

Assessment of Digital Payment Transaction Efficiency Using the PROMETHEE II Method: A Multi-Method Comparative and Sensitivity Analysis

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Abstract

The proliferation of digital payment channels confronts merchants, platform operators, and regulators with a genuinely multi-criteria efficiency question: channels that settle fastest are rarely the cheapest, and the most secure are rarely the most interoperable. This study assesses the transaction efficiency of eight digital payment channels (QRIS, e-wallet, mobile banking, internet banking, virtual account, online debit card, online credit card, and chip-based e-money) against six conflicting criteria (processing time, transaction fee, success rate, security, availability, and interoperability) using PROMETHEE II with a linear (V-shape) preference function as the featured outranking method. To satisfy robustness expectations for methodological studies, the PROMETHEE II ranking is benchmarked against four compensatory and compromise methods (TOPSIS, SAW, WASPAS, and VIKOR) using Spearman rank correlation and Borda aggregation, and stressed through 24 weight-perturbation scenarios. PROMETHEE II ranks mobile banking first (net flow $\phi = 0.2632$) narrowly ahead of QRIS ($\phi = 0.2490$), a result reproduced exactly by VIKOR ($\rho = 0.9762$), whereas the three compensatory methods rank QRIS first (ρ between 0.6905 and 0.7143 with PROMETHEE II). Sensitivity analysis shows high ordinal stability ($\rho \geq 0.9762$ in all scenarios) but a weight-dependent leader: QRIS overtakes mobile banking in 8 of 24 scenarios, precisely when speed or interoperability weights rise or reliability-related weights fall. The paper is presented as a methodological demonstration on an illustrative dataset and discusses the managerial meaning of the compensatory–outranking divergence for payment-channel portfolio decisions.

Keywords: Digital Payment, Transaction Efficiency, PROMETHEE II, Multi-Criteria Decision-Making, Sensitivity Analysis

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1. Introduction

Digital payment systems have become the operational backbone of retail commerce in emerging economies. In Indonesia, the introduction of the Quick Response Code Indonesian Standard (QRIS) by the central bank, alongside the rapid expansion of server-based e-wallets, mobile banking applications, and virtual-account rails, has produced a dense and heterogeneous landscape of transaction channels (Adawiyah, 2025; Indonesia, 2020; Nurhaliza & Prasetyo, 2025). Empirical studies consistently report that digital payment adoption improves transaction efficiency for micro, small, and medium enterprises (MSMEs) by accelerating settlement, reducing cash-handling costs, and minimizing recording errors (Putri & Prabowo, 2022; Rusli & Amiruddin, 2025), and that interoperability standards such as QRIS lower merchant-side friction relative to fragmented wallet-specific acceptance (Kurniawati et al., 2025). At the macro level, fast retail payment systems are recognized as efficiency-enhancing infrastructure (Settlements, 2021), and inclusive digital payments are documented as a driver of formal financial participation.

Yet the practical question faced by a merchant selecting which channels to accept, a platform operator prioritizing integration effort, or a regulator monitoring system performance is not whether digital payments are efficient in the aggregate, but which channel is most efficient when several desirable properties conflict. A chip-based e-money card settles in roughly two seconds but offers weak interoperability and limited security guarantees; an online credit card offers broad acceptance but carries the highest merchant fees and the lowest success rates; internet banking transfers

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are secure but slow. Efficiency assessment in this setting is therefore an intrinsically multi-criteria problem in which no channel dominates all others, and single-indicator comparisons can be actively misleading.

Multi-criteria decision-making (MCDM) methods are the established formal apparatus for such problems (Hwang & Yoon, 1981), (Triantaphyllou, 2000). Within the MCDM family, two methodological traditions coexist. Compensatory methods such as Simple Additive Weighting (SAW) (Churchman & Ackoff, 1954), the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) (Hwang & Yoon, 1981), and the Weighted Aggregated Sum Product Assessment (WASPAS) (Zavadskas et al., 2012) allow a strong performance on one criterion to fully offset a weak performance on another. Outranking methods, most prominently the Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) family (Brans et al., 1986; Brans & De Smet, 2016; Brans & Vincke, 1985) instead build pairwise preference relations criterion by criterion, which limits compensation and rewards balanced performance profiles. PROMETHEE II, which produces a complete ranking through net outranking flows, has a long record of application in financial and banking contexts (Doupou & Zopounidis, 2010; Mareschal & Brans, 1991; Opricovic & Tzeng, 2004; Sklavos et al., 2024) and remains among the most widely used outranking procedures (Akmaludin et al., 2023; Behzadian et al., 2010; Taherdoost & Madanchian, 2023).

A review of the digital payment literature reveals a gap at the intersection of these two streams. Studies of QRIS and e-wallet efficiency are predominantly perceptual or econometric: they use technology-acceptance surveys (Davis, 1989; Hidayat et al., 2023) regression on adoption outcomes, intervention time-series analysis, or qualitative synthesis (Adawiyah, 2025; Nurhaliza & Prasetyo, 2025). They establish that digital channels improve efficiency, but they do not rank heterogeneous channels against each other on an explicit multi-criteria basis. Conversely, the MCDM literature has applied PROMETHEE and hybrid frameworks to vendor selection (Akmaludin et al., 2023), banking performance (Doupou & Zopounidis, 2010; Mareschal & Brans, 1991), ESG disclosure (Sklavos et al., 2024), and technology selection, but digital payment channel efficiency itself has received little outranking-based treatment. Moreover, the methodological literature repeatedly warns that different MCDM methods can produce different rankings on the same data (Akmaludin et al., 2023; Corrente & Greco, 2023; Shekhovtsov & Sařabun, 2020; Zamani-Sabzi et al., 2016), so a single-method application without agreement and robustness analysis is difficult to interpret (Bădinăuță, 2024; Kabassi & Martinis, 2021).

This study addresses that gap with four contributions. First, it formulates digital payment transaction efficiency as an explicit MCDM problem with eight channels and six criteria spanning speed, cost, reliability, security, availability, and interoperability, and solves it with PROMETHEE II using a linear preference function. Second, it benchmarks the PROMETHEE II ranking against four widely used methods (TOPSIS, SAW, WASPAS, VIKOR) and quantifies agreement with Spearman rank correlations and a Borda aggregate ranking. Third, it stresses the featured ranking with a 24-scenario weight-perturbation sensitivity analysis and identifies the exact weight conditions under which the recommended channel changes. Fourth, it interprets the observed compensatory–outranking divergence managerially, showing that the choice between QRIS and mobile banking as the “most efficient” channel is, in substance, a choice between rewarding peak performance and rewarding balanced reliability.

2. Methods

2.1. Research Framework

The research follows a five-stage computational pipeline (Figure 1). Stage 1 constructs the decision matrix of eight alternatives evaluated on six criteria. Stage 2 assigns criterion types (benefit or cost) and weights. Stage 3 applies PROMETHEE II as the featured method, computing pairwise preference degrees, positive and negative outranking flows, and the net-flow ranking. Stage 4 recomputes the ranking with four benchmark methods and measures cross-method agreement. Stage 5 perturbs each criterion weight by ± 0.05 and ± 0.10 (with renormalization) and re-runs PROMETHEE II in each scenario. All computations were implemented in Python (NumPy), and every number reported in this paper is taken directly from the resulting machine-generated output file; no value was computed or transcribed manually.



Figure 1. Research workflow

2.2. Case, Alternatives, Criteria, and Data

The case concerns the assessment of transaction efficiency across eight digital payment channels commonly available in the Indonesian retail payment landscape: QRIS payment (A1), server-based e-wallet (A2), mobile banking transfer (A3), internet banking transfer (A4), virtual account (A5), online debit card (A6), online credit card (A7), and chip-based e-money (A8). Six evaluation criteria were defined from the transaction-efficiency literature (Adawiyah, 2025; Nurhaliza & Prasetyo, 2025; Rusli & Amiruddin, 2025; Settlements, 2021): C1 processing time in seconds (cost criterion lower is better), C2 transaction fee as a percentage of transaction value (cost), C3 transaction success rate in percent (benefit), C4 security index on a 1–10 expert scale (benefit), C5 system availability in percent (benefit), and C6 interoperability on a 1–10 scale (benefit). Table 1 lists the criteria, types, and weights. The weight vector (0.20, 0.20, 0.25, 0.15, 0.10, 0.10) reflects an assumed managerial judgment that reliability (success rate) is the single most important property, followed equally by speed and cost; the weights are stated assumptions rather than elicited expert values.

Table 1. Evaluation criteria, types, and weights ($\sum w = 1$)

Code	Criterion	Type	Weight
C1	Processing Time (s)	cost	0.20
C2	Transaction Fee (%)	cost	0.20
C3	Success Rate (%)	benefit	0.25
C4	Security Index	benefit	0.15
C5	Availability (%)	benefit	0.10
C6	Interoperability	benefit	0.10

The decision matrix (Table 2, visualized in Figure 2) contains illustrative values constructed to be plausible for the Indonesian market for example, a QRIS merchant discount rate of 0.30%, sub-five-second QR and chip-based settlement, and success rates between 97.8% and 99.6% but it is a synthetic dataset assembled for methodological demonstration, not an empirical measurement. This design choice makes every computation fully reproducible and auditable while restricting the claims the study can make.

Table 2. Decision matrix: raw performance of the eight channels on the six criteria.

Alternative	C1	C2	C3	C4	C5	C6
A1 - QRIS Payment	4	0.3	99.2	8.5	99.5	9.5
A2 - E-Wallet	3	0.7	99	8	99.6	7
A3 - Mobile Banking	8	0.45	99.5	9	99.7	8
A4 - Internet Banking	25	0.5	98.8	9	99.4	7.5
A5 - Virtual Account	10	0.55	99.4	8.5	99.5	8.5
A6 - Online Debit Card	12	0.8	98.5	8	99.2	7
A7 - Online Credit Card	10	2	97.8	7.5	99.3	8
A8 - Chip-Based E-Money	2	0.6	99.6	7	99	6

2.3. PROMETHEE II

PROMETHEE II (Brans et al., 1986; Brans & Vincke, 1985) compares every ordered pair of alternatives a and b across n criteria. The performance difference for criterion j is:

$$d_j(a, b) = \begin{cases} f_j(a) - f_j(b), & \text{for a benefit criterion,} \\ f_j(b) - f_j(a), & \text{for a cost criterion.} \end{cases} \quad (1)$$

The preference threshold is determined using the observed range of criterion j :

$$p_j = \max_{a \in A} f_j(a) - \min_{a \in A} f_j(a). \quad (2)$$

The linear V-shape preference function is:

$$P_j(a, b) = \begin{cases} 0, & d_j(a, b) \leq 0, \\ \frac{d_j(a, b)}{p_j}, & 0 < d_j(a, b) < p_j, \\ 1, & d_j(a, b) \geq p_j. \end{cases} \quad (3)$$

The aggregated preference index is calculated as:

$$\pi(a, b) = \sum_{j=1}^n w_j P_j(a, b), \quad (4)$$

where the criterion weights satisfy:

$$w_j \geq 0, \sum_{j=1}^n w_j = 1. \quad (5)$$

For m alternatives, the positive outranking flow is:

$$\phi^+(a) = \frac{1}{m-1} \sum_{\substack{b \in A \\ b \neq a}} \pi(a, b). \quad (6)$$

The negative outranking flow is:

$$\phi^-(a) = \frac{1}{m-1} \sum_{\substack{b \in A \\ b \neq a}} \pi(b, a). \quad (7)$$

The PROMETHEE II net flow is:

$$\phi(a) = \phi^+(a) - \phi^-(a). \quad (8)$$

The net-flow value satisfies:

$$-1 \leq \phi(a) \leq 1. \quad (9)$$

The alternatives are ranked in descending order of their net-flow values:

$$a > b \Leftrightarrow \phi(a) > \phi(b). \quad (10)$$

A higher net-flow value indicates a more preferred alternative. The alternative with the highest value of $\phi(a)$ is ranked first.

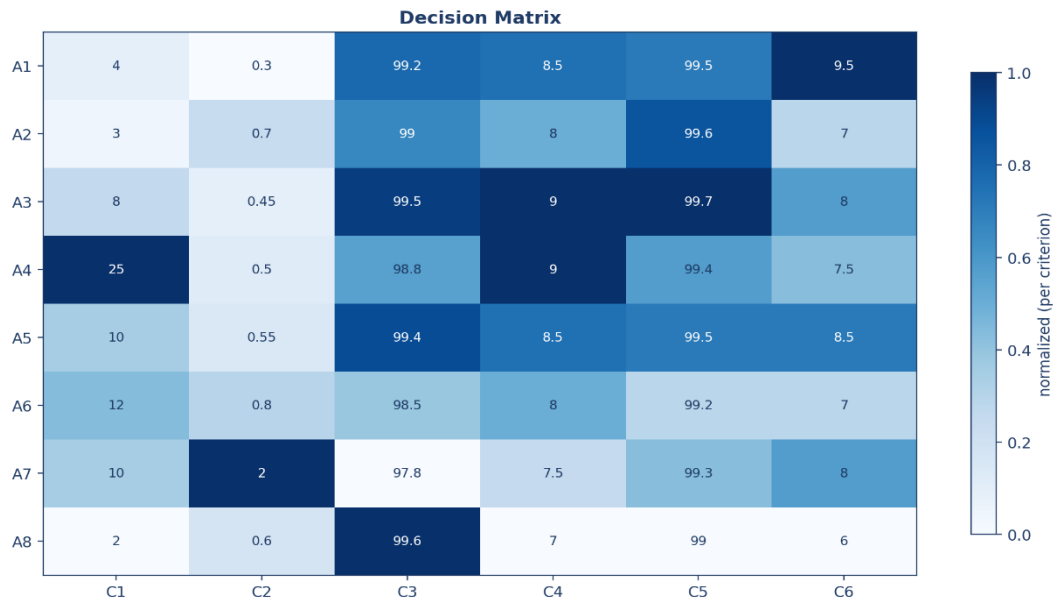


Figure 2. Decision matrix heatmap with per-criterion normalized shading (raw values printed in cells).

2.4. Benchmark methods

Four benchmark methods were computed on the identical decision matrix, weights, and criterion types. SAW (Churchman & Ackoff, 1954) normalizes benefit criteria by the column maximum and cost criteria by the column minimum, then aggregates additively, $V_i = \sum_j w_j r_{ij}$. TOPSIS (Hwang & Yoon, 1981) applies vector normalization, weights the normalized matrix, identifies the positive and negative ideal solutions, and ranks by the relative closeness $C_i = D^-_i / (D^+_i + D^-_i)$, where D^+_i and D^-_i are Euclidean distances to the two ideals. WASPAS (Zavadskas et al., 2012) combines the weighted-sum and weighted-product models as $Q_i = \lambda \cdot WSM_i + (1-\lambda) \cdot WPM_i$ with $\lambda = 0.5$. VIKOR

(Opricovic & Tzeng, 2004) computes the group utility S_i and the individual regret R_i from linearly normalized distances to the best values, and the compromise index:

$$Q_i = v(S_i - S^*)/(S^- - S^*) + (1-v)(R_i - R^*)/(R^- - R^*), \quad v = 0.5$$

In VIKOR, lower Q is better, and the top-ranked alternative is accepted as a single compromise solution only if two conditions hold: acceptable advantage, $Q(A(2)) - Q(A(1)) \geq 1/(m-1)$, and acceptable stability, $A(1)$ also best on S or R .

2.5. Rank Agreement and Sensitivity Procedure

Cross-method agreement is quantified with the Spearman rank correlation coefficient [35], computed for every pair of the five methods over the eight alternatives, following standard practice in comparative MCDM studies (Corrente & Greco, 2023; Kou et al., 2012; Shekhovtsov & Sałabun, 2020; Zamani-Sabzi et al., 2016). A consensus ordering is derived by Borda aggregation, in which each alternative receives $m - r$ points from each method that ranks it r -th, and points are summed across methods (Bădinăuță, 2024; Kou et al., 2012). The sensitivity procedure perturbs each of the six criterion weights in turn by $\Delta w \in \{-0.10, -0.05, +0.05, +0.10\}$, renormalizes the weight vector to sum to one, and re-runs the featured PROMETHEE II model, yielding 24 scenarios. Each scenario is summarized by its top-ranked alternative and its Spearman correlation with the base ranking, following established robustness-analysis practice (Kabassi & Martinis, 2021; Mukhametzyanov & Pamucar, 2018; Torki Harchegani, 2025)

3. Result and Discussion

3.1. PROMETHEE II preference aggregation and ranking

Table 3 reports the aggregated preference matrix $\pi(a, b)$ computed from Equations (1)–(2). Row values show how strongly each channel is preferred over each other channel across all six weighted criteria. The largest single preference degree, $\pi(A3, A7) = 0.6055$, confirms that mobile banking dominates the online credit card on almost every weighted criterion, while near-zero entries such as $\pi(A6, A1) = 0.0000$ and $\pi(A7, A1) = 0.0000$ show that the debit and credit card channels are preferred to QRIS on essentially nothing.

Table 3. Aggregated preference matrix $\pi(a, b)$; row alternative preferred over column alternative.

$\pi(a,b)$	A1	A2	A3	A4	A5	A6	A7	A8
A1	0.0000	0.1838	0.0953	0.3331	0.1102	0.3774	0.5930	0.3192
A2	0.0230	0.0000	0.0435	0.2477	0.0752	0.2166	0.4608	0.1893
A3	0.1077	0.2167	0.0000	0.3081	0.1091	0.3898	0.6055	0.3248
A4	0.0375	0.1128	0.0000	0.0000	0.0434	0.1948	0.4421	0.2618
A5	0.0278	0.1536	0.0143	0.2566	0.0000	0.2950	0.5107	0.2612
A6	0.0000	0.0000	0.0000	0.1130	0.0000	0.0000	0.2759	0.1321
A7	0.0000	0.0286	0.0000	0.1447	0.0000	0.0602	0.0000	0.1375
A8	0.0729	0.1038	0.0661	0.3111	0.0973	0.2633	0.4843	0.0000

Table 4 presents the positive, negative, and net outranking flows from Equations (3)–(4), and Figure 3 visualizes the net flows. Mobile banking (A3) ranks first with $\phi = 0.2632$, driven jointly by the highest leaving flow ($\phi^+ = 0.2945$) and the lowest entering flow ($\phi^- = 0.0313$): it is simultaneously the channel that most outranks others and the channel least outranked by others. QRIS (A1) follows closely at $\phi = 0.2490$, with a comparable leaving flow ($\phi^+ = 0.2874$) but a slightly larger entering flow ($\phi^- = 0.0384$), reflecting the pairwise preferences it concedes on success rate, security, and availability. Virtual account (A5, $\phi = 0.1549$) and e-wallet (A2, $\phi = 0.0653$) complete the positive-flow group. Chip-based e-money (A8, $\phi = -0.0325$) is the pivot case: its exceptional speed cannot, under limited-compensation outranking logic, offset weak security and interoperability. Internet banking (A4, $\phi = -0.0888$), the online debit card (A6, $\phi = -0.1823$), and the online credit card (A7, $\phi = -0.4288$) form the negative tail, with A7 outranked on $\phi^- = 0.4818$ of the maximum possible preference mass by far the least efficient channel in the set.

3.2. Benchmark method results

TOPSIS produces a different leader. Table 5 reports the Euclidean distances to the positive and negative ideal solutions and the relative closeness. QRIS attains an exceptionally high closeness $C = 0.9366$ because it sits very near the positive ideal ($D^+ = 0.0127$) its 0.30% fee and 9.5 interoperability score define the ideal on two heavily weighted dimensions

while mobile banking falls to fourth ($C = 0.8049$), penalized in Euclidean distance terms by its 8-second processing time. Figure 4 shows the distance decomposition.

Table 4. PROMETHEE II positive, negative, and net outranking flows with final ranks.

Alternative	ϕ^+	ϕ^-	ϕ (net)	Rank
A1 - QRIS Payment	0.2874	0.0384	0.2490	2
A2 - E-Wallet	0.1794	0.1142	0.0653	4
A3 - Mobile Banking	0.2945	0.0313	0.2632	1
A4 - Internet Banking	0.1561	0.2449	-0.0888	6
A5 - Virtual Account	0.2170	0.0622	0.1549	3
A6 - Online Debit Card	0.0744	0.2567	-0.1823	7
A7 - Online Credit Card	0.0530	0.4818	-0.4288	8
A8 - Chip-Based E-Money	0.1998	0.2323	-0.0324	5

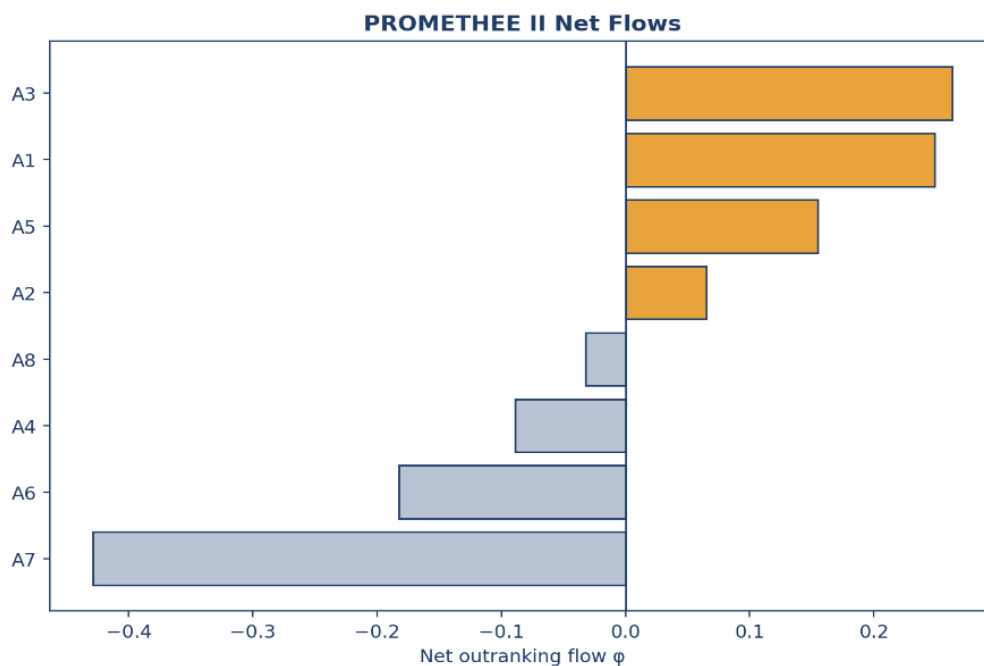


Figure 3. PROMETHEE II net outranking flows ϕ ; positive-flow channels highlighted.

Table 5. TOPSIS distances to ideal solutions and relative closeness.

Alternative	D^+	D^-	C	Rank
A1 - QRIS Payment	0.0127	0.1876	0.9366	1
A2 - E-Wallet	0.0349	0.1702	0.8297	3
A3 - Mobile Banking	0.0393	0.1622	0.8049	4
A4 - Internet Banking	0.1423	0.1201	0.4576	7
A5 - Virtual Account	0.0533	0.1482	0.7357	5
A6 - Online Debit Card	0.0743	0.1246	0.6265	6
A7 - Online Credit Card	0.1442	0.0926	0.3909	8
A8 - Chip-Based E-Money	0.0315	0.1797	0.8510	2

SAW and WASPAS agree with TOPSIS on the leader. Table 6 reports the SAW additive scores together with the WASPAS weighted-sum, weighted-product, and combined scores. QRIS leads on all three columns (SAW $V = 0.8905$; WASPAS $Q = 0.8763$), followed by chip-based e-money (0.8291; 0.8146), whose two-second settlement and adequate scores elsewhere are fully rewarded under compensatory aggregation. The WPM column is systematically lower than the WSM column, with the gap widest for internet banking (0.7126 vs 0.5309) the multiplicative model punishes its 25-second processing time more severely than the additive model does, illustrating within a single method the same compensation effect that separates the method families.

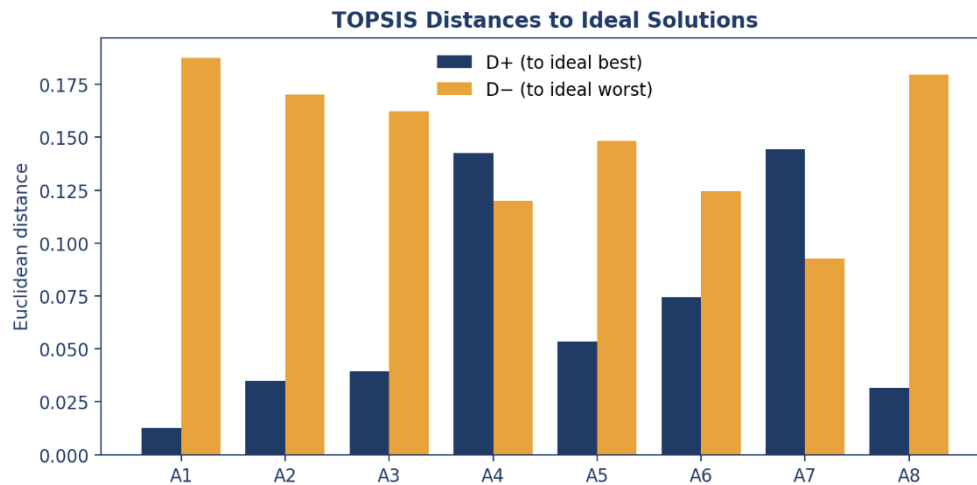


Figure 4. TOPSIS Euclidean distances to the ideal best (D^+) and ideal worst (D^-) solutions.

Table 6. SAW and WASPAS ($\lambda = 0.5$) scores; SAW ranks equal WASPAS ranks except A4/A6 order under SAW follows the same sequence.

Alternative	SAW V	WSM	WPM	WASPAS Q	Rank (WASPAS)
A1 - QRIS Payment	0.8905	0.8905	0.8621	0.8763	1
A2 - E-Wallet	0.7745	0.7745	0.7405	0.7575	3
A3 - Mobile Banking	0.7673	0.7673	0.6867	0.7270	4
A4 - Internet Banking	0.7126	0.7126	0.5309	0.6217	6
A5 - Virtual Account	0.7295	0.7295	0.6291	0.6793	5
A6 - Online Debit Card	0.6621	0.6621	0.5455	0.6038	7
A7 - Online Credit Card	0.6243	0.6243	0.4720	0.5481	8
A8 - Chip-Based E-Money	0.8291	0.8291	0.8001	0.8146	2

VIKOR, the compromise-programming benchmark, reproduces the PROMETHEE II ordering at the top. Table 7 reports S, R, and Q. Mobile banking is best on all three indices ($S = 0.1266$, $R = 0.0522$, $Q = 0.0000$), and QRIS is second ($Q = 0.0188$). The acceptable-advantage condition, however, fails: $Q(A1) - Q(A3) = 0.0188$ is far below the threshold $1/(m-1) = 0.1429$, and the third-placed virtual account ($Q = 0.1223$) also falls inside the threshold. VIKOR therefore does not certify a single winner but proposes the compromise set $\{A3, A1, A5\}$; the acceptable-stability condition is satisfied because A3 is also best on both S and R. This is a substantively important nuance: the compromise method formally declares mobile banking, QRIS, and the virtual account statistically indistinguishable at the top under $v = 0.5$.

Table 7. VIKOR indices (lower Q = better); compromise set $\{A3, A1, A5\}$ after acceptance-condition checks.

Alternative	S (utility)	R (regret)	Q	Rank
A1 - QRIS Payment	0.1390	0.0556	0.0188	2
A2 - E-Wallet	0.2998	0.0833	0.2218	4
A3 - Mobile Banking	0.1266	0.0522	0.0000	1
A4 - Internet Banking	0.4346	0.2000	0.6280	7
A5 - Virtual Account	0.2214	0.0696	0.1223	3
A6 - Online Debit Card	0.5164	0.1528	0.5762	6
A7 - Online Credit Card	0.7321	0.2500	1.0000	8
A8 - Chip-Based E-Money	0.3853	0.1500	0.4609	5

3.3. Cross-method comparison

Table 8 assembles the rank of every alternative under every method, visualized in Figure 5. The methods split into two coherent blocks. The compensatory block (TOPSIS, SAW, WASPAS) ranks QRIS first and chip-based e-money second; the outranking-compromise block (PROMETHEE II, VIKOR) ranks mobile banking first, QRIS second, and

demotes chip-based e-money to fifth. The blocks agree perfectly on the bottom: the online credit card is eighth under all five methods, and the online debit card and internet banking occupy ranks six and seven throughout (in method-dependent order).

Table 8. Rank of each alternative under the five methods (1 = best).

Alternative	PROMETHEE II	TOPSIS	SAW	VIKOR	WASPAS
A1 - QRIS Payment	2	1	1	2	1
A2 - E-Wallet	4	3	3	4	3
A3 - Mobile Banking	1	4	4	1	4
A4 - Internet Banking	6	7	6	7	6
A5 - Virtual Account	3	5	5	3	5
A6 - Online Debit Card	7	6	7	6	7
A7 - Online Credit Card	8	8	8	8	8
A8 - Chip-Based E-Money	5	2	2	5	2

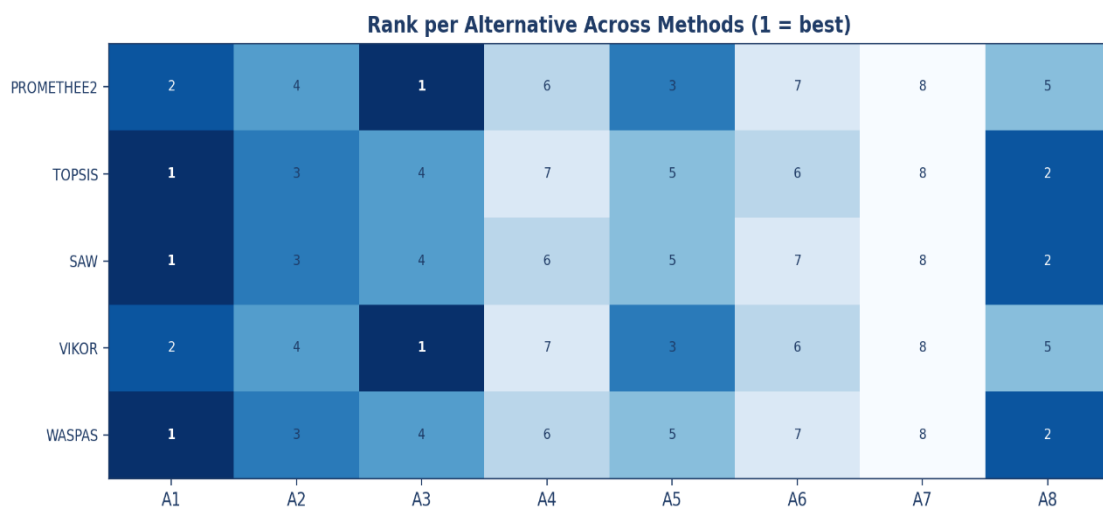


Figure 5. Rank-per-alternative heatmap across methods; darker cells indicate better ranks.

Table 9 quantifies the block structure with Spearman correlations. Within-block agreement is near-perfect: SAW–WASPAS $\rho = 1.0000$, TOPSIS–SAW and TOPSIS–WASPAS $\rho = 0.9762$, and PROMETHEE II–VIKOR $\rho = 0.9762$. Between blocks, correlations drop to between 0.6905 (PROMETHEE II–TOPSIS; SAW–VIKOR; VIKOR–WASPAS) and 0.7143 (PROMETHEE II–SAW; PROMETHEE II–WASPAS; TOPSIS–VIKOR). The pattern replicates a regularity reported across comparative MCDM studies – additive and distance-based compensatory methods cluster together, while outranking and compromise methods cluster separately [14], [16], [17] – and confirms that the disagreement observed here is methodological rather than an artifact of this dataset.

Table 9. Spearman rank correlations between method rankings ($m = 8$).

Method pair	ρ
PROMETHEE II – TOPSIS	0.6905
PROMETHEE II – SAW	0.7143
PROMETHEE II – VIKOR	0.9762
PROMETHEE II – WASPAS	0.7143
TOPSIS – SAW	0.9762
TOPSIS – VIKOR	0.7143
TOPSIS – WASPAS	0.9762
SAW – VIKOR	0.6905
SAW – WASPAS	1.0000
VIKOR – WASPAS	0.6905

The Borda aggregation (Table 10) offers a consensus reading. QRIS accumulates 33 of a possible 35 points and takes the aggregate first place, mobile banking is second with 26, and chip-based e-money third with 24; the online credit

card collects zero points, ranked last by every method. On consensus grounds, then, QRIS is the most efficient channel overall, but the aggregate conceals that the two methods designed to resist compensation both prefer mobile banking a distinction the Discussion returns to.

Table 10. Borda aggregate ranking across the five methods (max = 35 points).

Rank	Alternative	Borda points
1	A1 - QRIS Payment	33
2	A3 - Mobile Banking	26
3	A8 - Chip-Based E-Money	24
4	A2 - E-Wallet	23
5	A5 - Virtual Account	19
6	A4 - Internet Banking	8
7	A6 - Online Debit Card	7
8	A7 - Online Credit Card	0

3.4. Sensitivity analysis

Table 11 summarizes the 24 weight-perturbation scenarios for the featured PROMETHEE II model; Figure 6 plots the Spearman correlation of each scenario against the base ranking. Ordinal stability is high throughout: ρ never falls below 0.9762, meaning at most a single adjacent swap occurs in any scenario. The identity of the leader, however, is genuinely weight-dependent. Mobile banking retains first place in 16 of 24 scenarios, but QRIS takes the top position in 8 scenarios with a fully interpretable pattern: it wins when the processing-time weight rises ($\Delta w = +0.10$ on C1), when the interoperability weight rises ($\Delta w = +0.05$ or $+0.10$ on C6), or when the weights of the reliability criteria on which mobile banking excels fall ($\Delta w = -0.10$ on C3; $\Delta w = -0.05$ or -0.10 on C4; $\Delta w = -0.05$ or -0.10 on C5). No third alternative reaches the top in any scenario, and the bottom three ranks never change.

Table 11. Top-ranked alternative and Spearman ρ vs. the base PROMETHEE II ranking per weight-perturbation scenario.

Criterion	$\Delta w = -0.10$	$\Delta w = -0.05$	$\Delta w = +0.05$	$\Delta w = +0.10$
C1 - Processing Time (s)	A3 ($\rho=0.976$)	A3 ($\rho=0.976$)	A3 ($\rho=1.000$)	A1 ($\rho=0.976$)
C2 - Transaction Fee (%)	A3 ($\rho=1.000$)	A3 ($\rho=1.000$)	A3 ($\rho=1.000$)	A3 ($\rho=1.000$)
C3 - Success Rate (%)	A1 ($\rho=0.976$)	A3 ($\rho=1.000$)	A3 ($\rho=1.000$)	A3 ($\rho=1.000$)
C4 - Security Index	A1 ($\rho=0.976$)	A1 ($\rho=0.976$)	A3 ($\rho=0.976$)	A3 ($\rho=0.976$)
C5 - Availability (%)	A1 ($\rho=0.976$)	A1 ($\rho=0.976$)	A3 ($\rho=1.000$)	A3 ($\rho=0.976$)
C6 - Interoperability	A3 ($\rho=1.000$)	A3 ($\rho=1.000$)	A1 ($\rho=0.976$)	A1 ($\rho=0.976$)

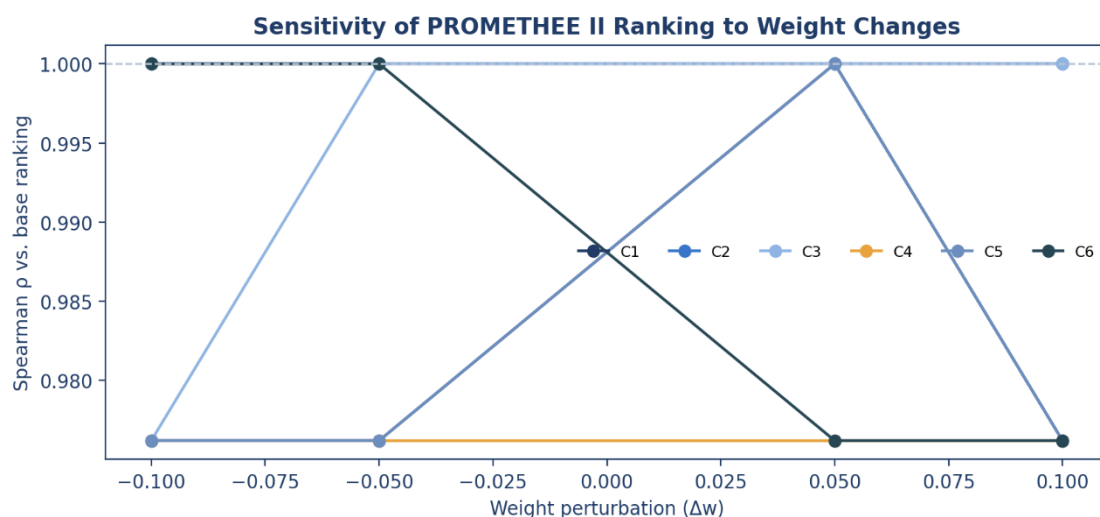


Figure 6. Sensitivity of the PROMETHEE II ranking to weight perturbations (ρ vs. base ranking).

3.5. Performance profiles of the leading channels

Figure 7 profiles the three channels at the top of the featured ranking on min–max-normalized criteria (cost criteria inverted so that outward is always better). The radar makes the structural difference between the two contenders visible: mobile banking (A3) traces a balanced polygon that is strong on success rate, security, and availability and never collapses toward the center, whereas QRIS (A1) spikes to the maximum on fee and interoperability but recedes on security relative to A3. The virtual account (A5) is a slightly attenuated version of the mobile-banking profile. This geometry is precisely what the two method families evaluate differently.

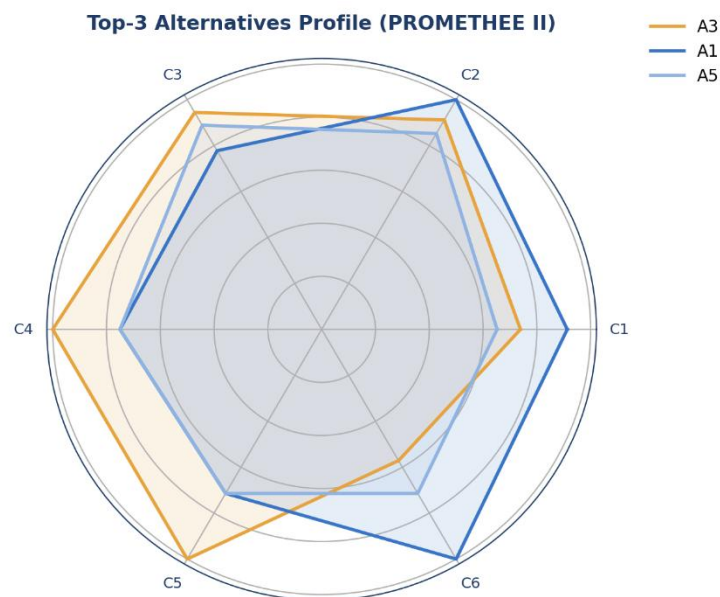


Fig 7. Normalized performance profiles of the top-3 channels under PROMETHEE II (cost criteria inverted).

Why does mobile banking win under PROMETHEE II while QRIS wins under the compensatory methods? The preference-flow decomposition provides the mechanism. Under the linear preference function, an advantage larger than the criterion range earns no additional preference: QRIS's 0.30% fee against the credit card's 2.00% earns the maximum preference degree on C2, but the same maximum a merely “clearly cheaper” channel would earn. Compensatory methods, by contrast, propagate the full magnitude of QRIS's fee and interoperability advantages through normalization into the aggregate score. TOPSIS places QRIS at Euclidean distance 0.0127 from the ideal, an order of magnitude closer than mobile banking's 0.0393 (Table 5). PROMETHEE II instead credits mobile banking for being outranked on almost nothing ($\phi^- = 0.0313$, the lowest in the set): its worst criterion (8-second processing) is only moderately worse than the field, whereas QRIS concedes preference mass on three reliability criteria simultaneously. The outranking result therefore rewards the absence of weaknesses; the compensatory result rewards the presence of peaks. VIKOR's agreement with PROMETHEE II ($\rho = 0.9762$) is consistent with this reading, since its regret component R penalizes the single worst weighted deviation and mobile banking has the smallest regret ($R = 0.0522$).

The sensitivity analysis converts this methodological observation into a managerial decision rule. The leadership boundary between the two channels tracks a single trade-off axis: throughput versus reliability. A decision-maker who weights settlement speed or interoperability even five percentage points more heavily than the base vector a defensible stance for high-volume, low-ticket retail should prefer QRIS under every method computed here. A decision-maker who maintains or increases the weight on success rate, security, and availability defensible for higher-value transfers or risk-averse institutions obtains mobile banking from the outranking and compromise perspectives. Because $\rho \geq 0.9762$ in all 24 scenarios, everything below the top two positions is effectively settled: virtual accounts are a robust third option, and the online credit card is robustly the least efficient channel, its 2.00% fee and 97.8% success rate leaving it outranked on $\phi^- = 0.4818$ of the possible preference mass. VIKOR's refusal to certify a single winner (compromise set $\{A3, A1, A5\}$) is best read not as indecision but as an accurate statement that, at these weights, the top of this field is genuinely close.

The findings align with, and extend, the empirical digital-payment literature. Survey and regression studies report that QRIS and e-wallet adoption improve MSME transaction efficiency through speed, cost, and recording accuracy (Putri

& Prabowo, 2022; Rusli & Amiruddin, 2025), and that QRIS's interoperability is its distinctive merchant-side advantage over fragmented wallet acceptance (Kurniawati et al., 2025; Nurhaliza & Prasetyo, 2025); the compensatory rankings computed here are the multi-criteria formalization of exactly those advantages. The outranking perspective adds what adoption studies do not measure: when reliability criteria enter the assessment with substantial weight, a mature bank-operated channel can rank above the newer standard despite losing on cost and speed. For platform operators and regulators, the practical implication is portfolio-shaped rather than winner-take-all the analysis supports QRIS and mobile banking as complementary first-tier channels serving different transaction profiles, echoing the complementarity argument in recent adoption research (Kurniawati et al., 2025).

Four limitations bound these conclusions. First, the decision matrix is illustrative: although the values were constructed to be realistic for the Indonesian market, no channel-level conclusion should be transferred to practice without re-estimating the matrix from operational data (transaction logs, uptime reports, scheme fee schedules). Second, the weights are assumed rather than elicited; the sensitivity analysis mitigates but does not eliminate this, and pairwise elicitation (for example, AHP with consistency checking) would strengthen a field application. Third, the criterion set omits dimensions that may matter in specific contexts fraud-loss rates, chargeback exposure, offline capability, and user experience among them. Fourth, the preference thresholds p_j were set mechanically to the criterion ranges; PROMETHEE results can be sensitive to threshold choices, and decision-maker-supplied indifference and preference thresholds would refine the flows. None of these limitations affects the paper's methodological demonstration, which is the primary contribution.

4. Conclusion

This study assessed the transaction efficiency of eight digital payment channels against six weighted criteria using PROMETHEE II with a linear preference function, benchmarked the result against four established MCDM methods, and stress-tested it across 24 weight-perturbation scenarios. PROMETHEE II ranked mobile banking first ($\phi = 0.2632$) ahead of QRIS ($\phi = 0.2490$), an ordering reproduced by VIKOR ($\rho = 0.9762$) which nonetheless placed both channels, with the virtual account, inside a formal compromise set. The compensatory methods (TOPSIS, SAW, WASPAS) unanimously ranked QRIS first, with cross-block Spearman correlations of 0.6905–0.7143 quantifying a clean compensatory-versus-outranking divergence; the Borda consensus favored QRIS (33/35 points), and the online credit card ranked last under every method and every scenario. Sensitivity analysis showed near-perfect ordinal stability ($\rho \geq 0.9762$) with a weight-dependent leader: QRIS overtakes mobile banking in exactly the 8 scenarios that raise the weight of speed or interoperability or lower the weight of reliability criteria. The substantive lesson is that “most efficient digital payment channel” is not a single answer but a function of whether the assessor rewards balanced reliability (outranking logic) or peak performance on cost and interoperability (compensatory logic) and the paper makes that dependence explicit and quantitative.

Future work should proceed along four lines: replacing the illustrative matrix with operational data from acquirers, switching providers, or central-bank statistics; eliciting weights and PROMETHEE preference thresholds from payment-industry experts, with AHP consistency verification; extending the criterion set to fraud, chargeback, and user-experience dimensions, possibly under fuzzy or interval representations of uncertain values; and implementing the pipeline as a web-based decision support system so that merchants and platform operators can re-rank channels interactively as fees, uptime, and regulation evolve.

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