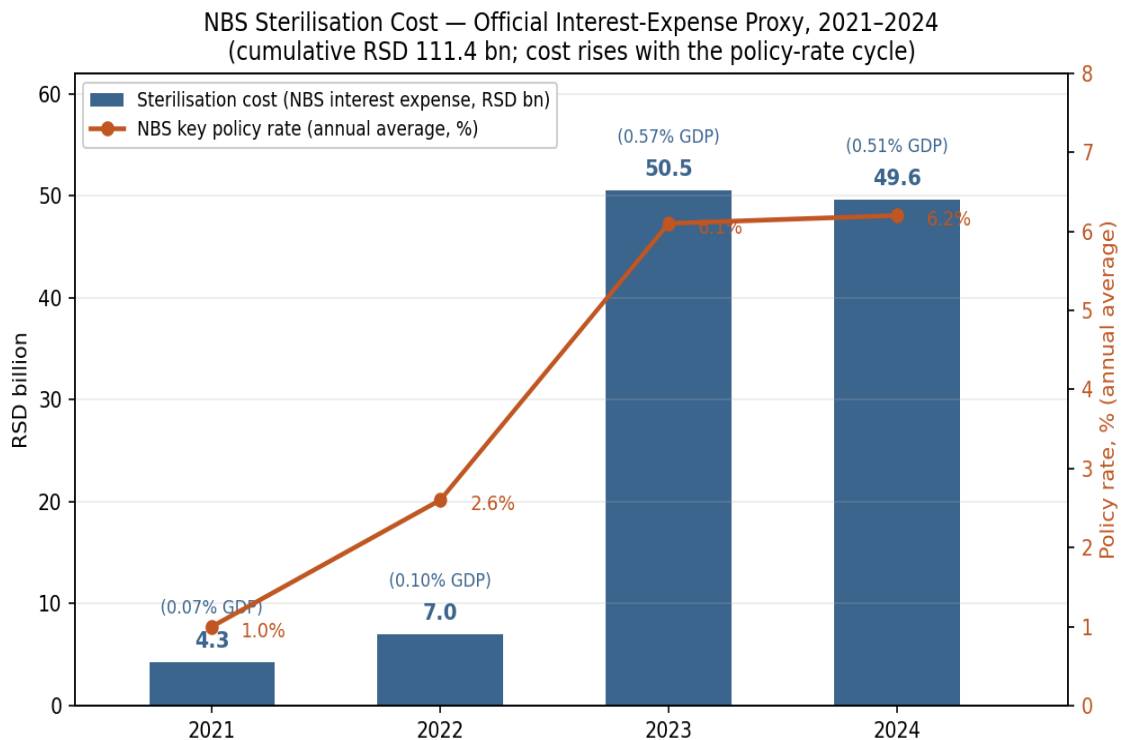


Figure 6. Estimated sterilization cost of NBS FX purchases (2021–2024). The cost is driven primarily by the policy-rate cycle rather than by intervention volumes. Source: NBS Annual Reports (2021–2024); authors’ calculations. Cost = NBS published annual interest expense (rashodi kamata), the official audited proxy for sterilization cost covering all instruments (repo sales, deposit facilities, reserve requirements). Repo rate = actual annual-average NBS key policy rate. FX purchases = authors’ estimates from NBS publications; exact net FX purchase totals are not separately itemized in NBS annual reports. The FX-purchase column is therefore an indicative reconstruction; the primary cost measure (the audited interest-expense line) is independent of it, and Equation (9), which uses the FX-purchase estimates, is retained only as a lower-bound decomposition device.

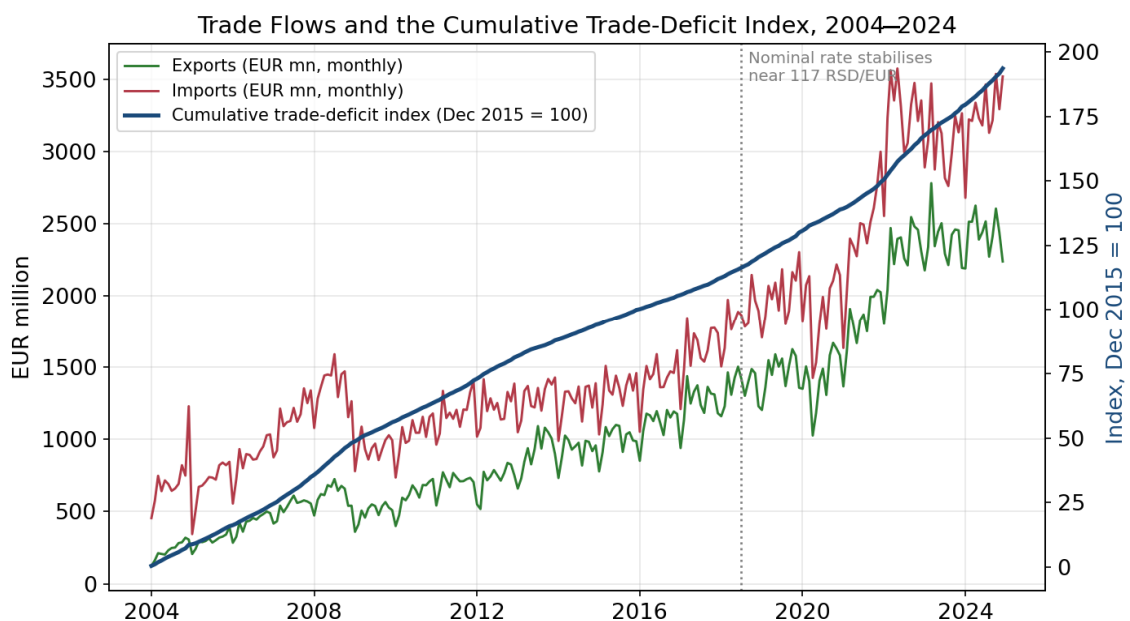


Figure 7. Trade Flows and the Cumulative Trade Deficit, 2004–2024. The cumulative deficit accelerates after the nominal rate stabilises in mid-2018. The cumulative trade-deficit index is normalized to 100 in December 2015 and cumulates monthly merchandise trade deficits from January 2004 onwards. Source: Authors’ calculations.

5. Discussion

The macro results provide a differentiated signal across the three equilibrium concepts. The PPP benchmark yields the largest price-based gap. The FEER implies a smaller but still economically meaningful overvaluation, whereas the fundamentals-based BEER places the dinar close to equilibrium over the observed sample. This divergence supports a core insight from the transition-economy literature. Even under prolonged nominal exchange-rate stability, persistent real appreciation/overvaluation can emerge as inflation differentials vis-à-vis the anchor-currency area accumulate during the catching-up process [47,48]. Methodologically, the finding that different benchmarks capture different notions of “equilibrium” and, therefore, motivate triangulation is consistent with standard applied practice in equilibrium exchange-rate assessment [17,18]. In this context, while the benchmarks differ, the FEER and PPP estimates can be operationally interpreted as bracketing a policy-relevant adjustment range for the dinar, with the BEER providing a fundamentals-based lower bound near the prevailing rate [19,21]. The direction of the price- and external-balance signals is consistent with earlier single-method evidence for Serbia—ARDL-based equilibrium estimates and current-account-norm calculations pointing to persistent medium-term overvaluation [22,23]—and with regional evidence that fundamentals-based benchmarks are informative for Western Balkan currencies [32,33]. The finding that a fundamentals-based BEER can sit close to the prevailing rate while price- and external-balance measures signal overvaluation also echoes the broader assessment literature, in which BEER-type models estimated over managed-rate samples tend to deliver smaller gaps than PPP- or FEER-type benchmarks [19].

The sectoral simulations highlight that exchange-rate misalignment is not distribution-neutral across agricultural subsectors. In export-oriented fruit/IQF processing, revenue is predominantly euro-linked and pass-through is relatively high, while only a fraction of costs is effectively euro-priced. Accordingly, a higher RSD/EUR tends, *ceteris paribus*, to improve dinar-denominated margins and investment incentives. This mechanism is consistent with classic arguments that real overvaluation can depress tradables-sector performance [15] and with empirical evidence on pass-through and pricing frictions shaping how exchange-rate movements map into domestic profitability [16,37]. By contrast, livestock systems are primarily exposed through the imported-input channel—feed and energy-linked inputs—so depreciation can raise costs materially while output prices adjust only partially over the relevant horizon. This aligns with the broader literature emphasizing that imported-input intensity and pricing rigidities can shift the burden of depreciation onto input costs rather than into output prices, thereby compressing margins [34,37]. The robustness checks further support the view that currency matching—whether revenues are foreign-currency-linked relative to local-currency costs and/or FX-linked liabilities—is central for competitiveness and investment incentives in euroized settings, because depreciation can simultaneously raise local-currency cash flows from export revenues while increasing the local-currency burden of FX-linked obligations [49,50]. At the same time, the exchange rate is only one determinant of agricultural competitiveness, and the results should not be read as implying that realignment alone would restore it. Productivity growth at the farm level, compliance with EU quality and food-safety standards, cold-chain and processing infrastructure, value-chain organization and market access, and the sector’s capacity to absorb new technology all shape competitiveness independently of the currency [12,14,40]. The appropriate reading of the sectoral results is,

therefore, conditional. For a given level of these structural determinants, the prevailing exchange-rate configuration redistributes profitability away from euro-revenue-intensive activities, while structural upgrading can partially offset an unfavourable currency configuration—as the fresh-berry case study illustrates.

Finally, the sterilization-cost estimates underline that exchange-rate smoothing via sustained net FX purchases can carry a material quasi-fiscal burden. This result is consistent with IMF/BIS-related work stressing that sterilized intervention has balance-sheet and fiscal implications—particularly in higher-rate environments—so exchange-rate policy should be evaluated jointly as stabilization policy and as a resource-allocation instrument [36]. More broadly, FEER-style assessments are explicitly designed to provide an operational yardstick for external sustainability, and persistent deviations from such benchmarks, therefore, raise policy-relevant trade-offs [18,27,28].

A further limitation concerns measurement. Sterilization costs are measured using the NBS official interest-expense line (*rashodi kamata*), which is an audited and comprehensive proxy; however, the true quasi-fiscal burden may differ if off-balance-sheet instruments or unreported sterilization operations exist beyond the scope of the published annual reports. In addition, the measure is a gross interest-expense concept. It does not net out the return earned on the foreign-exchange reserves acquired through intervention, so the net carrying cost of the policy could be lower than the gross figure reported here (or higher under adverse interest-rate differentials).

As a concluding policy brief, the following summarises what the evidence does and does not support. What the evidence shows is that (1) price-based and external-balance benchmarks indicate real overvaluation of the dinar by end-2024 (PPP $\approx$ -23% ; FEER $\approx$ -13%), while the fundamentals-based BEER places the dinar near equilibrium—the divergence itself is the finding; (2) exchange-rate exposure is strongly asymmetric across agricultural subsectors: in simulation, a move to 130–140 RSD/EUR raises fruit/IQF IRR from 3% to 8–12% and lowers livestock IRR from 9% to 8–6%; and (3) defending the nominal corridor carried an audited quasi-fiscal cost of RSD 111.4 billion over 2021–2024, driven mainly by the policy-rate cycle. The conditional implications are that any realignment would be more consistent with the external-balance evidence if gradual and pre-announced; sterilization costs merit explicit treatment as a policy constraint; and agricultural support could be differentiated by exchange-rate exposure (imported-input risk instruments for livestock; investment-friction easing for export-oriented horticulture). What the evidence does not support is that a unique equilibrium exchange rate, causal estimates of realignment effects, or the expectation that realignment alone would restore competitiveness without structural upgrading.

6. Conclusions and Policy Implications

This paper provides integrated evidence that the Serbian dinar exhibited persistent real overvaluation over 2010–2024 when assessed through price-based and external-balance benchmarks. PPP-based calculations imply the largest price gap, reaching approximately -22.7% by end-2024, while the FEER benchmark points to a moderate external-balance overvaluation of around -13% . In contrast, the fundamentals-based BEER model, estimated on the observed 2016Q1–2024Q3 sample, places the dinar close to equilibrium, within approximately $\pm 5\%$ of the prevailing nominal rate (-0.8% at 2024Q3). Taken together, the three approaches do not converge on a single equilibrium point. Rather, they bracket a policy-relevant range from the prevailing BEER-consistent rate to approximately 135 RSD/EUR under FEER and 151 RSD/EUR under the PPP benchmark. For the sectoral simulations, 130–140 RSD/EUR is, therefore, treated as a FEER-informed policy-relevant adjustment corridor, not as a common PPP–BEER–FEER equilibrium estimate; the Monte

Carlo exercise corroborates the robustness of the sectoral inference under plausible parameter uncertainty.

A second core finding is that exchange-rate smoothing through sustained net FX purchases carries a non-trivial quasi-fiscal cost. Using published NBS annual interest-expense data as the official proxy for total sterilization cost (encompassing repo sales, deposit facilities and reserve requirements), the implied annual cost ranges from RSD 4.3 billion (2021, when the policy rate stood at 1.0%) to RSD 50.5 billion (2023, when the annual-average policy rate reached 6.1%), equivalent to 0.07–0.57% of GDP. The cumulative official sterilization cost over 2021–2024 amounts to RSD 111.4 billion (approximately 0.4% of cumulative GDP over the same period). While trade-flow evidence is descriptive rather than causal, the increase in the cumulative trade-deficit index to approximately 194 by end-2024 (from a 2015 base of 100) is qualitatively consistent with the FEER-based conclusion that an externally sustainable exchange rate lies above the prevailing nominal level.

At the micro level, the IRR simulations point to strong redistribution effects across agricultural subsectors. For export-oriented fruit production, depreciation raises dinar revenues more than costs, lifting orchard IRR from 3% (117) to 8% (130) and 12% (140). Given the structural heterogeneity and concentration patterns within Serbian agriculture, macroeconomic conditions can influence capital allocation across subsectors and shape longer-run competitiveness dynamics [51]. In contrast, livestock production exhibits the opposite exposure. Depreciation increases feed and other tradable input costs while output prices adjust only partially, with farm IRR declining from 9% ($S = 117$) to 8% ($S = 130$) and 6% ($S = 140$). The Monte Carlo analysis reinforces this asymmetry. At 130 RSD/EUR, the fruit-sector's median IRR approaches, and at 140 RSD/EUR exceeds, the commercial viability threshold (with downside cases below 8% in the lower tail), whereas the livestock IRR distribution shifts downward, with the median falling to 6% at 140 RSD/EUR. Taken together, the results imply that a depreciation-driven competitiveness boost would tend to be concentrated in export-oriented horticulture, while input-intensive livestock systems would face tighter margins unless productivity and value-chain upgrading offset the cost shock. In this respect, fruit growing remains strategically important for Serbian agriculture [52], but sustaining its competitiveness would require continued productivity gains and further upgrading of export-oriented value chains. Three policy implications follow directly from these results.

1. Evaluate gradual adjustment only as a conditional scenario, not as a fixed target. If policymakers choose to reduce persistent price- and external-balance misalignment, a gradual and pre-announced adjustment path within the FEER-informed scenario corridor provides a conditional illustration of how such an adjustment might be evaluated; it should not be read as a uniquely identified equilibrium target. Predictability would be crucial to limit abrupt repricing and balance-sheet stress;
2. Treat sterilization costs as a first-order policy constraint. The magnitude of sterilization expenditures in 2021–2024 indicates that exchange-rate management entails an economically meaningful quasi-fiscal component. Optimizing the maturity structure and mix of sterilization instruments is, therefore, a natural complement to any exchange-rate strategy;
3. Design agricultural measures that are differentiated by exposure. The IRR results imply that uniform support is unlikely to be cost-effective. Livestock policy could prioritize instruments that mitigate imported-input risk, while fruit-sector policy could focus on easing investment frictions in export-enhancing technology (e.g., processing, cold-chain, sorting), thereby leveraging the stronger profitability response under depreciation scenarios.

Overall, the broader implication is that exchange-rate realignment is not distribution-neutral. It can improve competitiveness for euro-revenue-intensive activities while

compressing margins in input-import-intensive production. A flexible but transparent exchange-rate regime, combined with targeted, exposure-based agricultural measures, therefore offers a coherent and policy-feasible framework for improving competitiveness and resilience in Serbian agriculture. Although calibrated to Serbia, the framework—triangulated misalignment benchmarks mapped into subsector-level investment metrics—travels directly to other Western Balkan economies that combine de facto exchange-rate stabilization, high euroization and agri-food trade exposure, and the asymmetry identified here suggests that exchange-rate policy debates in the region should routinely incorporate their distributional consequences across agricultural subsectors.

Supplementary Materials: The following supporting information can be downloaded at <https://www.mdpi.com/article/10.3390/agriculture16151591/s1>: File S1: Calibrated eight-year discounted cash-flow model with complete year-by-year cash flows for the beef-fattening (livestock) system, reproducing the IRR values of 9%, 8% and 6% reported in Table 6; File S2: Live-formula workbook reproducing the Table 6 livestock IRRs and the Section 4.2 discount-rate, payback and initial-outlay sensitivity results; File S3: Data sources and variable construction, unit-root pre-tests, Johansen cointegration and VECM output with diagnostics and stability tests, robustness and out-of-sample checks, the FEER sensitivity matrix and the reconciliation table; File S4: The observed estimation dataset with data-status flags, live-formula variable transformations, all test output and the fitted equilibrium series reproducing the BEER estimates and Figure 2; File S5: The complete set of raw source-data files (NBS, SORS, Eurostat, IMF, UNCTAD, FAOSTAT) used to construct all series analyzed in the study.

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Data Availability Statement: Publicly available datasets were analyzed in this study. The underlying data are available as follows: the nominal RSD/EUR exchange rate from the National Bank of Serbia, <https://webappcenter.nbs.rs/ExchangeRateWebApp/ExchangeRateAverage/Index> (accessed on 16 January 2026); the Serbian consumer price index, quarterly national accounts and merchandise-trade flows from the Statistical Office of the Republic of Serbia, <https://www.stat.gov.rs/> (accessed on 13 June 2026); euro-area HICP monthly data (prc_hicp_midx) and purchasing-power-parity price-level indices (prc_ppp_ind) from Eurostat, <https://ec.europa.eu/eurostat/> (accessed on 8 January 2026 and 8 February 2026, respectively); consumer-price inflation series for Serbia and the euro area from FRED, <https://fred.stlouisfed.org/data/FPCPITOTLZGSRB> and <https://fred.stlouisfed.org/data/FPCPITOTLZGEMU> (accessed on 1 December 2025); the monthly USD/EUR exchange rate used for the GDP-to-USD conversions in the BEER replication workbook (Supplementary File S4) from the Federal Reserve H.10/G.5 release as disseminated via FRED [53], <https://fred.stlouisfed.org/series/EXUSEU> (accessed on 7 July 2026); the quarterly international investment position for the Republic of Serbia from the IMF data portal [54], <https://data.imf.org/> (accessed on 13 June 2026); export and import unit-value indices from UNCTADstat, <https://unctadstat.unctad.org/> (accessed on 18 May 2025); raspberry producer-price benchmarks from FAOSTAT, <https://www.fao.org/faostat/en/#data/PP> (accessed on 13 June 2026); and the sterilization-cost figures from the NBS Annual Reports 2021–2024, <https://www.nbs.rs/> (accessed on 13 June 2026). The derived data generated in this study, namely the intermediate calculations underlying Tables 1–9, the IRR and Monte Carlo simulations, the quarterly BEER dataset, the estimated cointegrating-

vector and VECM output, the FEER workbook, and the fruit and livestock cash-flow models, are provided in the Supplementary Materials (Supplementary Files S1–S4). Figures 1–7 were generated from the final locked dataset documented therein. In addition, the complete set of raw source-data files used to construct the series analyzed here, obtained from NBS, SORS, Eurostat, IMF, UNCTAD, and FAOSTAT, has been deposited as Supplementary Materials (File S5) accompanying this article.

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