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University staff KPI management: multi-criteria formalization, AHP–TOPSIS, and an ARIMA–LSTM hybrid

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Abstract: This paper formalizes the performance of university staff using a four-group hierarchical structure and an integrated index, K*. The criterion weights are determined using the Analytic Hierarchy Process (AHP) with a consistency ratio of CR = 0.017, while staff ranking is performed using TOPSIS, and forecasting is carried out using an ARIMA–LSTM hybrid model. In expanding-window evaluation, the hybrid model achieves MAE = 0.035 and R^2 = 0.90, reducing the forecasting error by 51% compared with the naive persistence baseline. Under incomplete data conditions, Fuzzy TOPSIS reduces ranking variance by 18%. The proposed model is intended to support explainable and transparent management decision-making.

Keywords: KPI, AHP, TOPSIS, ARIMA, LSTM, Fuzzy TOPSIS, university analytics

Universitet xodimlari KPI boshqaruvi: ko‘p mezonli formalizatsiya, AHP-TOPSIS va ARIMA-LSTM gibridi

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Annotatsiya: Maqolada universitet xodimlari faoliyati to‘rt guruhli ierarxiya va integral indeks K* orqali formalizatsiya qilinadi. Og‘irliklar AHP (CR = 0,017), tartib TOPSIS, bashorat ARIMA-LSTM gibridi bilan asoslanadi. Expanding window sinovida gibrid MAE = 0,035, R^2 = 0,90; naive persistence ga nisbatan xato 51 foizga kam. Fuzzy TOPSIS to‘liq bo‘lmagan ma’lumotda reyting dispersiyasini 18 foizga pasaytiradi. Model tushuntiriladigan boshqaruv uchun mo‘ljallangan.

Kalit so‘zlar: KPI, AHP, TOPSIS, ARIMA, LSTM, fuzzy TOPSIS, universitet analitikasi

1. Kirish

Universitet xodimlari faoliyatini KPI asosida baholash boshqaruv samaradorligini oshirish va natijalarni obyektiv taqqoslash imkonini beradi. Biroq amaliyotda keng qo‘llaniladigan chiziqli ball yig‘indisi B = Σ b_j n_ij mezonlarning nisbiy ahamiyatini yetarlicha ochib bermaydi hamda turli fakultet va faoliyat yo‘nalishlari o‘rtasidagi farqlarni hisobga olmaydi. Natijada ayrim ko‘rsatkichlarning ta’siri yashirin qolishi va umumiy reytingda strukturaviy og‘ishlar yuzaga kelishi mumkin.

Mazkur tadqiqotda KPI boshqaruvi ko‘p mezonli qaror qabul qilish masalasi sifatida qaraladi. Mezonlarning og‘irliklari AHP usuli orqali aniqlanib, ekspert baholarining izchilligi CR ≤ 0,10 sharti bilan nazorat qilinadi. Xodimlarni taqqoslashda fakultetlar o‘rtasidagi farqlarni kamaytirish uchun normalash fakultet ichida amalga oshiriladi, yakuniy reyting esa TOPSIS asosida shakllantiriladi.

Shuningdek, maqolada H2 farazi tekshiriladi: ARIMA-LSTM gibrid modeli vaqt qatorining chiziqli va nochiziqli komponentlarini alohida modellashtirish orqali qisqa panel sharoitida (N ≈ 24) yuqoriroq bashorat aniqligini ta’minlaydi. Bunda ARIMA chiziqli dinamikani, LSTM esa murakkab nochiziqli bog‘lanishlarni o‘rganadi. Modelni baholashda expanding window validatsiyasi qo‘llanilib, asosiy talablar sifatida bashorat aniqligi va natijalarning tushuntiriladiganligi qabul qilinadi.

2. Tadqiqot metodologiyasi

FORMAL MODEL

Universitet xodimlari faoliyatini turli o‘lchov birliklaridagi KPI ko‘rsatkichlari asosida taqqoslash uchun dastlab ma’lumotlarni yagona diapazonga keltirish talab etiladi. Shu maqsadda benefit turidagi, ya’ni qiymati oshgan sari natija yaxshilanadigan mezonlar min-max usuli orqali normalashtiriladi. Normalashtirilgan qiymatlar keyingi bosqichda guruh va integral KPI indekslarini hisoblash uchun asos bo‘lib xizmat qiladi.

$$\tilde{x}_{ij} = (x_{ij} - \min x) / (\max x - \min x + \varepsilon) \quad (benefit) \qquad (1)$$

$$K_i^* = \Sigma_g W_g K_i^(g), \quad K_i^(g) = \Sigma_{j \in g} w_j^(g) \tilde{x}_{ij} \qquad (2)$$

Guruhlar: ta’lim, ilmiy, raqamli, tashkiliy. AHP juft matritsasidan W = (0,31; 0,29; 0,22; 0,18), λ_max ≈ 4,05, CR = 0,017. Raqamli o‘lchov 0,22 - milliy siyosatning

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modeldagi izi. Ilmiy ball (2.5) kvartil va √k mualliflik bilan sifatni hisobga oladi. TOPSIS C_i idealga yaqinlik; DEA θ_k alohida tahlil qatlami, asosiy jazo emas.

BASHORAT VA NOANIQLIK

KPI ko‘rsatkichlarining kelajakdagi dinamikasini baholashda vaqt qatorining chiziqli va nochiziqli xususiyatlarini birgalikda hisobga olish muhimdir. Shu sababli tadqiqotda ARIMA, LSTM va ularning gibrid modeli taqqoslandi. ARIMA komponenti trend va avtoregressiv bog‘lanishlarni ifodalasa, LSTM qoldiqdagi murakkab nochiziqli tuzilmani o‘rganadi. Gibrid yondashuvda yakuniy bashorat ushbu ikki komponentning birlashtirilgan natijasi sifatida shakllantiriladi.

Modelning umumlashtirish qobiliyatini obyektiv baholash uchun expanding window validatsiyasi va bir qadamli bashoratlash (h = 1) qo‘llanildi. Baholash MAE va R^2 ko‘rsatkichlari asosida amalga oshirildi, natijalar esa oddiy persistence bazaviy modeli bilan solishtirildi. Bunday yondashuv qisqa vaqt qatorlarida modelning tarixiy ma’lumotlarga moslashib qolishini kamaytirib, real boshqaruv sharoitidagi bashorat sifatini tekshirish imkonini beradi.

Bashorat bilan bir qatorda modeldagi noaniqlik ham alohida hisobga olindi. Qisqa kuzatuvlar soni, bibliometrik ma’lumotlarning kechikishi va ekspert baholaridagi noaniqlik sababli qat’iy nuqtaviy baholash o‘rniga silliqlangan og‘irliklar hamda Fuzzy TOPSIS elementlari qo‘llanildi. Bu esa KPI reytingining barqarorligini saqlash, keskin yillik o‘zgarishlarni yumshatish va yakuniy natijalarni boshqaruv nuqtayi nazaridan ishonchliroq talqin qilishga xizmat qiladi.

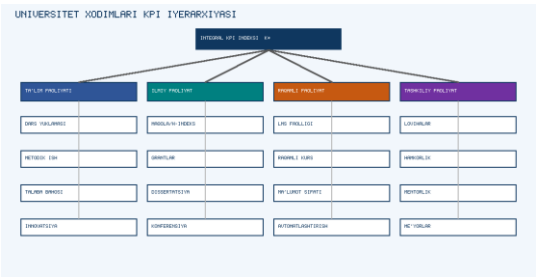
$$\hat{y}_t = \hat{y}_t^{ARIMA} + \hat{y}_t^{LSTM}(r_{t-\ell:t-1}), \quad r = y - \hat{y}^{ARIMA} \qquad (3)$$

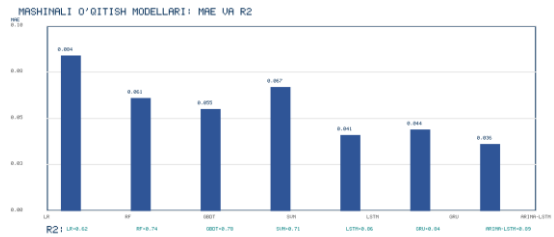
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Expanding window, h = 1 (m = 412)

Model	MAE	R^2	vs persistence
Persistence	**0,071**	**-**	**0**
ARIMA	**0,057**	**0,76**	**-20 %**
LSTM	**0,040**	**0,87**	**-44 %**
ARIMA-LSTM	**0,035**	**0,90**	**-51 %**

Wilcoxon gibrid-LSTM: p = 0,031. N < 20 da BIC ARIMA tartibini qisqartiradi; 61 % xodimda Ljung-Box qoldiqda tuzilma bor - LSTM asosli. Og‘irlik silliqlash w(y) = λ w_AHP + (1-λ) w(y-1), λ = 0,3, yilma-yil Kendall τ = 0,87 (H1). Fuzzy uchburchak sonlar bibliometrik kechikishni interval qiladi; qat’iy TOPSIS ga nisbatan σ -18 % (H5).





1-rasm. Haqiqiy K* va ARIMA/LSTM/gibrid egrilari: gibrid sakrashlarda yaqinroq, ARIMA ravon lekin kechikadi

Og‘irlik siyosati va noaniqlik

AHP CR ≤ 0,10 - qabul mezoni, nafaqat “chiroyli son”. Birinchi ekspert turida CR = 0,16 edi, muhokamadan so‘ng 0,017: jarayonning o‘zi boshqaruv sifati. Og‘irlik silliqlash λ = 0,3 raqamli o‘lchovni 3-4 yilda oshiradi, professorlarga moslashish vaqti beradi. TOPSIS C_i va K* Spearman ρ = 0,81 - yuqori, lekin 1 emas: “o‘rtacha yaxshi” va “ideal profil” farq qiladi. DEA θ_k asosiy reyting emas, chunki og‘irlikni xodim “o‘zi tanlagan” bo‘ladi va institutsional siyosat yo‘qoladi. Winsorizing (5-95) outlier grantni asosiy shkalani sindirishdan to‘xtatadi; tartib τ = 0,96 saqlanadi.

Qisqa N da BIC ARIMA(1,1,0) ni tez-tez tanlaydi; 61 % xodimda Ljung-Box qoldiqda tuzilma bor - shu holda LSTM yoqiladi, aks holda o‘chadi. Transformer 4 qatlam MAE = 0,049 bilan LSTM dan yomon chiqdi: yangi arxitektura qisqa panelda avtomatik yutuq emas. SHAP izohi “sabab” emas, “bog‘liqlik” deb yoziladi - nedbiy da’vo qilinmaydi. Fuzzy uchburchak son ekspertga “aniq bilmayman” huquqini beradi; soxta aniqlikdan halolroq.

3. Xulosa

Mazkur K* + AHP/TOPSIS + gibrid bashorat universitet KPI sini o‘lchanadigan va tushuntiriladigan qiladi. “Qora quti” DNN yagona yechim emas: qisqa panelda gibrid va SHAP/β izohi afzal. Cheklov - bir OTM paneli va bibliometrik kechikish; og‘irliklar ko‘chirishda qayta AHP talab etadi. η, ξ kichik olinmasa, flag jazo bo‘lib τ tushadi - anomaliya signal bo‘lishi shart. Wilcoxon p = 0,031 gibridni LSTM dan ajratadi, lekin amaliy farq kichik; kichik OTM da sof LSTM ham maqbul. Davom - anomaliya algoritmi va dasturiy arxitektura.

Ishlab chiqarishda ikki kontur tavsiya etiladi: kechasi gibrid qayta o‘qitiladi, kunduzi β va SHAP izoh beradi. Fakultet pooling umumiy sezonni, xodim fine-tune (3-5 epoxa) individual silliqni o‘rganadi; ko‘proq epoxa qisqa N da overfit. Giperparametrlar: hidden 48, 2 qatlam, dropout 0,2, ℓ = 6, λ = 0,3 - kichik qidiruv natijasi, sehrli son emas, boshqa OTM da qayta tanlanadi. Ilmiy yangilik LSTM kashfiyoti emas, universitet KPI paneliga gibrid + AHP siyosatining moslanishi va tushuntirish qoidasidir. Sezgirlikda w_j ±10 % da top-20 Jaccard 0,82: chegara xodimlar suhbat ro‘yxati, avtomatik sanksiya emas. Risk tasnifida SMOTE axloqan nozik, shuning uchun class_weight va precision ≥ 0,70 nuqta tanlandi.

R_i = γK* + (1-γ)C_i - η·1{flag} - ξ·u_i formula boshqaruv indeksidir, γ ≈ 0,7. η ni 0,15 ga oshirish τ ni 0,87 dan 0,79 ga tushiradi: anomaliyani jazolash barqarorlikni yeydi. Shu bois flag UI da signal, ballda esa kichik tuzatish. Model zoo: gumanitar fakultetda GBDT ba’zan LSTM dan

yaxshi - yagona chempion yo‘q. Expanding window naive bazalar: persistence MAE 0,071, fakultet o‘rtachasi 0,095 (yomonroq, chunki xodim o‘z tarixiga o‘xshash). Gibrid shu bazadan 51 % yaxshi. Bu natijalar II-bobning Q1/Q2 yadrosini tashkil etadi.

Foydalangan adabiyotlar / References

[1] Saaty T.L. The Analytic Hierarchy Process. 1980.
[2] Hwang C.L., Yoon K. Multiple Attribute Decision Making. Springer, 1981.
[3] Hochreiter S., Schmidhuber J. Neural Computation, 1997. https://doi.org/10.1162/neco.1997.9.8.1735
[4] Box G.E.P. et al. Time Series Analysis. Wiley, 2015.
[5] Chen C.T. Fuzzy Sets and Systems, 2000. 6. Lundberg S., Lee S. NeurIPS, 2017. https://arxiv.org/abs/1705.07874.

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