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COMPETITIVE STRATEGIES OF KNOWLEDGE AND INNOVATION COMMERCIALIZATION: A UNIFIED SWOT AND FUZZY AHP APPROACH

ESTRATEGIAS COMPETITIVAS DE CONOCIMIENTO Y COMERCIALIZACIÓN DE LA INNOVACIÓN: UN DOFA UNIFICADO Y UN ENFOQUE DE PROCESO DE ANÁLISIS JERÁRQUICO DIFUSO (FUZZY AHP)

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ABSTRACT

Universities have shown a strong desire to commercialize researches and innovations. As a result, they are increasingly weaning themselves from public budgets. Commercialization has become the gateway for privatization, but the improper selection of commercialization strategies often results in the elimination of resources and time. The correct evaluation and ranking of strategies for the best resources is essential for the competitive performance of a university. The hybrid SWOT and Fuzzy AHP model adopted in this study provides a clear categorization of these university strategies. The first and relevant criteria as well as sub-criteria are identified using SWOT analysis. Fuzzy AHP tool is then used to evaluate and rank the internal and external factors that affect competition in Iranian universities. Based on the IE matrix, the growth and the process of building strategies are important priorities when considering commercializing. The results of this study revealed that academic startups, joint technology, joint research laboratories, strategic alliances, recruiting pundit and contracting with industry are the best strategies for Iranian universities.

KEYWORDS

Knowledge; Innovation; Commercialization; Strategy; FAHP approach; SWOT matrix.

RESUMEN

Las universidades han mostrado un fuerte deseo de comercializar investigaciones e innovación. Como resultado de esto, cada vez más buscan depender menos de los presupuestos públicos. La

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comercialización se ha convertido en la entrada a la privatización, sin embargo, la selección incorrecta de las estrategias de comercialización con frecuencia resulta en la eliminación de recursos y tiempo. La correcta evaluación y ranking de estrategias para los mejores recursos es esencial para el desempeño competitivo de una universidad. El híbrido entre el DOFA y el modelo proceso de análisis jerárquico difuso (Fuzzy AHP) adoptado en este estudio, provee una categorización clara de las estrategias de estas universidades. Los criterios principales y relevantes, al igual que los subcriterios, son identificados utilizando el análisis DOFA. La herramienta Fuzzy AHP se utiliza luego para evaluar y valorar los factores internos y externos que afectan la competencia en las universidades de Irán. Teniendo como base la matriz IE, el crecimiento y el proceso de construcción de las estrategias son prioridades cuando se tiene en cuenta la comercialización. Los resultados de este estudio revelan que los emprendimientos académicos, la tecnología conjunta, los laboratorios de investigación conjunta, las alianzas estratégicas, los expertos en reclutamiento y las contrataciones con la industria son las mejores estrategias para las universidades iraníes.

PALABRAS CLAVE
Conocimiento; innovación; comercialización; estrategia; enfoque AHP; matriz DOFA.

INTRODUCTION
Knowledge and innovation has a direct impact on an economy, especially in fast-growing new startup companies. Knowledge workers are the key towards gaining competitive advantage for innovative organizations (Gonzalez-Perez & Leonard, 2013). Factors such as globalization, along with other factors, have fundamentally changed the relationship between industry and universities.

This is part of a general trend towards the rapid development of knowledge markets. Currently, national policies are focused on the relation between industry players and university. The aim is to facilitate the improvement of entrepreneurship in fast-growing industries (The Organization for Economic Co-operation and Development (OECD), 2002). Hence, universities are considered as important actors in the knowledge-based economy. And the commercialization of research in universities, the innovations that originate from the research and development are considered as important factors for the economic stability of countries (Arora, 2003). Innovation often results in entrepreneurship as new ventures are created (Khajeheian, 2013) and by allowing firms to survive and compete in turbulent markets (Khajeheian, 2016a,b). Innovation also emanates from knowledge and creativity expected to be fostered in universities. The change in the universities' role from a knowledge producer to an entity that commercializes knowledge, has led to an increase in innovative activities in the past two decades. But despite the importance of innovation; little attention has been paid to the successful commercialization of university research in developing countries especially in Iran
(Z□□□□ □□□ S□□□□ □□□□h □□□□□□□ □□□□□□□□U□□□□□□□□□ S□□□□ □□□□h □□□□4□□□□5) □With th □i□ □□□t □□□□ □□□□□ □ □□□i□i□i□□ □□□□□□□h th□t □□ □□□t□□ □□□□ □□i□□□□iti□□□□□□ th □□□t th□t th □□□□□t□□ □□□ □□□ □ □□□i□i□□t□□ □t □□t □□□ i□th □h □□□t □□□□□□□□i□□ i□□□□t□□□□□□ □ □□□i□i□t□□ □□t □□□ i□□□th □ □□th th□□□h □h i□h □□□□i□□t□□□ □□i□□ □□□□□□□ □□□ □□□□t □□□th □ □□□□□□t □ □□□ i□□□□t□□ (S□□□□998) □□h □□□□□□ □□□i□□ □tt□□t□□ t□th □ □ □□□ □□□□□□t□□ □ □t □□t □□□ □ith it□ □□□□□t □ □□h □□i□□ i□ i□ □□□t □□t □□□t □□t □□i □□□i□□ i□ i□ □□i□□□iti□□

AD-minister Nº. 30 january-june 2017 pp. 45 - 72 · ISSN 1692-0279 · eISSN 2256-4322

RESEARCH BACKGROUND

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AD-minister Nº. 30 january-june 2017 pp. 45 - 72 · ISSN 1692-0279 · eISSN 2256-4322

STRATEGIES FOR COMMERCIALIZATION OF UNIVERSITY RESEARCHES

AD-minister Nº. 30 january-june 2017 pp. 45 - 72 · ISSN 1692-0279 · eISSN 2256-4322

Table 1: Formal and informal mechanisms for commercialization of academic research.

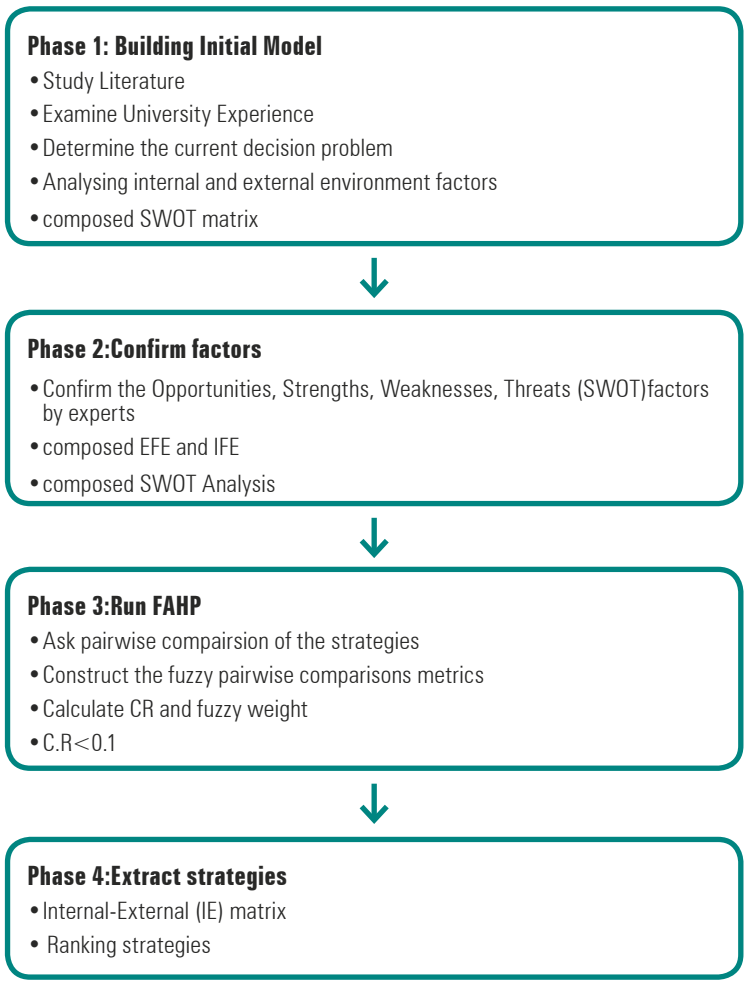
Mechanism	Definition
Research with funding	A contract in which the university receives funding for research.
The copyright	Legal rights to use the intellectual property of university.
Employment of students	Employing university students, especially those who work in sponsored projects.
Spin-off companies	The new concept which is based on academic research or university license.
Chance	Fortune

Source: Bercovitz and Feldmann, 2006.

RESEARCH METHOD

AD-minister Nº. 30 january-june 2017 pp. 45 - 72 · ISSN 1692-0279 · eISSN 2256-4322

Figure 1: The phase of proposed methodologies.



FAHP Approach: [illegible]
St [illegible]

Table 2. Linguistic terms and the corresponding triangular fuzzy numbers.

Saaty scale	Definition	Fuzzy triangular S
1	Equally important (Eq. Imp.)	(1, 1, 1)
3	Weakly important (W. Imp.)	(2, 3, 4)
5	Fairly important (F. Imp.)	(4, 5, 6)
7	Strongly important (S. Imp.)	(6, 7, 8)
9	Absolutely important (A. Imp.)	(9, 9, 9)
2	The intermittent values between two adjacent scales	(1, 2, 3)
4		(3, 4, 5)
6		(5, 6, 7)
8		(7, 8, 9)

[illegible]

$$\tilde{A}^k = \begin{bmatrix} \tilde{d}^k_{11} & \tilde{d}^k_{12} & \dots & \tilde{d}^k_{1n} \\ \tilde{d}^k_{21} & \dots & \dots & \tilde{d}^k_{2n} \\ \dots & \dots & \dots & \dots \\ \tilde{d}^k_{11} & \tilde{d}^k_{12} & \dots & \tilde{d}^k_{nn} \end{bmatrix} \quad [illegible]$$

[illegible]

$$\tilde{d}_{ij} = \frac{\sum_{k=1}^{k} \tilde{d}^k_{ij}}{K} \quad [illegible]$$

[illegible]

$$\tilde{A} = \begin{bmatrix} \tilde{d_{11}} & \dots & \tilde{d_{1n}} \\ \vdots & \ddots & \vdots \\ \tilde{d_{n1}} & \dots & \tilde{d_{nn}} \end{bmatrix} \quad [illegible]$$

AD-minister Nº. 30 january-june 2017 pp. 45 - 72 · ISSN 1692-0279 · eISSN 2256-4322

Step 4: [illegible]

$$\tilde{r}_i = \left(\prod_{j=1}^{n} \tilde{d}_{ij} \right)^{1/n}, \; i=1, 2,...,n$$ [illegible] 4)

Step 5: [illegible]

Step 5[illegible]: [illegible] $\tilde{r}_i$

5[illegible]: [illegible]

Step 5[illegible]: [illegible] $\tilde{r}_i$ [illegible]

$$\tilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \cdots \oplus \tilde{r}_n)^{-1} = (lw_i, mw_i, uw_i)$$ [illegible] 5)

Step [illegible]: [illegible] $\tilde{w}_i$ [illegible]

$$M_i = \frac{lw_i, mw_i, uw_i}{3}$$ [illegible])

Step 7: M_i [illegible]

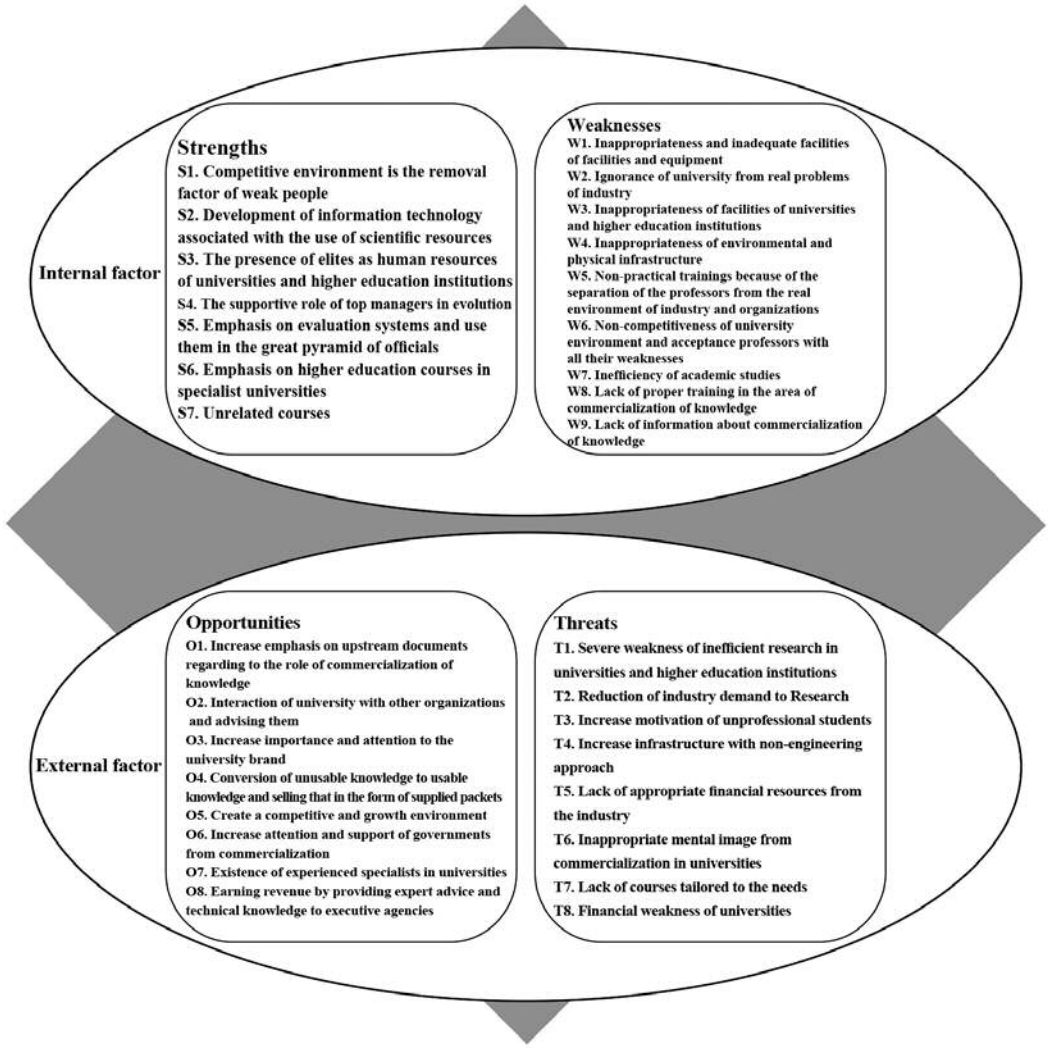
$$N_i = \frac{M_i}{\sum_{i=1}^{n} M_i}$$ [illegible] 7)

[illegible]

FINDINGS:

[illegible]

Figure 2. Confirmed internal factors (Strengths, Weaknesses) and Confirmed external factors (Opportunities, Threats).



Source: Authors.

[illegible]

AD-minister Nº. 30 january-june 2017 pp. 45 - 72 · ISSN 1692-0279 · eISSN 2256-4322

[illegible]

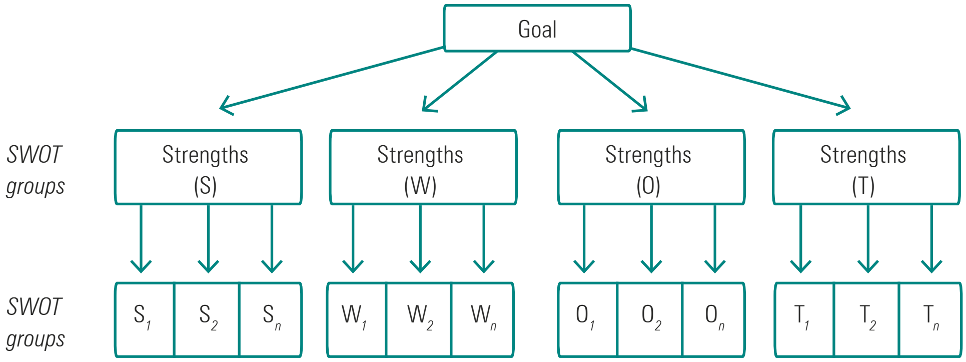
Table 3. Matrix of commercialization strategies of knowledge in universities.

	Strengths (S1, S2, S3, S4, S5, S6, S7)	Weaknesses (W1, W2, W3, W4, W5, W6, W7, W8, W9)
Opportunities (O1, O2, O3, O4, O5, O6, O7, O8)	SO strategies SO1: corporate venture business SO2: contracting with industry to conduct research SO3: academic start-ups SO4: strategic alliances SO5: chance SO6: recruiting skilled personnel for knowledge transfer in complex environments SO7: joint technology development by formal co-operation agreements with the industry sector SO8: joint research laboratories with industry sector	WO strategies WO1: counseling of university professors to industry sector WO2: use of facilities WO3: conducting conference WO4: publishing research results in scientific journals WO5: non-official or pre-official discussions WO6: shareholding hold shares in a company WO7: research joint meetings with industry and organizations WO8: reading and attracting talented people to the local economy and cooperation with local industries through the provision of formal and technical supports WO9: joint supervision of graduate students' dissertations and doctoral theses
Threats (T1, T2, T3, T4, T5, T6, T7, T8)	ST strategies ST1: research parks, science parks, incubators and technology parks ST2: Licensing ST3: patents ST4: Royalty ST5: employment of students ST6: advice to industrial enterprises by university professors ST7: Agreements to conduct R&D projects	WT strategies WT1: joint research and development agreements WT2: Partnership for transfer or commercialization of technology, participation in joint papers and consultation WT3: university interactions WT4: exchange programs WT5: extradition matters for government WT6: Technical Cooperation WT7: Interaction between university and industry WT8: The exchange of personnel and joint staff WT9: Research with sponsorship WT10: Mobility of professors between industry and university

Source: Authors.

[illegible]

Figure 3. Hierarchical structure of the SWOT matrix.



[illegible]

Table 4. Comparison matrices for criteria.

Strengths Criteria	S1	S2	S3	S4	S5	S6	S7
S1	(1,1,1)	(3,4,4.5)	(0.222,0.25,0.333)	(3,3.5,4)	(1,2,2)	(0.036,0.038,0.04)	(0.084,0.111,0.117)
S2	(0.222,0.25,0.333)	(1,1,1)	(0.167,0.182,0.2)	(1,2,2)	(1,2,2)	(0.203,0.269,0.456)	(0. 194,0. 356,0. 768
S3	(3,4,4.5)	(5,5.5,6)	(1,1,1)	(5,5.5,6)	(3,4,4.5)	(0.203,0.269,0.282)	(0. 235,0. 353,0. 765)
S4	(0.25,0.286,0.333)	(0.5,0.5,1)	(0.167,0.182,0.2)	(1,1,1)	(3,3.5,4)	(0.036,0.038,0.04)	(0.084,0.111,0.117)
S5	(0.5,0.5,1)	(0.5,0.5,1)	(0.222,0.25,0.333)	(0.25,0.286,0.333)	(1,1,1)	(0. 834,2. 532,3. 176)	(0. 345,0. 765,0. 547)
S6	(0.122,0.131,0.149)	(0.064,0.067,0.093)	(0.056,0.061,0.068)	(0.122,0.131,0.149)	(0.064,0.067,0.093)	(1,1,1)	(0. 325,0. 657,0. 432)
S7	(0.111,0.143,0.2)	(0.111,0.143,0.2)	(0. 346,0. 766,0. 467)	(0.278,0.322,0.35)	(0.203,0.269,0.282)	(0.268,0.311,0.338)	(1,1,1)

AD-minister Nº. 30 january-june 2017 pp. 45 - 72 · ISSN 1692-0279 · eISSN 2256-4322

[illegible]

Table 5. Geometric means of fuzzy comparison values.

Strengths Criteria	Geometric means ($\widetilde{r}_i$)
S1	(2.51, 2.71, 3.30)
S2	(2.65, 3.10,3.29)
S3	(0.41, 0.54, 0.78)
S4	(0.36, 0.402, 0.439)
S5	(2.552, 2.959, 3.198)
S6	(0.42, 0.54, 0.45)
S7	(1. 42, 1. 24, 2.59)
Total	(10.332, 11.491, 14.47)
Reverse (power of -1)	(0.096, 0.087, 0.069)
Increasing Order	(0.069,0.087, 0.096)

[illegible]

Table 6. Relative fuzzy weights of each criterion.

Strengths Criteria	Fuzzy weight ($\widetilde{w}_i$)
S1	(0.178, 0.237,0.316)
S2	(0.188, 0.269, 0.315)
S3	(0.029, 0.046, 0.074)
S4	(0.025, 0.034, 0.042)
S5	(0.181, 0.257, 0.307)
S6	(0.029, 0.046, 0.043)
S7	(0.100, 0.107, 0.24)

[illegible]

Table 7. Averaged and normalized relative weights of strengths criteria.

Strengths criteria	M_i	N_i
S1	0.243	0.237
S2	0.257	0.251
S3	0.050	0.048
S4	0.034	0.033
S5	0.248	0.242
S6	0.04	0.038
S7	0.152	0.148

[illegible]

Table 8. Averaged and normalized relative weights of Weaknesses criteria.

Weaknesses criteria	M_i	N_i
W1	0.353	0.247
W2	0.32	0.224
W3	0.243	0.170
W4	0.124	0.086
W5	0.148	0.103
W6	0.044	0.030
W7	0.052	0.036
W8	0.067	0.046
W9	0.075	0.052

AD-minister Nº. 30 january-june 2017 pp. 45 - 72 · ISSN 1692-0279 · eISSN 2256-4322

Table 9. Averaged and normalized relative weights of Opportunities criteria.

Opportunities criteria	M_i	N_i
O1	0.143	0.126
O2	0.032	0.028
O3	0.073	0.064
O4	0.004	0.003
O5	0.158	0.140
O6	0.139	0.123
O7	0.282	0.250
O8	0.297	0.263

Table 10. Averaged and normalized relative weights of Threats criteria.

Threats criteria	M_i	N_i
T1	0.166	0.107
T2	0.288	0.187
T3	0.265	0.172
T4	0.314	0.204
T5	0.123	0.079
T6	0.039	0.025
T7	0.182	0.118
T8	0.161	0.104

[illegible]

Table 11. Overall Priority Scores of SWOT Factors.

SWOT Group	Group Priority	SWOT Factors	Factor Priority within the Group	Overall Priority of Factor
Strengths	0.355	S1	0.237	0.084
		S2	0.251	0.089
		S3	0.048	0.017
		S4	0.033	0.011
		S5	0.242	0.085
		S6	0.038	0.013
		S7	0.148	0.052
Weaknesses	0.142	W1	0.247	0.035
		W2	0.224	0.031
		W3	0.170	0.024
		W4	0.086	0.012
		W5	0.103	0.014
		W6	0.030	0.004
		W7	0.036	0.005
		W8	0.046	0.006
		W9	0.052	0.007
Opportunities	0.349	O1	0.126	0.044
		O2	0.028	0.009
		O3	0.064	0.022
		O4	0.003	0.001
		O5	0.140	0.048
		O6	0.123	0.043
		O7	0.250	0.087
		O8	0.263	0.091
Threats	0.154	T1	0.107	0.016
		T2	0.187	0.028
		T3	0.172	0.026
		T4	0.204	0.031
		T5	0.079	0.012
		T6	0.025	0.003
		T7	0.118	0.018
		T8	0.104	0.016

AD-minister Nº. 30 january-june 2017 pp. 45 - 72 · ISSN 1692-0279 · eISSN 2256-4322

IE matrix: [illegible]

[illegible]

Table 12. Internal Factors Evaluation matrix (IFE), commercialization of knowledge in universities.

Internal factors Evaluation (IFE): strengths (S) and Weaknesses (W)	Fuzzy weight (normalized overall Priority of factor)	Rank	Weighted score
S1	0.171	3	0.515
S2	0.182	3	0.546
S3	0.034	4	0.139
S4	0.022	4	0.089
S5	0.173	4	0.695
S6	0.026	2	0.053
S7	0.106	2	0.212
W1	0.071	4	0.286
W2	0.063	4	0.253
W3	0.049	4	0.196
W4	0.024	3	0.073
W5	0.028	3	0.085
W6	0.008	2	0.016
W7	0.010	2	0.020
W8	0.012	2	0.024
W9	0.014	2	0.028
Total all weighted scores	1		3.237

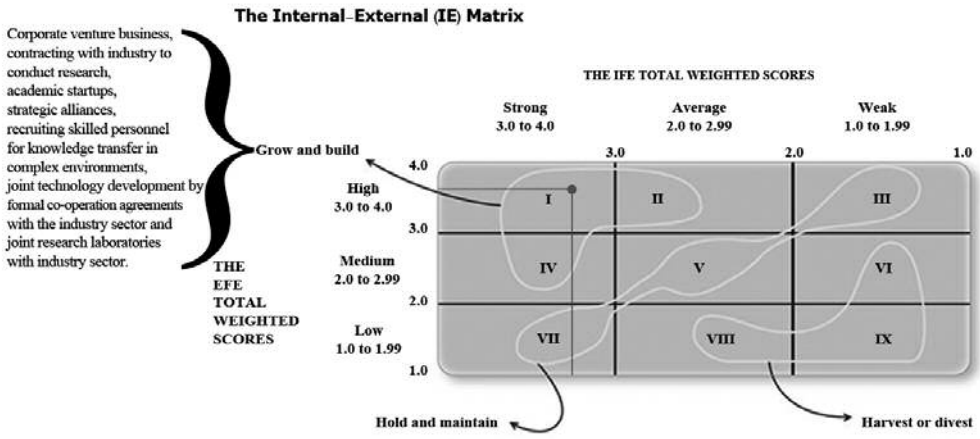
AD-minister Nº. 30 january-june 2017 pp. 45 - 72 · ISSN 1692-0279 · eISSN 2256-4322

Table 13. External factors Evaluation matrix (EFE), commercialization of knowledge in universities.

External factors Evaluation (EFE): Opportunities (O) and threats (T)	Fuzzy weight (normalized overall Priority of factor)	Rating	Weighted score
O1	0.088	4	0.352
O2	0.018	3	0.054
O3	0.044	3	0.132
O4	0.002	1	0.002
O5	0.096	3	0.288
O6	0.086	3	0.258
O7	0.175	4	0.7
O8	0.183	4	0.732
T1	0.032	3	0.096
T2	0.056	4	0.224
T3	0.052	4	0.208
T4	0.062	4	0.248
T5	0.024	3	0.072
T6	0.006	2	0.012
T7	0.036	3	0.108
T8	0.032	3	0.096
Total all weighted scores	1		3.582

[illegible] 4:

Figure 4. Internal-External Matrix.



CONCLUSION

AD-minister Nº. 30 january-june 2017 pp. 45 - 72 · ISSN 1692-0279 · eISSN 2256-4322

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