

Impacts of Sports League Transitions on Carbon Footprints: A Case Study of the J.League

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In recent years, sports events have generated benefits for regional economies while also producing CO₂ emissions through spectator travel and match-related consumption. Quantifying such emissions is essential for sustainable league management. Football (soccer) is particularly relevant because promotion and relegation reshape matchups and spectator demand across seasons, potentially altering spectator-driven emissions. However, empirical studies remain limited that evaluate league-transition effects within a unified framework integrating direct travel emissions with supply-chain emissions induced by match-related consumption (e.g., accommodation and food services). This study examines the J.League and estimates an integrated spectator carbon footprint (CF) that accounts for both travel- and consumption-related channels to clarify how league transitions affect spectator CF.

We analyze six clubs that experienced tier transitions between 2015 and 2016 across J1 and J2: promoted clubs—Avispa Fukuoka, Omiya Ardija, and Júbilo Iwata—and relegated clubs—Shimizu S-Pulse, Montedio Yamagata, and Matsumoto Yamaga FC. For each club-year, spectator CF is estimated by combining supply-chain emissions induced by match-related spending with direct emissions from inter-prefectural spectator travel. Match-related spending vectors are constructed using tourism expenditure unit values, category shares, and ticket prices. Consumption-induced emissions are calculated using the 2015 Japan 47-prefecture multi-regional input-output (MRIO) table with emission intensities from the National Institute for Environmental Studies (3EID). Travel emissions are estimated by combining spectator counts, inter-prefectural round-trip distances, and transport-mode shares with mode-specific emission factors. Inputs are drawn from the league's official statistics database, Japanese tourism statistics, and national passenger-flow and transport statistics. Home-fixture attendance is used because club-year counts are consistently available on a home-stadium basis.

League transitions generated substantial demand-side shifts. Average attendance per home match increased for all promoted clubs between 2015 and 2016—Avispa Fukuoka (+47.9%), Júbilo Iwata (+45.5%), and Omiya Ardija (+24.5%)—while it decreased for all relegated clubs—Montedio Yamagata (−37.7%), Shimizu S-Pulse (−23.8%), and Matsumoto Yamaga FC (−19.0%). These shifts matter because match-related consumption largely scales with spectator numbers and can also vary with per-capita spending and composition.

We evaluate how integrated spectator CF responded to league transitions. Because the institutional number of matches differs between leagues (J1: 34; J2: 42), we report match-count-adjusted CF per match (t-CO₂/match) alongside annual totals (t-CO₂/year). Match-adjusted CF per match increased for all promoted clubs: Avispa Fukuoka rose from 88 to 181 t-CO₂/match (+106%), Omiya Ardija from 70 to 84 (+20%), and Júbilo Iwata from 80 to 107 (+34%). In contrast, it decreased for all relegated clubs: Matsumoto Yamaga FC fell from 166 to 132 (−20%), Montedio Yamagata from 86 to 55 (−36%), and Shimizu S-Pulse from 94 to 88 (−6%). Annual CF in 2016 ranged from 2,298 to 6,149 t-CO₂/year, indicating substantial cross-club heterogeneity; year-on-year changes in annual totals did not follow a simple “promotion increases / relegation decreases” pattern.

Channel composition also varied. In 9 of 12 club-year cases, consumption-induced emissions

exceeded travel emissions, implying that travel-only assessments can miss a substantial share of spectator CF. Travel-dominant patterns nonetheless emerged under specific conditions; for Avispa Fukuoka in 2016, travel emissions (3,555 t-CO₂/year) exceeded consumption-induced emissions (2,595 t-CO₂/year). This heterogeneity is consistent with the idea that consumption-related emissions respond primarily to spectator numbers and spending behavior, whereas travel-related emissions respond to geography-driven changes in away-trip distances and transport-mode choices after tier transitions.

Overall, league transitions affect not only the level of spectator CF but also its composition across travel and consumption channels and across clubs. By integrating these channels within a single accounting framework and presenting schedule-adjusted indicators alongside annual totals and channel contributions, this study provides diagnostic insights for emissions management and policy design in sustainable league operations beyond travel-only assessments. The results suggest that mitigation priorities should be tailored: travel-focused measures may be most effective when long-distance trips and aviation shares rise after transitions, whereas consumption-side measures targeting electricity and transport-related services become salient when spectator numbers expand.