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## **PARENTAL CHOICE OF PRIVATE PRIMARY SCHOOLS: A FUZZY MULTI-CRITERIA DECISION-MAKING EVALUATION**

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### **Abstract**

This study develops a fuzzy multi-criteria decision-making (MCDM) model to assist parents in selecting private primary schools in İzmir, Türkiye. Faced with growing educational options, the model provides objective, data-driven guidance by evaluating five main criteria: academic quality, economic conditions, physical characteristics, managerial/social support, and location. Criterion weights were determined using the Fuzzy Analytic Hierarchy Process (F-AHP), and school rankings were derived using Fuzzy Multi-Attributive Ideal-Real Comparative Analysis (F-MAIRCA). Data from ten parents were collected via structured forms; uncertainty was modeled using triangular fuzzy numbers, followed by defuzzification and normalization. Results show that academic quality (0.465) is the most influential factor, followed by economic conditions (0.216). Among subcriteria, teacher and management quality ranked highest. F-MAIRCA analysis identified İzmir Anka College, MEF International School, and İ.T.Ü. İzmir Primary School as top performers. Sensitivity analysis confirmed the stability of rankings under varying weights. The integrated F-AHP → F-MAIRCA approach offers a reliable and transparent tool for educational decision-making, highlighting educational quality as the dominant factor in parental preferences.

**Keywords:** Fuzzy AHP, Fuzzy MAIRCA, Private School Selection, Parental Preference.

**Jel Codes:** C44, D12, I21.

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## VELİLERİN ÖZEL İLKOKUL TERCİHLERİNİN BULANIK ÇOK KRİTERLİ KARAR VERME YAKLAŞIMIYLA DEĞERLENDİRİLMESİ

### Öz

Bu çalışma, İzmir, Türkiye'deki özel ilkokulları değerlendirmek ve ebeveynlerin okul seçimini desteklemek amacıyla bulanık çok kriterli karar verme (ÇKKV) modeli geliştirmektedir. Artan okul çeşitliliği karşısında, model; akademik kalite, ekonomik koşullar, fiziksel özellikler, yönetsel/sosyal destek ve konum olmak üzere beş ana kriteri esas alarak nesnel ve veri temelli bir rehberlik sunmaktadır. Kriter ağırlıkları Bulanık Analitik Hiyerarşi Süreci (F-AHP) ile belirlenmiş, okul sıralamaları ise Bulanık MAIRCA (F-MAIRCA) yöntemiyle yapılmıştır. On ebeveynden yapılandırılmış formlar aracılığıyla veri toplanmış; yargılardaki belirsizlik üçgenel bulanık sayılarla modellenmiş, ardından ağırlıklar ve puanlar hesaplanmıştır. Sonuçlara göre, akademik kalite (0,465) en etkili kriter olmuş, onu ekonomik koşullar (0,216) izlemiştir. Alt kriterler arasında öğretmen ve yönetim kalitesi öne çıkmıştır. İzmir Anka Koleji, MEF Uluslararası Okulu ve İ.T.Ü. İzmir İlkokulu en üst sıralarda yer almıştır. Ağırlık değişimlerine göre yapılan duyarlılık analizi sıralamaların kararlılığını doğrulamıştır. Bu model, eğitim yönetimi ve politika için güvenilir, şeffaf bir karar destek aracı sunmaktadır.

**Anahtar Sözcükler:** Bulanık AHP, Bulanık MAIRCA, Ebeveyn Tercihi, Özel Okul Seçimi.

**Jel Kodları:** C44, D12, I21.

### 1. INTRODUCTION

The cultivation of qualified human resources required by societies is only possible through an effective education system. Accordingly, countries shape the profile of individuals they aim to raise through the educational services they provide (Otrar & Kandemir, 2016). Education is a fundamental process that shapes not only the academic but also the social and cultural development of individuals. Therefore, parents consider numerous factors and make their decisions carefully when guiding their children's educational paths. As the quality of education increases, families who prioritize their children's development increasingly seek high-quality schools, which brings private school preferences to the forefront (Bayar & Akın, 2023; Kurban, 2021).

In Türkiye, the education system is divided into two main categories: formal and non-formal education. Formal education is provided through public and private institutions (Aslan, 2019). Historically, private educational institutions emerged as complementary to state-provided education but gradually became more widespread with growing demand and social transformation. The Turkish Language Association (TDK, 2021) defines private schools as institutions owned by private individuals or organizations that provide education services in return for a fee. Similarly, according to Law No. 5580 on Private Education Institutions, such schools are established and operated by natural or legal persons under the supervision and control of the Ministry of National Education (Küçükçayır & Cemaloğlu, 2017). The concept of private education is comprehensively defined in Article 2 of Law No. 5580, encompassing private schools, study centers, courses, and institutions offering certificate programs (Taşkın,

2010). Private schools, which constitute the focus of this study, were identified as priority areas in the Ministry of National Education's Strategic Plans for 2015–2019 and 2019–2023, aiming to facilitate access to education and increase the share of private schooling (Toprakçı et al., 2018). The history of private schools in Türkiye dates back to the Tanzimat Era and includes state-supported institutions such as Galatasaray Sultanisi, along with privately established schools like Şemsülmaarif (Aslan & Altay, 2019). During the Republican era, private schools were regulated under the Law on the Unification of Education (Tevhid-i Tedrisat), institutionalized over time, supported by organizations such as the Turkish Education Association (TED), and gained a constitutional basis with the 1982 Constitution (Çallı, 2009; Law No. 5580, 2007).

In recent years, government incentive policies and the conversion of tutoring centers into private schools have led to a quantitative increase in private education. The share of private schools rose from 10.3% in 2014–2015 to 20.1% in 2020–2021 (MEB Statistics, 2014/2015–2020/2021). This growing trend in private schooling has drawn the attention of multidisciplinary academic studies due to its implications for educational quality, economic dynamics, employment, and socioeconomic outcomes (Şener, 2018; Yılmaz, 2018).

Private schools have become attractive options for parents due to their strong physical infrastructure, foreign language instruction, variety of social and sports activities, technological equipment, and high academic performance (Bozyiğit, 2017; Gürler, 2020). The adoption of neoliberal policies in Türkiye after the 1980s significantly increased interest in private education; these schools, under the supervision of the Ministry of National Education, now offer formal education at all levels (Canitez & Kocabaş, 2020; Kurada, 2022). While public schools are financed by public resources, private schools are funded by individuals or private entities and operate on a tuition-based model (Yaman, 2021). Working parents' limited time and their desire to protect their children from negative environmental influences direct them toward private schools that provide not only academic success but also value-based education (Avşar, 2016).

Despite the growing number of studies examining factors influencing parents' school preferences, most research focuses on individual determinants such as academic performance, school facilities, or socioeconomic background. Comprehensive analytical models that simultaneously evaluate multiple criteria in private primary school selection remain limited. In particular, studies integrating fuzzy multi-criteria decision-making approaches for evaluating private primary school alternatives are still scarce in the literature. Therefore, a systematic

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framework that combines fuzzy logic with multi-criteria decision analysis is needed to better capture the complexity of parental decision-making processes.

This study develops and empirically validates a fuzzy logic-based multi-criteria decision model for evaluating private primary schools—combining Fuzzy AHP to elicit defensible criterion weights with Fuzzy MAIRCA to derive transparent, policy-relevant rankings—across five main and nineteen subcriteria grounded in the literature and stakeholder input. The contribution is twofold: methodologically, the model captures rater subjectivity through triangular fuzzy numbers, yields traceable local-to-global weights, and establishes robustness via systematic weight-variation sensitivity analysis; substantively, it delivers decision-ready evidence that foregrounds the primacy of academic and teacher quality while situating cost and facilities as important but secondary constraints. Taken together, the proposed F-AHP → F-MAIRCA pipeline offers a valid, reliable, and practically deployable assessment tool for high-stakes school selection under uncertainty.

## 2. LITERATURE REVIEW

Parents play a decisive role in determining the educational path of their children, and selecting the school they will attend is one of the most critical decisions in this process. School choice is not limited to academic achievement but involves multiple dimensions such as teacher quality, class size, disciplinary approach, curriculum structure, value education, and physical facilities (Cruz, 2014; De Angelis & Holmes Erickson, 2017; Holmes Erickson, 2017). Smith (2017) argued that academic quality is the primary determinant in private school preference, while Johnson and Johnson (2019) emphasized that small class sizes, qualified teachers, and specialized educational programs meet both academic and emotional development expectations of students. Similarly, Brown et al. (2020) stated that individualized learning environments provided by private schools positively influence student achievement. Furthermore, parents tend to prefer schools whose pedagogical approaches and value orientations align with their own beliefs and expectations (Williams, 2018).

From a theoretical perspective, parental school choice can also be interpreted through several conceptual frameworks discussed in the education literature. Rational Choice Theory suggests that parents behave as rational decision-makers who evaluate different school alternatives and select the option that maximizes expected benefits for their children in terms of academic success, social development, and future opportunities (Goldring & Rowley, 2006; Burgess et al., 2014). Another important concept is Parentocracy, introduced by Brown (1990), which describes an education system in which a child's educational success increasingly depends on

parents' preferences, resources, and decision-making capacity rather than solely on the child's ability. Within this framework, parents actively shape their children's educational trajectories through strategic school selection. In addition, the socioeconomic inequality perspective highlights that families' economic resources, educational background, and social capital significantly influence access to high-quality educational institutions and the ability to choose private schools (Chesters, 2018; Pesando et al., 2020). These theoretical perspectives indicate that school choice decisions are not only educational but also social and economic processes.

Socioeconomic conditions also significantly influence school selection decisions. De Angelis and Holmes Erickson (2017) emphasized that parents' willingness to pay for private education is associated not only with educational expectations but also with practical factors such as safety, commuting time, and financial constraints. Similarly, Smith (2017) and Yang et al. (2019) reported that income level and socioeconomic status are strong determinants of private school demand, while Lavy (2018) and Tian and Zhang (2020) highlighted the importance of school reputation and perceived educational quality. In some countries, policy interventions such as voucher systems have expanded access to private education, making private schooling more affordable for certain groups (Stewart & Wolf, 2015).

Numerous studies have examined the determinants of parental school choice. Noor Alyani Yaacob et al. (2014) identified social status, income level, school academic performance, teacher quality, physical facilities, curriculum structure, and school location as key factors influencing private school preference. Similarly, Catsambis (1998) found that parents' education level, occupation, and ethnicity affect school choice decisions. Rehman et al. (2010) also reported that parents with higher occupational prestige tend to prefer private schools over public schools.

Academic performance and school reputation remain among the most influential factors in parental decision-making. Bosetti (2004), Jackson and Bisset (2005), West (2001), and Ungerleider (2003) demonstrated that examination results and school prestige strongly influence school selection decisions. NCES-based findings by Peterson and Llaudet (2006) indicated that students attending private schools often achieve higher academic outcomes than their public-school counterparts. Teacher quality is another crucial factor; OECD (2005) emphasized that industrialized countries expect higher-quality education from private schools. Nurahimah (2010) associated teacher competence with knowledge and pedagogical skills, while Wilkinson et al. (2004) suggested that private schools tend to employ more qualified teaching staff.

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Curriculum structure and school environment also influence school selection. Van Pelt et al. (2007) noted that parents choosing faith-based schools prioritize moral values and family-oriented educational environments. Smith (2000) highlighted the importance of school facilities in supporting both academic and social development. Accessibility is another practical consideration, as Flatley (2001) and Goldring and Rowley (2006) identified geographic proximity as a significant factor. Bernal (2005) found that middle-class families may be willing to travel longer distances in order to enroll their children in higher-quality schools.

Overall, the literature suggests that parental school choice decisions involve a complex interaction of academic, socioeconomic, institutional, and contextual factors. These multifaceted determinants make school selection a multidimensional decision problem that requires systematic evaluation.

Because private school selection involves evaluating multiple criteria simultaneously, Multi-Criteria Decision-Making (MCDM) methods have increasingly been used to support decision-making processes in educational contexts. These methods allow decision-makers to analyze both qualitative and quantitative factors in a structured framework.

One of the most widely used MCDM techniques is the Analytic Hierarchy Process (AHP), which enables the systematic weighting of decision criteria and identification of the most suitable alternative (Murugeswari & Anbuselvi, 2016; Myint, 2019). Riana and Syamsudin (2023) applied Confirmatory Factor Analysis (CFA) to determine key determinants of preschool selection and found that school excellence, teacher competence, education cost, social development, and language development explain a significant proportion of parental preferences. Similarly, Jonathan et al. (2023) reported that religious values and the affordability of additional educational costs are important factors influencing private school selection.

Recent studies have emphasized that MCDM techniques can provide systematic and transparent evaluation frameworks for complex educational decision problems. Tuğrul and Çitil (2021) highlighted that methods such as AHP, fuzzy MCDM, and PROMETHEE enable objective comparisons among school alternatives based on criteria such as academic performance, teacher quality, safety, and school infrastructure. Yüksel et al. (2023) also emphasized that these approaches help families evaluate both qualitative and quantitative factors simultaneously.

In addition to academic factors, contextual and socioeconomic variables also influence school preferences. Chesters (2018) and Pesando et al. (2020) argued that school choice decisions depend not only on academic quality but also on social context, school facilities, and additional

services. Stumm and Plomin (2020) pointed out that selective admission policies of private schools may reinforce socioeconomic inequalities. Similarly, Li (2024) noted that private school preference is closely related to social class and consumption patterns. Within the context of educational inequality, Wamalwa and Burns (2018), Jabri et al. (2021), and Pianta and Ansari (2018) suggested that private schools may also provide opportunities for improving educational access for disadvantaged groups.

Recent research has increasingly recognized the complexity of parental school choice decisions. Some parents prioritize socio-emotional development, while others focus primarily on academic outcomes (Stumm & Plomin, 2019; Ullah & Mukherjee, 2023). Given the presence of numerous interrelated criteria, MCDM approaches provide an effective framework for systematically evaluating parental preferences (Baum, 2018; Exley, 2019; Lee et al., 2024; Singhal & Das, 2019).

Despite the growing number of studies examining school selection and decision-making processes, research integrating fuzzy logic with multi-criteria decision-making methods for evaluating private primary school alternatives remains limited. Therefore, there is a need for comprehensive analytical frameworks capable of systematically evaluating the complex criteria influencing school choice decisions.

### **3. MATERIALS AND METHODS**

This study employs a hybrid multi-criteria decision-making framework that integrates the Fuzzy Analytic Hierarchy Process (F-AHP) and the Fuzzy Multi-Attributive Ideal-Real Comparative Analysis (F-MAIRCA) methods using triangular fuzzy numbers. In this framework, F-AHP is used to determine the relative importance of evaluation criteria, while F-MAIRCA is applied to evaluate and rank the alternatives according to these criteria.

F-AHP is widely used in decision-making problems to determine criterion weights under uncertainty, allowing decision makers to express their judgments using linguistic variables represented by triangular fuzzy numbers (Chang, 1996; Kahraman et al., 2004). However, although F-AHP effectively derives criterion weights, it does not provide a complete mechanism for ranking decision alternatives. For this reason, the MAIRCA method is employed to rank alternatives based on the difference between theoretical and real evaluation matrices, enabling a stable and consistent ranking process (Gigović et al., 2016). The fuzzy extension of MAIRCA further improves its ability to handle subjective assessments and uncertainty in complex decision environments.

The integration of F-AHP and F-MAIRCA therefore provides a complementary analytical framework in which F-AHP determines reliable criterion weights while F-MAIRCA performs the final ranking of alternatives. Compared with single-method approaches, this hybrid structure improves the robustness and transparency of the evaluation process and enables a more comprehensive evaluation of complex decision problems such as private school selection, where multiple qualitative and quantitative criteria must be considered simultaneously.

The following sections present triangular fuzzy numbers, the arithmetic operations defined on them, and the detailed procedures of the F-AHP and F-MAIRCA methods.

### 3.1. Triangular Fuzzy Numbers and Their Arithmetic Operations

Fuzzy logic, introduced to the literature by Zadeh (1965), is grounded in the theory of fuzzy sets. In classical set theory, an element either belongs to a set or does not; by contrast, in fuzzy set theory the degree to which an element  $x$  belongs to a set  $A$ .  $A$  is specified by its membership value ( $\mu_A(x)$ ).

$$0 \leq \mu_A(x) \leq 1$$

With  $0 \leq \mu_A(x) \leq 1$ ,  $\mu_A(x) = 0$  indicates that  $x$  does not belong to  $A$ , while  $\mu_A(x) = 1$  indicates that  $x$  belongs fully to  $A$ ; intermediate values in  $(0,1)$  represent partial degrees of membership. Triangular fuzzy numbers are a subclass of fuzzy sets and are denoted by  $(l, m, u)$ . Here,  $l \leq m \leq u$ , where  $l$  is the lower (minimum) bound,  $m$  is the modal (most plausible/peak) value, and  $u$  is the upper (maximum) bound. The membership function of a triangular fuzzy number  $(l, m, u)$  is defined as:

$$\mu_A(x) = \begin{cases} 0, & x < l, x > u, \\ \frac{x-l}{m-l} & l \leq x \leq m, \\ \frac{u-x}{u-m} & m \leq x \leq u, \end{cases}$$

is defined as such (Başlıgil, 2005).

Let  $A_1 = (l_1, m_1, u_1)$  and  $A_2 = (l_2, m_2, u_2)$  be two triangular fuzzy numbers; the arithmetic operations between triangular fuzzy numbers are defined as follows (Boral et al., 2020):

$$\tilde{A}_1 \oplus \tilde{A}_2 = (l_1 + l_2, m_1 + m_2, u_1 + u_2)$$

$$\tilde{A}_1 \ominus \tilde{A}_2 = (l_1 - u_2, m_1 - m_2, u_1 - l_2)$$

$$\tilde{A}_1 \otimes \tilde{A}_2 = (l_1 x l_2, m_1 x m_2, u_1 x u_2)$$

$$\tilde{A}_1 \oplus \tilde{A}_2 = \left( \frac{l_1}{u_2}, \frac{m_1}{m_2}, \frac{u_1}{l_2} \right), \text{ eğer } l_1 \geq 0 \text{ ve } l_2 > 0$$

$$k \otimes \tilde{A}_1 = (kxl_1, kxm_1, kxu_1), \text{ eğer } k > 0$$

$$k \otimes \tilde{A}_1 = (kxu_1, kxm_1, kxl_1), \text{ eğer } k < 0$$

### 3.2. Fuzzy Analytic Hierarchy Process (F-AHP) Method

The Analytic Hierarchy Process (AHP), proposed by Saaty (1980), is a decision-support tool based on pairwise comparisons of criteria or alternatives with respect to those criteria in multi-criteria decision-making (MCDM) problems. It is widely used to guide decision-makers in identifying the best alternative that satisfies all criteria in problems involving multiple conflicting factors.

However, the classical AHP method has been criticized for its inadequacy in handling situations involving uncertainty when comparing criteria or alternatives under various conditions. In decision problems where uncertainty is significant, it is more appropriate to apply the principles of fuzzy logic, developed by Zadeh (1965), to better capture the vagueness and imprecision inherent in human judgment. This integration enables decision-makers to handle uncertainty more effectively throughout the decision-making process (Ertuğrul, 2007).

The Fuzzy Analytic Hierarchy Process (F-AHP), based on fuzzy set theory, expresses pairwise comparisons of criteria and alternatives using linguistic variables represented by fuzzy numbers. One of the first applications of the F-AHP was carried out by Van Laarhoven and Pedrycz (1983), while Buckley (1985) enhanced the method by defining fuzzy priorities for comparison ratios using triangular membership functions.

In this study, the weighting of criteria was performed using the method proposed by Buckley (1985). The steps of the method are as follows:

Step 1. Pairwise comparisons of the criteria (or alternatives with respect to the criteria) are conducted by decision-makers using linguistic terms (Equation 1). In this study, the comparison matrices were constructed using triangular fuzzy numbers, as presented in Table 1.

$$\tilde{A}^K = \begin{bmatrix} \tilde{a}_{11}^K & \tilde{a}_{12}^K & \dots & \dots & \tilde{a}_{1n}^K \\ \tilde{a}_{21}^K & \tilde{a}_{22}^K & \dots & \dots & \tilde{a}_{2n}^K \\ \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ \tilde{a}_{n1}^K & \tilde{a}_{n2}^K & \dots & \dots & \tilde{a}_{nn}^K \end{bmatrix} \quad K = 1, 2, 3, \dots, k \tag{1}$$

Step 2. In cases where there is more than one decision-maker, the aggregated decision matrix is constructed using Equation (2) and combined as shown in Equation (3).

$$\tilde{d}_{ij} = \frac{\sum_{k=1}^k \tilde{d}_{ij}^k}{k} \quad (2)$$

$$\tilde{A} = \begin{bmatrix} \tilde{d}_{11} & \tilde{d}_{12} & \dots & \dots & \tilde{d}_{1n} \\ \tilde{d}_{21} & \tilde{d}_{22} & \dots & \dots & \tilde{d}_{2n} \\ \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ \tilde{d}_{n1} & \tilde{d}_{n2} & \dots & \dots & \tilde{d}_{nn} \end{bmatrix} \quad (3)$$

Step 3. The geometric mean of the fuzzy comparison values for each criterion is calculated as shown in Equation (4).

$$\tilde{r}_i = \left( \prod_{j=1}^n \tilde{d}_{ij} \right)^{\frac{1}{n}}, \quad i = 1, 2, 3, \dots, n \quad (4)$$

Step 4. The fuzzy weights of the criteria are determined using Equation (5).

$$\tilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \dots \oplus \tilde{r}_n)^{-1} \quad (5)$$

Step 4. The triangular fuzzy weights  $\tilde{w}_i$  obtained in Step 4 are defuzzified via the Center of Area (CoA) method proposed by Chou and Chang (2008) (Equation 6), yielding the corresponding crisp values  $M_i$ .

$$M_i = \frac{l\tilde{w}_i + m\tilde{w}_i + u\tilde{w}_i}{3} \quad (6)$$

Step 5. The crisp scores  $M_i$  obtained in Step 5 are normalized using Equation (7) to yield the final normalized criterion weights.

$$N_i = \frac{M_i}{\sum_{i=1}^n M_i} \quad (7)$$

### 3.3. Fuzzy MAIRCA (F-MAIRCA) Method

The Multi-Attributive Ideal-Real Comparative Analysis (MAIRCA) method was developed in 2014 by the Logistics Research Center of the University of Defence in Belgrade (Gigović et al., 2016). The fundamental assumption of the MAIRCA method is the determination of the difference (or gap) between the ideal and empirical weights. For each criterion, the sum of these gaps provides the total deviation for each observed alternative. Consequently, alternatives are ranked, and the best alternative is the one with the smallest total gap value. In other words, the

alternative with the smallest total deviation possesses the values closest to the ideal weights across the greatest number of criteria (Pamučar et al., 2014). The steps of the F-MAIRCA method are presented as follows (Pamučar et al., 2014; Yenilmez & Ertuğrul, 2024):

Step 1. According to the preferences of the decision maker(s) or experts, each alternative is evaluated based on the predefined criteria using linguistic terms. The linguistic evaluations are then converted into their corresponding triangular fuzzy numbers (see Table 1), and the initial decision matrix ( $\tilde{X} = [\tilde{x}_{ij}]$ ,  $i=1,2, 3, \dots, m$ ;  $j=1,2, 3, \dots, n$ ) is constructed (Equation 8).

$$\tilde{X} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \dots & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots & \dots & \dots & \tilde{x}_{2n} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \dots & \dots & \tilde{x}_{mn} \end{bmatrix} \tag{8}$$

In the case of k decision-makers, the aggregated initial decision matrix is constructed by taking the arithmetic mean of their evaluations: ( $\tilde{x}_{11} = \frac{\tilde{x}_{11}^{(1)} + \tilde{x}_{11}^{(2)} + \tilde{x}_{11}^{(3)} + \dots + \tilde{x}_{11}^{(k)}}{k}$ )

Step 2. In the MAIRCA method, it is assumed that the decision-maker is neutral regarding the selection of alternatives. In other words, each alternative has an equal probability of being selected. Therefore, in the second step, the preference probability for each alternative ( $P_{A_i}$ ) is calculated using Equation (9):

$$P_{A_i} = \frac{1}{m} \tag{9}$$

where,

$$\sum_{i=1}^m P_{A_i} = 1.$$

Step 3. The fuzzy theoretical evaluation matrix ( $\tilde{T}_p$ ) is calculated by multiplying the determined criterion weights ( $\tilde{w}_i$ ) with the preferences made for the alternatives ( $P_{A_i}$ ), as shown in Equation (10).

$$\tilde{T}_p = \begin{bmatrix} P_{A_1} \cdot \tilde{w}_1 & P_{A_1} \cdot \tilde{w}_2 & \dots & \dots & P_{A_1} \cdot \tilde{w}_n \\ P_{A_2} \cdot \tilde{w}_1 & P_{A_2} \cdot \tilde{w}_2 & \dots & \dots & P_{A_2} \cdot \tilde{w}_n \\ \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ P_{A_m} \cdot \tilde{w}_1 & P_{A_m} \cdot \tilde{w}_2 & \dots & \dots & P_{A_m} \cdot \tilde{w}_n \end{bmatrix} = \begin{bmatrix} \tilde{t}_{p11} & \tilde{t}_{p12} & \dots & \dots & \tilde{t}_{p1n} \\ \tilde{t}_{p21} & \tilde{t}_{p22} & \dots & \dots & \tilde{t}_{p2n} \\ \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ \tilde{t}_{pm1} & \tilde{t}_{pm2} & \dots & \dots & \tilde{t}_{pmn} \end{bmatrix} \tag{10}$$

Step 6. The initial decision matrix ( $\tilde{X}$ ) is normalized using Equations (11), (12), and (13), then multiplied by the theoretical evaluation matrix ( $\tilde{T}_r$ ) to obtain the real evaluation matrix ( $\tilde{T}_r$ ) as shown in Equation (14).

$$n_{ij}^l = \frac{x_{ij}^l}{\sqrt{\sum_{i=1}^m [(x_{ij}^l)^2 + (x_{ij}^m)^2 + (x_{ij}^u)^2]}} \tag{11}$$

$$n_{ij}^m = \frac{x_{ij}^m}{\sqrt{\sum_{i=1}^m [(x_{ij}^l)^2 + (x_{ij}^m)^2 + (x_{ij}^u)^2]}} \tag{12}$$

$$n_{ij}^u = \frac{x_{ij}^u}{\sqrt{\sum_{i=1}^m [(x_{ij}^l)^2 + (x_{ij}^m)^2 + (x_{ij}^u)^2]}} \tag{13}$$

$$\tilde{T}_r = \begin{bmatrix} \tilde{n}_{11} \otimes \tilde{t}_{p11} & \tilde{n}_{12} \otimes \tilde{t}_{p12} & \dots & \dots & \dots & \dots & \tilde{n}_{1n} \otimes \tilde{t}_{p1n} \\ \tilde{n}_{21} \otimes \tilde{t}_{p21} & \tilde{n}_{22} \otimes \tilde{t}_{p22} & \dots & \dots & \dots & \dots & \tilde{n}_{2n} \otimes \tilde{t}_{p2n} \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ \tilde{n}_{m1} \otimes \tilde{t}_{pm1} & \tilde{n}_{m2} \otimes \tilde{t}_{pm2} & \dots & \dots & \dots & \dots & \tilde{n}_{mn} \otimes \tilde{t}_{pmn} \end{bmatrix} = \begin{bmatrix} \tilde{t}_{r11} & \tilde{t}_{r12} & \dots & \dots & \dots & \dots & \tilde{t}_{r1n} \\ \tilde{t}_{r21} & \tilde{t}_{r22} & \dots & \dots & \dots & \dots & \tilde{t}_{r2n} \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ \tilde{t}_{rm1} & \tilde{t}_{rm2} & \dots & \dots & \dots & \dots & \tilde{t}_{rmn} \end{bmatrix} \tag{14}$$

Step 7. The difference between the theoretical and real evaluations of each alternative for each criterion is calculated (Equation 15), resulting in the total gap matrix ( $g_{ij}$ ).

$$g_{ij} = \sqrt{\frac{(\tilde{t}_{pijl} - \tilde{t}_{rijl})^2 + (\tilde{t}_{pijm} - \tilde{t}_{rijm})^2 + (\tilde{t}_{piju} - \tilde{t}_{riju})^2}{3}} \tag{15}$$

Step 8. The gap values ( $Q_i$ ) of each alternative for all criteria are summed (Equation 16) to calculate the final values of the criterion functions.

$$Q_i = \sum_{j=1}^n g_{ij}, \quad i = 1, 2, 3, \dots, m \tag{16}$$

The alternative with the smallest gap value is selected as the best alternative.

**Table 1.** Scale Fuzzy Number Evaluation Scale for the F-AHP and F-MAIRCA Methods

F-MAIRCA Evaluation Scale		F-AHP Evaluation Scale		
Linguistic Term	Triangular Fuzzy Number Scale	Fuzzy Number	Linguistic Expression	Triangular Fuzzy Number (TFN)
Very Poor	(0, 0.05, 0.15)	$\tilde{9}$	Extremely Important	(8,9,10)
Poor	(0.1, 0.2, 0.3)	$\tilde{8}$	Between Very Strongly and Extremely Important	(7,8,9)
Fairly Poor	(0.2, 0.35, 0.5)	$\tilde{7}$	Very Strongly Important	(6,7,8)
Moderate	(0.3, 0.5, 0.7)	$\tilde{6}$	Between Strongly and Very Strongly Important	(5,6,7)

Fairly Good	(0.5, 0.65, 0.8)	5̄	Strongly Important	(4,5,6)
Good	(0.7, 0.8, 0.9)	4̄	Between Moderately and Strongly Important	(3,4,5)
Very Good	(0.85, 0.95, 1)	3̄	Moderately Important	(2,3,4)
		2̄	Intermediate between Equal and Moderate Importance	(1,2,3)
		1̄	Equal Importance	(1,1,1)

Resource. Mohammadi et.al. (2024)

### 3.4. Private School Selection Using F-AHP and F-MAIRCA Methods

This study was conducted to select the private primary school that best meets the criteria considered by parents when choosing among private primary schools operating in İzmir/Gaziemir.

Primary education, as the first stage of formal schooling, is one of the main factors influencing a student's future academic success and career choice. In addition to its academic function, primary school plays a crucial role in shaping a child's socialization, independence, sense of responsibility, and awareness of individuality.

In recent years, the number of private schools in Türkiye has increased rapidly. The growing demand for private schools can be attributed to their ability to develop practices tailored to parental needs, maintain smaller class sizes, and place greater emphasis on school–family collaboration, among other factors.

In today's context, parents' expectations from schools extend beyond academic achievement to include economic, social status, interest, safety, and accessibility considerations, all of which have become determining factors in school selection. Given the diversity of expectations and the multitude of available alternatives, fuzzy multi-criteria decision-making (MCDM) techniques emerge as highly appropriate tools for achieving optimal selection outcomes.

In this study, the aim was to identify the criteria and their priority rankings that parents consider in private school selection. Based on the identified criteria, private schools located in the Gaziemir district of İzmir were evaluated, and the school that best satisfies these criteria was selected using fuzzy MCDM techniques.

### 3.5. Materials and Methods

In this study, a literature review was conducted, social media blogs were examined, and face-to-face interviews were held with ten parents who have school-age children to identify the criteria considered in private school selection. A total of 19 sub-criteria were determined and

classified under five main criteria. These criteria were structured into evaluation matrices in accordance with the F-AHP format, and pairwise comparisons were performed by the ten participating parents using linguistic expressions. By applying the F-AHP steps described above, the local and global weights of the criteria were obtained.

Thirteen primary schools operating in the Gaziemir district were evaluated by the ten parents according to the determined criteria. The evaluation matrices were then aggregated to construct the initial decision matrix used for ranking alternatives through the F-MAIRCA method. Finally, the alternative schools were ranked by applying the steps of the F-MAIRCA methodology.

### 3.6. Application

The main and sub-criteria considered in private school preference were determined as presented in Table 2.

**Table 2.** Main and Sub-Criteria

Main Criteria	Code	Sub-Criteria	Supporting Literature
Academic Factors	C11	Quality of Management and Teachers	OECD (2005); Wilkinson et al. (2004)
	C12	Foreign Language Education	Bray (1999); Dearden et al. (2011)
	C13	Appropriateness of the Curriculum	Van Pelt et al. (2007)
	C14	Academic Achievements	Bosetti (2004); Peterson & Llaudet (2006)
Physical Conditions	C21	Physical Infrastructure	Smith (2000)
	C22	Number of Students per Class	Johnson & Johnson (2019)
	C23	Safety and Health Services	De Angelis & Holmes Erickson (2017)
	C24	Nutrition and Hygiene	Bundy et al. (2018); Alsuiadi (2015)
	C25	Discipline	Cruz (2014)
Economic Factors	C31	School Fees	De Angelis & Holmes Erickson (2017)
	C32	Scholarship and Installment Opportunities	Stewart & Wolf (2015)
	C33	Tuition Increase Policy	Lavy (2018); Yang et al. (2019)
Administrative Support	C41	Expertise of School Management	Brown et al. (2020)
	C42	Social and Sports Activities	Bozyiğit (2017); Gürler (2020)
	C43	Quality of Guidance Services	Uygun (2023)

	C44	Parent–School Communication	Kingdon (2010)
School Location	C51	Distance from Home/Workplace	Flatley (2001)
	C52	School Reputation	Bosetti (2004)
	C53	Ease of Transportation	Goldring & Rowley (2006); Bernal (2005)

As shown in Table 2, the evaluation criteria used in this study were derived from a comprehensive review of the literature on school choice and educational quality. Previous studies emphasize that parents evaluate private schools based on a wide range of factors including academic quality, teacher competence, curriculum structure, and foreign language education (Bosetti, 2004; Bray, 1999; Peterson & Llaudet, 2006). In addition to academic factors, physical conditions such as school infrastructure, class size, safety, and health-related services including nutrition and hygiene are considered important determinants influencing parental preferences (Smith, 2000; Bundy et al., 2018; Alsuiadi, 2015). Economic aspects such as tuition fees, scholarship opportunities, and tuition policies also play a significant role in school selection decisions, particularly for families evaluating the long-term affordability of private education (Dearden et al., 2011; Lavy, 2018; Yang et al., 2019). Furthermore, administrative and socio-cultural elements, including school management expertise, social and sports activities, guidance services, and effective parent–school communication, contribute to parents’ trust and perceptions of school quality (Brown et al., 2020; Kingdon, 2010). Location-related factors such as distance, transportation accessibility, and school reputation also influence parental decision-making (Flatley, 2001; Goldring & Rowley, 2006; Bernal, 2005). Based on these findings, the criteria used in this study were categorized into five main groups and nineteen sub-criteria, which form the basis of the subsequent F-AHP weighting and F-MAIRCA ranking analyses.

The evaluation process in this study was conducted by ten parents whose children were about to start the first grade of primary school and who were actively searching for suitable private schools. These parents participated in the study as decision makers since they were directly involved in the school selection process and were responsible for making educational decisions for their children.

The participants were selected using a purposive sampling approach. All participants were parents who were planning to enroll their children in the first grade of a private primary school in the upcoming academic year. The decision-making group included parents with different

socio-economic backgrounds, educational levels, and occupational profiles, ensuring a diverse representation of parental perspectives in the evaluation process.

Appendix A presents the demographic profile of the participants. As shown in the table, the decision makers represent different income levels, professional backgrounds, and education levels. This diversity allowed the study to capture heterogeneous parental preferences in the school selection process.

Although the number of participants is limited to ten parents, the purpose of this study is not statistical generalization but rather to model parental decision-making behavior using a multi-criteria decision-making framework. In many MCDM studies, decision makers are selected based on their relevance and familiarity with the decision problem rather than large sample sizes. Since the participants in this study were directly involved in selecting schools for their children, their evaluations provide meaningful and realistic insights into parental preferences.

Before the evaluation stage, participants were informed about the purpose of the study and the evaluation criteria. Each participant evaluated the criteria and alternatives using linguistic expressions represented by triangular fuzzy numbers. The individual evaluations were then aggregated to obtain a collective decision matrix used in subsequent analyses. The pairwise comparison matrices for the main and sub-criteria were evaluated by the decision-makers using the linguistic expressions given in Table 1. The comparison matrices obtained from each decision-maker were then aggregated (Appendix B, C, D, E, F,G), and the combined matrices were used to construct the decision matrices for the F-AHP method. The calculation steps for determining the weights of the main criteria using the Fuzzy Analytic Hierarchy Process (F-AHP) method are explained below.

Step 1. Pairwise comparison matrices were constructed by each decision maker through pairwise comparisons of the evaluation criteria.

Step 2. The pairwise comparison matrices evaluated by the decision makers were aggregated by calculating their arithmetic mean, resulting in the combined decision matrix for the main criteria (see Appendix B).

Step 3. Using Equation (4), the geometric mean of the fuzzy comparison values for each criterion was calculated according to Equation (3).

For criterion C1;  $l = \sqrt[5]{1 \times 4,5 \times 2,6 \times 4,1 \times 5} = 2,992$ ,  $m = \sqrt[5]{1 \times 5,5 \times 3,1 \times 5,1 \times 5,9} = 3,484$ ,  $u = \sqrt[5]{1 \times 6,5 \times 3,6 \times 6,1 \times 6,8} = 3,957$

For criterion C2;  $l = \sqrt[5]{1,169 \times 1 \times 0,983 \times 0,967 \times 1,5} = 0,753, m = \sqrt[5]{0,209 \times 1 \times 1,409 \times 1,7 \times 2,1} = 1,01, u = \sqrt[5]{0,277 \times 1 \times 1,875 \times 2,5 \times 2,7} = 1,285$

For criterion C3;  $l = \sqrt[5]{0,588 \times 1,708 \times 1 \times 1,9 \times 2,4} = 1,356, m = \sqrt[5]{0,609 \times 2,15 \times 1 \times 2,9 \times 2,9} = 1,616, u = \sqrt[5]{0,646 \times 2,65 \times 1 \times 3,9 \times 3,4} = 1,867$

For criterion C4;  $l = \sqrt[5]{1,85 \times 0,525 \times 0,277 \times 1 \times 1,7} = 0,54, m = \sqrt[5]{0,236 \times 0,833 \times 0,395 \times 1 \times 2,1} = 0,696, u = \sqrt[5]{1 \times 6,5 \times 3,6 \times 6,1 \times 6,8} = 0,966$

For criterion C5;  $l = \sqrt[5]{0,229 \times 0,558 \times 0,591 \times 0,692 \times 1} = 0,554, m = \sqrt[5]{0,254 \times 0,617 \times 0,613 \times 0,723 \times 1} = 0,586, u = \sqrt[5]{0,293 \times 0,75 \times 0,8 \times 0,8 \times 1} = 0,675$

Step 4. The triangular fuzzy numbers corresponding to the criteria are summed, and the total triangular fuzzy number is obtained.

$$T = (2.992 + 0.753 + 1.356 + 0.540 + 0.554, 3.484 + 1.010 + 1.616 + 0.696 + 0.586, 3.957 + 1.285 + 1.867 + 0.966 + 0.675) = (6.195, 7.392, 8.751)$$

The triangular fuzzy numbers obtained by calculating the geometric mean of the fuzzy comparison values for each criterion are divided by the total triangular fuzzy number (Equation 5) to determine the triangular fuzzy weights of the criteria.

For criterion C1, the fuzzy weight is calculated as follows:  $(\frac{2.992}{8.751}, \frac{3.484}{7.392}, \frac{3.957}{6.195}) = (0.342, 0.471, 0.639)$

The obtained triangular fuzzy numbers were then defuzzified using Equation (6). The defuzzification example for criterion C1 is given below:

$$W_{C1} = \frac{0.342 + 0.471 + 0.639}{3} = 0.484$$

The defuzzified weight values of each criterion are normalized by dividing them by the sum of the defuzzified weights of all criteria (Equation 7). The total sum of the defuzzified weights of all criteria is 1.040, and the normalized weight of criterion C1 is obtained as:

$$W_{C1} = 0.465$$

By applying the procedural steps of the F-AHP method to the fuzzy decision matrices, the fuzzy and defuzzified weights of both the main and sub-criteria were obtained. The resulting weights are presented in Table 3.

**Table 3.** Main and Sub-Criteria Criterion Weights

Main Criteria	Sub-Criteria		Fuzzy Local Weights	Local Weights	Global Weights
Academic Factors (C1) (0.342, 0.471, 0.639) (0.465)	C11	Quality of Management and Teachers	(0.278, 0.443, 0.674)	0,435	0,202
	C12	Foreign Language Education	(0.144, 0.224, 0.353)	0,225	0,105
	C13	Appropriateness of the Curriculum	(0.117, 0.186, 0.304)	0,189	0,088
	C14	Academic Achievements	(0.100, 0.148, 0.236)	0,151	0,070
Physical Conditions and Facilities (C2) (0.086, 0.137, 0.207) (0.138)	C21	Physical Infrastructure	(0.165, 0.247, 0.375)	0,245	0,034
	C22	Number of Students per Class	(0.165, 0.265, 0.414)	0,263	0,036
	C23	Safety and Health Services	(0.111, 0.178, 0.285)	0,179	0,025
	C24	Nutrition and Hygiene	(0.090, 0.147, 0.238)	0,148	0,020
	C25	Discipline	(0.108, 0.164, 0.255)	0,164	0,023
Economic Factors (C3) (0.155, 0.219, 0.301) (0.216)	C31	School Fees	(0.427, 0.614, 0.860)	0,603	0,130
	C32	Scholarship and Installment Opportunities	(0.166, 0.253, 0.388)	0,256	0,055
	C33	Tuition Increase Policy	(0.087, 0.134, 0.223)	0,141	0,030
Administrative and Socio-Cultural Support (C4) (0.062, 0.094, 0.156) (0.100)	C41	Expertise of School Management	(0.175, 0.284, 0.438)	0,280	0,028
	C42	Social and Sports Activities	(0.150, 0.248, 0.398)	0,248	0,025
	C43	Quality of Guidance Services	(0.148, 0.225, 0.365)	0,230	0,023
	C44	Quality of Parent-School Communication	(0.164, 0.244, 0.368)	0,242	0,024
School Location (C5) (0.063, 0.079, 0.109) (0.081)	C51	Distance from Home/Workplace	(0.425, 0.568, 0.754)	0,564	0,045
	C52	School's Social Environment and Reputation	(0.140, 0.211, 0.306)	0,212	0,017
	C53	Ease of Transportation	(0.167, 0.221, 0.304)	0,223	0,018

When Table 3 is examined, it is observed that the most important criterion considered in school selection is academic factors (0.465). The second most significant criterion is economic factors (0.216). The physical conditions and facilities of the school rank third with a weight score of 0.138, followed by administrative and social support (0.100) and school location (0.081). These results indicate that academic factors are the most decisive elements in school preference. Although economic factors also have a relatively high impact on the selection process, it can

be concluded that parents prioritize their children's educational quality and are willing to tolerate higher tuition fees to ensure better learning opportunities.

It is a known fact that transportation difficulties are common, especially in large metropolitan areas. When both parents are working, the need to pick up children from school or to arrive home earlier than them becomes a significant source of stress, particularly for families with primary school students. Therefore, parents tend to prefer schools close to their home or workplace. However, the obtained weight values demonstrate that when academic success is concerned, parents are willing to overcome such logistical challenges.

When the weights of the sub-criteria are analyzed, the most important sub-criterion is management and teacher quality (0.202), followed by tuition fee (0.130) and foreign language education (0.105). The appropriateness of the curriculum (0.088) also affects school preference, while the social environment and reputation of the school and ease of transportation appear to be the least influential factors. Nonetheless, it can be stated that parents prioritize the school's proximity to home over transportation convenience.

After obtaining the criteria weights, the school selection process was carried out using the F-MAIRCA method. The steps of the F-MAIRCA method are explained below.

Ten parents evaluated 13 private primary schools located in İzmir/Gaziemir (see Table 4) according to the criteria determined earlier by using the linguistic expressions given in Table 1. Step 1. The aggregated evaluation matrix (Appendix H) was obtained by calculating the arithmetic mean of the evaluation matrices provided by the decision makers who assessed the alternative schools according to the determined criteria (Equation 8).

Step 2. According to the MAIRCA method, it is assumed that the decision maker is neutral toward each alternative. Therefore, the preference probability for each alternative was calculated using Equation (9) as:

$$P_{A_i} = \frac{1}{13} = 0.0769 \quad (m = 13)$$

where  $m$  represents the number of alternatives, which is 13.

Step 3. The fuzzy theoretical evaluation matrix  $\tilde{T}_p$  was obtained by multiplying the weights determined for each criterion (Table 3) with the preference probabilities of the alternatives obtained in Step 2 (Equation 10) (see Appendix I).

Step 4. The initial decision matrix ( $\tilde{X}$ ) was normalized (see Appendix J) using Equations (11), (12), and (13), and then multiplied by the theoretical evaluation matrix ( $\tilde{T}_p$ ) as defined in Equation (14) to derive the real evaluation matrix  $\tilde{T}_r$  (see Appendix K).

Subsequently, the fifth and sixth steps of the F-MAIRCA method were implemented. Using Equation (15), the total gap matrix (see Appendix L) was obtained, and through Equation (16), the gap values for each alternative were aggregated to calculate the final values of the criterion functions for all alternatives, as presented in Table 4.

**Table 4.** Alternative  $Q_i$  Values and Alternative Rankings

School Code	School Name	$Q_i$ Values	Ranking
A1	İ.T.Ü. İzmir İ.O.	0.062640	3
A2	Ege Eğitim Gazıemir İ.O.	0.065197	8
A3	Egebil Koleji İ.O.	0.066833	9
A4	Elçin Tün İ.O.	0.067135	10
A5	Gazıemir Mod. Bil. Ak. İ.O.	0.063950	6
A6	Gazıemir Okyanus İ.O.	0.064150	7
A7	İzmir Anka Koleji İ.O.	0.061704	1
A8	İzmir İsabet İ.O.	0.068398	12
A9	Özel İzmir Mef Uluslararası İ.O.	0.062599	2
A10	Kent Koleji İ.O.	0.063409	4
A11	Kocatürk İ.O.	0.068564	13
A12	Rota İ.O.	0.063439	5
A13	Tekfen Koleji İ.O.	0.067438	11

According to the F-MAIRCA method, the alternative with the smallest gap value is selected as the best alternative. When the  $Q_i$  values shown in Table 4 are arranged in ascending order, the following ranking is obtained:

$$A7 < A9 < A1 < A10 < A12 < A5 < A6 < A2 < A3 < A4 < A13 < A8 < A11$$

Accordingly, the alternative that best satisfies the designated criteria is A7 (İzmir Anka Koleji Primary School).

### 3.7. Sensitivity Analysis

Sensitivity analysis is designed to validate the reliability of the obtained results. It allows decision makers to corroborate the method's outputs by introducing controlled changes to the solution model. Although the literature offers various sensitivity-analysis strategies, this study adopts a weight-variation approach. As described in Table 5, the main-criterion weights were

systematically altered to generate 32 distinct scenarios; the subcriterion weights were then recomputed, and the corresponding  $Q_i$  values were calculated for each scenario (see Appendix M). Rankings based on the computed  $Q_i$  values are reported in Table 6 and illustrated in Figure 1.

During the calculation of alternative weights, when a criterion was increased or decreased by a certain percentage, the corresponding decrease or increase was proportionally distributed among the remaining criteria.

For example, when the main criterion C1 was reduced by 5%, the total decrease amount was calculated as:  $0,465 \times 0,05 = 0,0233$

Accordingly, the new weight of criterion C1 was obtained as:  $0,465 - 0,0233 = 0,442$

The new weight of criterion C2 was then calculated by proportionally distributing the decrease among the remaining criteria:  $0,138 + 0,0233 \times 0,138 / (0,138 + 0,216 + 0,100 + 0,081) = 0,144$

In this way, the weight adjustments were proportionally redistributed among the other criteria to maintain the overall balance of the criteria weights.

**Table 5.** Sensitivity Analysis Scenarios

	C1	C2	C3	C4	C5	
O	0,465	0,138	0,216	0,100	0,081	Original weights
S1	0,442	0,144	0,226	0,104	0,084	C1 decreased by 5%, others increased proportionally
S2	0,419	0,150	0,235	0,109	0,088	C1 decreased by 10%, others increased proportionally
S 3	0,396	0,156	0,245	0,113	0,091	C1 decreased by 15%, others increased proportionally
S 4	0,372	0,162	0,254	0,117	0,095	C1 decreased by 20%, others increased proportionally
S 5	0,349	0,168	0,263	0,122	0,098	C1 decreased by 25%, others increased proportionally
S 6	0,326	0,174	0,273	0,126	0,102	C1 decreased by 30%, others increased proportionally
S 7	0,489	0,132	0,207	0,096	0,077	C1 increased by 5%, others decreased proportionally
S 8	0,512	0,126	0,197	0,091	0,074	C1 increased by 10%, others decreased proportionally
S 9	0,535	0,120	0,188	0,087	0,070	C1 increased by 15%, others decreased proportionally
S 10	0,442	0,153	0,205	0,111	0,089	C1 and C3 decreased by 5%, others increased proportionally
S 11	0,419	0,167	0,195	0,121	0,098	C1 and C3 decreased by 10%, others increased proportionally
S 12	0,396	0,182	0,184	0,132	0,107	C1 and C3 decreased by 15%, others increased proportionally
S 13	0,442	0,131	0,205	0,123	0,099	C1, C2, and C3 decreased by 5%, others increased proportionally

S 14	0,419	0,124	0,195	0,145	0,117	C1, C2, and C3 decreased by 10%, others increased proportionally
S 15	0,233	0,198	0,310	0,143	0,116	C1 decreased by 50%, others increased proportionally
S16	0,200	0,200	0,200	0,200	0,200	All main criteria equal
S17	0,461	0,145	0,214	0,099	0,081	C2 increased by 5%, others decreased proportionally
S18	0,443	0,179	0,206	0,095	0,077	C2 increased by 30%, others decreased proportionally
S19	0,459	0,136	0,227	0,099	0,080	C3 increased by 5%, others decreased proportionally
S20	0,430	0,128	0,281	0,093	0,068	C3 increased by 30%, others decreased proportionally
S21	0,462	0,137	0,215	0,105	0,081	C4 increased by 5%, others decreased proportionally
S22	0,450	0,134	0,210	0,130	0,076	C4 increased by 30%, others decreased proportionally
S23	0,463	0,137	0,215	0,100	0,085	C5 increased by 5%, others decreased proportionally
S24	0,454	0,135	0,211	0,097	0,105	C5 increased by 30%, others decreased proportionally
S25	0,469	0,131	0,218	0,101	0,082	C2 decreased by 5%, others increased proportionally
S26	0,487	0,097	0,226	0,105	0,085	C2 decreased by 30%, others increased proportionally
S27	0,471	0,140	0,205	0,101	0,082	C3 decreased by 5%, others increased proportionally
S28	0,503	0,149	0,151	0,108	0,088	C3 decreased by 30%, others increased proportionally
S29	0,468	0,139	0,217	0,095	0,082	C4 decreased by 5%, others increased proportionally
S30	0,481	0,143	0,223	0,070	0,084	C4 decreased by 30%, others increased proportionally
S31	0,467	0,139	0,217	0,100	0,077	C5 decreased by 5%, others increased proportionally
S32	0,477	0,142	0,222	0,103	0,057	C5 decreased by 30%, others increased proportionally

In all sensitivity-analysis scenarios, the best alternative remained A7, consistent with the original solution. In the 15th and 16th scenarios, the relative order of A4 and A13 changed. Setting all criterion weights equal—or reducing the C1 (main criterion) weight by 50% or more—did not materially affect the overall ranking of alternatives, but it did alter the ordering between A4 and A13. In Scenario 18, alternatives A1 and A9 have been rearranged compared to the other scenarios.

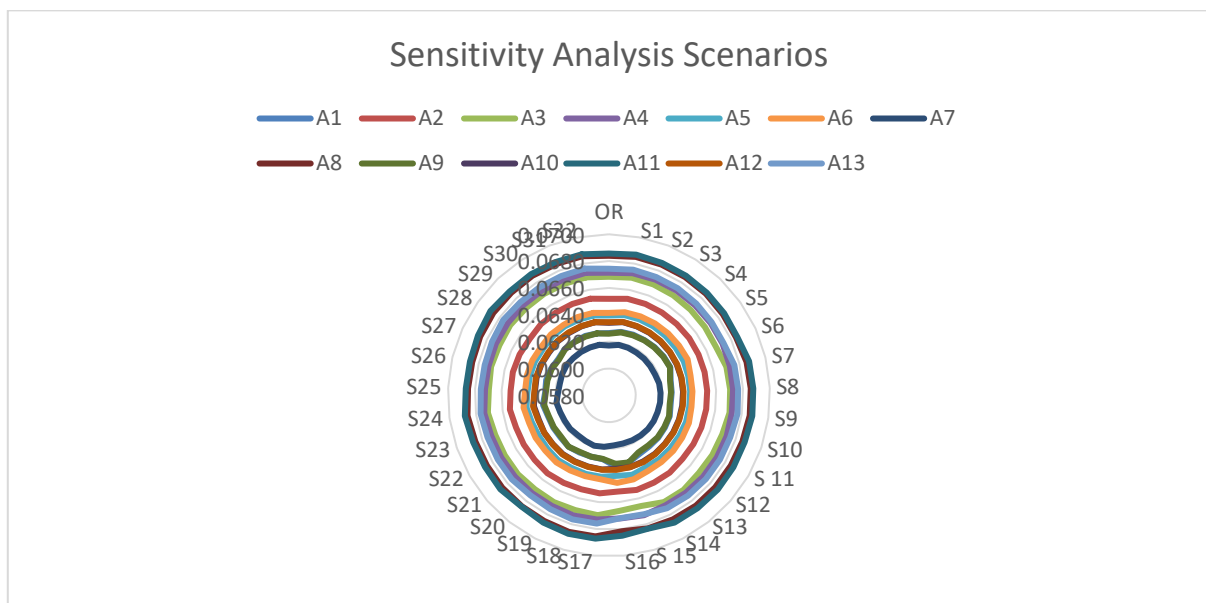
**Table 6.** Alternative Rankings by Sensitivity-Analysis Scenarios

	OR	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16
A1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
A2	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
A3	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
A4	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	11	11
A5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
A6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
A7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
A8	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
A9	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

A10	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
A11	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
A12	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
A13	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	10	10

	S17	S18	S19	S20	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30	S31	S32
A1	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
A2	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
A3	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
A4	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
A5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
A6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
A7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
A8	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
A9	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2
A10	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
A11	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
A12	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
A13	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11

Figure 1. Sensitivity Analysis Scenarios



### 3.8. Comparison with Other MCDM Techniques

Based on the determined criteria, the selection of the best school was also evaluated using the Fuzzy Combined Compromise Solution (F-CoCoSo) and Fuzzy Technique for Order of

Preference by Similarity to Ideal Solution (F-TOPSIS) methods. The resulting score values were calculated and are presented in Table 7.

**Table 7.** Alternatives' F-MAIRCA, F-CoCoSo and F-TOPSIS Score Values

Alternatives	F-MAIRCA	F-CoCoSo	F-TOPSIS
A1	0,0626	13,9399	0,8406
A2	0,0652	11,3685	0,5636
A3	0,0668	9,4773	0,3627
A4	0,0671	9,0665	0,3127
A5	0,0640	12,5922	0,7000
A6	0,0642	12,3847	0,6858
A7	0,0617	14,5218	0,9210
A8	0,0684	7,5142	0,1447
A9	0,0626	13,9191	0,8354
A10	0,0634	12,9589	0,7456
A11	0,0686	6,8314	0,1087
A12	0,0634	13,0138	0,8312
A13	0,0674	8,4458	0,4765

According to the F-MAIRCA method, the alternative with the lowest score is considered the best option. In contrast, according to the F-CoCoSo and F-TOPSIS methods, the alternative with the highest score value is regarded as the best alternative. The ranking of the alternatives according to all three methods is presented in Table 8.

**Table 8.** Alternative Rankings According to F-MAIRCA, F-CoCoSo and F-TOPSIS Methods

Sıra	F-MAIRCA	F-CoCoSo	F-TOPSIS
1	A7	A7	A7
2	A9	A1	A1
3	A1	A9	A9
4	A10	A12	A12
5	A12	A10	A10
6	A5	A5	A5
7	A6	A6	A6
8	A2	A2	A2
9	A3	A3	A13
10	A4	A4	A3
11	A13	A13	A4

12	A8	A8	A8
13	A11	A11	A11

Considering Table 8, it can be seen that according to all three methods, the best alternative is A7 (İzmir Anka Koleji Primary School).

#### 4. RESULTS

In this study, the weights of five main and nineteen subcriteria were computed using F-AHP, after which the ranking of thirteen private primary schools was obtained via the F-MAIRCA method. At the main-criterion level, the highest importance was observed for Academic Factors ( $w=0.465$ ), followed by Economic Factors ( $w=0.216$ ), Physical Conditions and Facilities ( $w=0.138$ ), Governance and Social/Cultural Support ( $w=0.100$ ), and School Location ( $w=0.081$ ). This distribution indicates that parents place the academic dimension as the primary determinant in school choice, while cost and physical conditions act as reinforcing yet secondary determinants.

Examining global (overall) weights at the subcriterion level, Teacher and Leadership Quality (0.202) ranks first, followed by Tuition/School Fees (0.130) and Foreign Language Education (0.105). These are followed by Curriculum Adequacy (0.088) and Academic Achievements (0.070). The comparatively lowest global weights fall under School Location: Distance to Home/Work (0.045), Ease of Transportation (0.018), and Social Environment/Reputation (0.017) exert limited influence on decisions. Taken together, these findings suggest that schools' pedagogical/academic quality and faculty strength are decisive, while financial accessibility operates as a critical but secondary filter.

In the F-MAIRCA ranking analysis,  $Q_i$  scores were calculated based on proximity to ideal values and empirical gap measures. The results indicate that İzmir Anka Koleji Primary School (A7) ranks first with  $Q_i = 0.061704$ . The upper tier also includes Özel İzmir MEF International Primary School (A9, 0.062599) and İ.T.Ü. İzmir Primary School (A1, 0.062640) in second and third place, respectively. The remaining members of the top ten and their values are: Kent Koleji (A10, 0.063409), Rota (A12, 0.063439), Gaziemir Modern Bilim Akademi (A5, 0.063950), Gaziemir Okyanus (A6, 0.064150), Ege Eğitim Gaziemir (A2, 0.065197), Egebil (A3, 0.066833), and Elçin Tün (A4, 0.067135). These are followed by Tekfen (A13, 0.067438), İzmir İsabet (A8, 0.068398), and Kocatürk (A11, 0.068564). The overall order is:  $A7 < A9 < A1 < A10 < A12 < A5 < A6 < A2 < A3 < A4 < A13 < A8 < A11$ .

According to the F-CoCoSo method, the ranking of the alternatives was obtained as:

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$A7 > A1 > A9 > A12 > A10 > A5 > A6 > A2 > A3 > A4 > A13 > A8 > A11$ ,

while according to the F-TOPSIS method, the ranking was determined as:

$A7 > A1 > A9 > A12 > A10 > A5 > A6 > A2 > A13 > A3 > A4 > A8 > A11$ .

In both methods, the alternative with the highest score value is considered the best alternative. Accordingly, alternative A7 was identified as the best alternative according to all three methods.

According to the F-MAIRCA method, A9 was ranked as the second-best alternative and A1 as the third-best alternative. However, according to both the F-CoCoSo and F-TOPSIS methods, A1 was ranked second, while A9 was ranked third among the alternatives.

Schools in the upper tier consistently exhibit strong performance in academic outcomes, teacher/leadership quality, and foreign-language provision, whereas the relative disadvantages of mid- and lower-tier schools are concentrated mainly in physical facilities and economic conditions.

To test the model's decision sensitivity, weight-variation scenarios of  $\pm 5\%$ ,  $\pm 10\%$ ,  $\pm 20\%$ ,  $\pm 25\%$ , and  $\pm 30\%$  were applied to the main-criterion weights. The sensitivity results show that the upper ranks remain largely stable, with only marginal positional changes among lower-ranked alternatives in a limited number of scenarios. In particular, the stability of A7 and A9 in the top two positions confirms that the proposed F-AHP  $\rightarrow$  F-MAIRCA pipeline provides a robust, decision-consistent structure under alternative weighting assumptions.

Overall, the findings demonstrate that academic quality and faculty strength occupy a central place in parents' decision space; financial accessibility and physical facilities reinforce the decision, while locational variables function as complementary factors with relatively limited influence. The obtained weight structure and ranking outputs indicate that, for a multi-criteria and uncertainty-laden school-choice problem, the model delivers transparent, traceable, and practically applicable decision support.

## 5. DISCUSSION AND CONCLUSION

In this study, two fuzzy logic-based methods were integrated into the MCDM framework for evaluating private primary schools. Using F-AHP, the relative weights of the criteria were determined; subsequently, F-MAIRCA was employed to compute the performance values of the alternatives and derive the final ranking. This methodological integration enabled the systematic modeling of uncertainty and subjective judgments within the decision-making process.

The criterion weights obtained via F-AHP quantitatively reflect decision makers' priorities regarding school choice. The findings show that the highest weight belongs to the main criterion Academic Factors (C1), with a local weight of 0.465, indicating that decision makers evaluate academic quality and educational standards as the primary priority in school selection. Within this domain, the subcriterion Teacher and Leadership Quality (C11) has a global weight of 0.202, making it the dominant variable in the process. This result is consistent with prior studies, which emphasize the direct influence of teacher quality and school leadership on student outcomes (Yalçın et al., 2017; Sezer & Çalışkan, 2022).

The main criterion Economic Factors (C3) ranks second with a weight of 0.216, with Tuition/School Fees (C31) drawing attention at 0.130 global weight. This indicates that, alongside educational quality, economic accessibility is a salient determinant in school choice.

Although the remaining main criteria—Physical Conditions and Facilities (C2), Governance and Social Support (C4), and School Location (C5) —have lower weights, some subcriteria (e.g., Class Size (C22) and Ease of Transportation (C53) still attract notable emphasis. Overall, decision makers appear to value pedagogical/academic quality more highly than economic conditions, while physical and logistical criteria play supportive roles.

In the F-MAIRCA analysis, 13 private primary schools were evaluated, and the suitability of each alternative was determined with respect to the decision matrix. Based on the resulting  $Q_i$  values, the ranking is:  $A7 < A9 < A1 < A10 < A12 < A5 < A6 < A2 < A3 < A4 < A13 < A8 < A11$ . The alternative with the smallest  $Q_i$ , İzmir Anka Koleji Primary School (A7)—is thus identified as the most suitable option under the study's criteria set. This school stands out particularly for teacher quality, academic achievement, and a comparatively favorable economic profile. Other top-ranked schools—Özel İzmir MEF International Primary School (A9), İ.T.Ü. İzmir Primary School (A1), and Kent Koleji Primary School—exhibit similarly strong academic and economic indicators. When Appendix H is examined, it can be observed that alternative A7 is clearly preferred over the other alternatives particularly in terms of academic staff quality, scholarship and installment opportunities, tuition increase policy, expertise of school management, social and sports activities, parent–school management communication, the social environment of the school location, and accessibility.

The fact that the scores of the alternatives are close to each other indicates that the other schools are not distinctly preferred over one another. The findings suggest that the criteria listed above play a decisive role in the school selection process.

Schools positioned in the lower tier tend to display relatively weaker performance either on academic criteria or on economic accessibility. Nevertheless, the closeness of the  $Q_i$  values across all schools should be noted, indicating no stark quality gaps among the alternatives, though some institutions outperform others on specific criteria.

A sensitivity analysis was conducted to examine whether alternative rankings shift in response to changes in criterion weights. Across 32 scenarios, the alternative orderings were obtained, and changes in the weights did not alter the overall ranking, indicating robustness. Within this framework, the scope of the study should be interpreted in relation to the characteristics of the decision-making group and the regional context of the analysis. The evaluation process reflects the preferences of parents whose children are about to start primary school and who are actively involved in the school selection process. Therefore, the model captures decision behaviors observed in real-life parental choices rather than representing a statistically representative population sample. In multi-criteria decision-making studies, decision makers are typically selected based on their relevance to the decision problem rather than large sample sizes. Accordingly, the findings of this study should be understood as illustrating how parental priorities can be structured and analyzed within a fuzzy multi-criteria framework rather than as universally generalizable results for all parents or educational contexts.

These results align with prior research on school choice: studies in educational management and parental preferences frequently identify teacher quality and academic achievement as leading determinants (Buyruk, 2020; Kırkıç & Pulat, 2020; Orhan & Demirkol, 2025). The importance of tuition and economic accessibility likewise underscores the role of socioeconomic factors in decision making.

The study's distinctive contribution is to structure the school-evaluation process systematically and quantitatively through a fuzzy logic-based multi-criteria model. In social-science contexts where uncertainty is prevalent, fuzzy MCDM methods are highly effective for modeling subjective judgments.

The findings are limited to private primary schools in a specific region (İzmir) and should be interpreted with caution regarding generalizability. In addition, the criterion weights reflect the assessments of a particular expert/parent group. Future work in different regions and socio-cultural contexts, using larger and more diverse samples, would enhance external validity.

In light of the results, we recommend the following: for school administrators, prioritize teacher quality, academic achievement, and economic accessibility in strategic planning; for

policymakers, complement oversight of physical infrastructure with regulations and initiatives that strengthen teacher qualifications; and for parents, employ decision tools that account for multi-criteria structures to make more informed school-choice decisions.

For future research, we suggest integrating output-oriented criteria (e.g., student achievement trajectories, alumni satisfaction, student feedback) into the model, conducting comparative analyses with other MCDM techniques, and developing more collective evaluation designs by integrating group decision-making approaches with fuzzy logic.

### **Declaration of Research and Publication Ethics**

In order to apply the survey method in this study, Ethics Committee approval was obtained from the Dokuz Eylül University Social and Human Sciences Scientific Research and Publication Ethics Board with decision number 1455101 dated July 16, 2025, and the research and publication ethics principles were complied with in the study.

### **Researcher's Contribution Rate Statement**

The authors contributed equally to the article.

### **Declaration of Researcher's Conflict of Interest**

There are no potential conflicts of interest in this study.

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**Appendix A**

## Profile of Decision Makers

Participant	Gender	Education Level	Occupation	Approx. Income Level
P1	Male	Bachelor's Degree	Engineer	Middle
P2	Female	Master's Degree	Teacher	Middle
P3	Male	Bachelor's Degree	Business Owner	High
P4	Female	Bachelor's Degree	Accountant	Middle
P5	Male	Master's Degree	Manager	High
P6	Female	Bachelor's Degree	Nurse	Middle
P7	Male	Bachelor's Degree	Civil Servant	Middle
P8	Female	High School	Self-employed	Middle
P9	Male	Bachelor's Degree	Architect	High
P10	Female	Bachelor's Degree	Lawyer	High

**Appendix B**

## Combined F-AHP Comparison Matrix for Main Criteria

	C1	C2	C3	C4	C5
C1	(1,1,1)	(3.804,4.975,6.071)	(2.941,3.837,4.663)	(3.282,4.498,5.614)	(3.333,4.253,5.09)
C2	(0.165,0.201,0.263)	(1,1,1)	(2.458,3.147,3.776)	(2.514,3.239,3.88)	(1.741,2.337,2.927)
C3	(0.214,0.261,0.34)	(0.265,0.318,0.407)	(1,1,1)	(1.246,1.736,2.295)	(2.748,3.367,3.954)
C4	(0.178,0.222,0.305)	(0.258,0.309,0.398)	(0.436,0.576,0.803)	(1,1,1)	(2.731,3.193,3.621)
C5	(0.196,0.235,0.3)	(0.342,0.428,0.574)	(0.253,0.297,0.366)	(0.276,0.313,0.366)	(1,1,1)

**Appendix C**

## Combined F-AHP Comparison Matrix for C1 Sub-Criteria

	C11	C12	C13	C14
C11	(1,1,1)	(3.007,3.445,3.855)	(2.816,3.515,4.137)	(2.361,2.9,3.366)
C12	(0.259,0.29,0.333)	(1,1,1)	(2.707,3.641,4.483)	(1.738,2.349,3.009)
C13	(0.242,0.284,0.355)	(0.223,0.275,0.369)	(1,1,1)	(0.975,1.358,1.844)
C14	(0.297,0.345,0.424)	(0.332,0.426,0.575)	(0.542,0.736,1.025)	(1,1,1)

**Appendix D**

Combined F-AHP Comparison Matrix for C2 Sub-Criteria

	C21	C22	C23	C24	C25
C21	(1,1,1)	(2.421,3.245,4.038)	(2.781,3.63,4.436)	(2.987,3.635,4.237)	(1.762,2.314,2.862)
C22	(0.248,0.308,0.413)	(1,1,1)	(1.99,2.577,3.162)	(2.385,3.038,3.812)	(2.166,2.712,3.187)
C23	(0.225,0.276,0.36)	(0.316,0.388,0.503)	(1,1,1)	(2.43,3.005,3.584)	(1.943,2.197,2.421)
C24	(0.236,0.275,0.335)	(0.262,0.329,0.419)	(0.279,0.333,0.412)	(1,1,1)	(3.266,3.879,4.457)
C25	(0.349,0.432,0.568)	(0.314,0.369,0.462)	(0.413,0.455,0.515)	(0.224,0.258,0.306)	(1,1,1)

**Appendix E**

Combined F-AHP Comparison Matrix for C3 Sub-Criteria

	C31	C32	C33
C31	(1,1,1)	(2.079,2.663,3.153)	(2.526,3.278,3.928)
C32	(0.317,0.376,0.481)	(1,1,1)	(2.14,2.633,3.153)
C33	(0.255,0.305,0.396)	(0.317,0.38,0.467)	(1,1,1)

**Appendix F**

Combined F-AHP Comparison Matrix for C4 Sub-Criteria

	C41	C42	C43	C44
C41	(1,1,1)	(1.516,1.984,2.548)	(2.325,3.075,3.837)	(1.625,2.104,2.564)
C42	(0.393,0.504,0.66)	(1,1,1)	(3.075,4.274,5.38)	(2.744,3.915,5.01)
C43	(0.261,0.325,0.325)	(0.186,0.234,0.325)	(1,1,1)	(1.888,2.481,2.98)
C44	(0.39,0.475,0.616)	(0.2,0.255,0.364)	(0.336,0.403,0.53)	(1,1,1)

**Appendix G**

Combined F-AHP Comparison Matrix for C5 Sub-Criteria

	C51	C52	C53
C51	(1.000,1.000,1.000)	(2.458,3.165,3.882)	(2.169,2.705,3.174)
C52	(0.258,0.316,0.407)	(1.000,1.000,1.000)	(2.530,3.661,4.729)
C53	(0.315,0.370,0.461)	(0.211,0.273,0.395)	(1.000,1.000,1.000)

**Appendix H**

Combined F-MAIRCA Evaluation Matrix

	C11	C12	C13	C14	C21
A1	(0.645,0.770,0.880)	(0.680,0.800,0.900)	(0.595,0.725,0.850)	(0.730,0.845,0.930)	(0.700,0.815,0.910)
A2	(0.430,0.575,0.720)	(0.420,0.575,0.730)	(0.500,0.635,0.770)	(0.470,0.620,0.770)	(0.440,0.590,0.740)
A3	(0.260,0.455,0.565)	(0.270,0.470,0.585)	(0.360,0.560,0.675)	(0.360,0.560,0.675)	(0.400,0.590,0.695)
A4	(0.380,0.560,0.655)	(0.320,0.515,0.625)	(0.300,0.500,0.615)	(0.280,0.485,0.605)	(0.280,0.485,0.605)
A5	(0.585,0.710,0.820)	(0.535,0.665,0.790)	(0.475,0.620,0.760)	(0.475,0.620,0.760)	(0.495,0.635,0.770)

	C11	C12	C13	C14	C21
A6	(0.555,0.695,0.820)	(0.540,0.680,0.810)	(0.530,0.665,0.790)	(0.505,0.650,0.790)	(0.525,0.665,0.800)
A7	(0.670,0.785,0.890)	(0.610,0.740,0.860)	(0.705,0.815,0.910)	(0.510,0.665,0.810)	(0.595,0.725,0.850)
A8	(0.230,0.470,0.540)	(0.250,0.485,0.550)	(0.190,0.425,0.490)	(0.210,0.440,0.500)	(0.250,0.485,0.550)
A9	(0.660,0.785,0.890)	(0.690,0.815,0.910)	(0.645,0.770,0.880)	(0.645,0.770,0.880)	(0.575,0.710,0.840)
A10	(0.550,0.680,0.810)	(0.605,0.725,0.830)	(0.530,0.665,0.800)	(0.570,0.695,0.820)	(0.555,0.680,0.800)
A11	(0.170,0.305,0.440)	(0.240,0.380,0.520)	(0.340,0.485,0.630)	(0.320,0.470,0.620)	(0.220,0.365,0.510)
A12	(0.555,0.725,0.795)	(0.575,0.710,0.830)	(0.485,0.635,0.780)	(0.560,0.695,0.820)	(0.570,0.710,0.840)
A13	(0.250,0.455,0.575)	(0.290,0.485,0.595)	(0.290,0.485,0.595)	(0.250,0.455,0.575)	(0.260,0.440,0.535)
	C22	C23	C24	C25	C31
A1	(0.595,0.725,0.840)	(0.625,0.755,0.870)	(0.580,0.710,0.840)	(0.620,0.740,0.860)	(0.205,0.530,0.425)
A2	(0.500,0.635,0.770)	(0.480,0.620,0.760)	(0.510,0.650,0.790)	(0.160,0.320,0.395)	(0.470,0.635,0.715)
A3	(0.460,0.635,0.725)	(0.450,0.590,0.730)	(0.420,0.605,0.705)	(0.170,0.305,0.440)	(0.410,0.575,0.740)
A4	(0.270,0.440,0.525)	(0.230,0.380,0.530)	(0.250,0.455,0.575)	(0.160,0.290,0.420)	(0.320,0.470,0.620)
A5	(0.510,0.650,0.780)	(0.570,0.695,0.810)	(0.475,0.620,0.760)	(0.205,0.320,0.430)	(0.570,0.695,0.810)
A6	(0.490,0.620,0.750)	(0.530,0.665,0.800)	(0.500,0.635,0.770)	(0.200,0.335,0.470)	(0.495,0.635,0.770)
A7	(0.510,0.665,0.810)	(0.650,0.770,0.880)	(0.650,0.770,0.880)	(0.345,0.470,0.590)	(0.705,0.815,0.910)
A8	(0.160,0.335,0.425)	(0.180,0.365,0.465)	(0.300,0.485,0.585)	(0.080,0.395,0.285)	(0.290,0.485,0.595)
A9	(0.530,0.665,0.790)	(0.590,0.725,0.850)	(0.590,0.725,0.850)	(0.140,0.500,0.350)	(0.640,0.770,0.870)
A10	(0.560,0.680,0.800)	(0.595,0.710,0.820)	(0.595,0.710,0.820)	(0.230,0.365,0.500)	(0.585,0.710,0.830)
A11	(0.210,0.395,0.495)	(0.260,0.425,0.590)	(0.240,0.440,0.555)	(0.200,0.335,0.470)	(0.240,0.410,0.580)
A12	(0.580,0.710,0.830)	(0.565,0.695,0.820)	(0.530,0.665,0.790)	(0.255,0.425,0.505)	(0.515,0.635,0.750)
A13	(0.250,0.425,0.515)	(0.250,0.455,0.575)	(0.330,0.515,0.615)	(0.230,0.365,0.500)	(0.250,0.425,0.600)

	C32	C33	C41	C42	C43
A1	(0.520,0.695,0.775)	(0.490,0.635,0.770)	(0.550,0.680,0.800)	(0.565,0.710,0.840)	(0.385,0.560,0.730)
A2	(0.390,0.575,0.675)	(0.520,0.650,0.780)	(0.450,0.605,0.760)	(0.360,0.530,0.700)	(0.440,0.605,0.770)
A3	(0.320,0.485,0.650)	(0.370,0.515,0.660)	(0.320,0.485,0.650)	(0.400,0.560,0.720)	(0.280,0.455,0.630)
A4	(0.320,0.470,0.620)	(0.320,0.470,0.620)	(0.330,0.485,0.640)	(0.310,0.470,0.630)	(0.330,0.485,0.640)
A5	(0.570,0.695,0.810)	(0.585,0.710,0.820)	(0.555,0.695,0.830)	(0.570,0.710,0.840)	(0.595,0.725,0.850)
A6	(0.500,0.635,0.770)	(0.200,0.335,0.470)	(0.495,0.635,0.770)	(0.480,0.620,0.760)	(0.440,0.590,0.740)
A7	(0.660,0.785,0.890)	(0.705,0.815,0.910)	(0.625,0.755,0.870)	(0.705,0.815,0.910)	(0.645,0.770,0.880)
A8	(0.360,0.530,0.615)	(0.370,0.545,0.635)	(0.320,0.500,0.595)	(0.280,0.470,0.575)	(0.290,0.485,0.595)
A9	(0.565,0.695,0.820)	(0.565,0.695,0.820)	(0.520,0.665,0.800)	(0.565,0.695,0.820)	(0.585,0.710,0.830)
A10	(0.500,0.635,0.770)	(0.390,0.560,0.730)	(0.560,0.695,0.830)	(0.500,0.650,0.800)	(0.615,0.740,0.860)
A11	(0.230,0.395,0.560)	(0.250,0.425,0.600)	(0.270,0.440,0.610)	(0.240,0.395,0.550)	(0.220,0.380,0.540)
A12	(0.515,0.650,0.780)	(0.490,0.620,0.750)	(0.555,0.695,0.830)	(0.485,0.635,0.780)	(0.555,0.695,0.830)
A13	(0.310,0.500,0.605)	(0.290,0.485,0.595)	(0.310,0.500,0.605)	(0.360,0.500,0.640)	(0.480,0.605,0.730)

	C44	C51	C52	C53
A1	(0.550,0.695,0.830)	(0.385,0.545,0.700)	(0.550,0.695,0.830)	(0.385,0.545,0.700)
A2	(0.540,0.680,0.820)	(0.320,0.485,0.650)	(0.440,0.605,0.770)	(0.540,0.680,0.820)

	C44	C51	C52	C53
A3	(0.420,0.560,0.700)	(0.320,0.485,0.650)	(0.320,0.485,0.650)	(0.400,0.560,0.720)
A4	(0.380,0.530,0.680)	(0.310,0.470,0.630)	(0.380,0.530,0.680)	(0.310,0.470,0.630)
A5	(0.430,0.590,0.750)	(0.550,0.680,0.810)	(0.530,0.665,0.800)	(0.595,0.725,0.850)
A6	(0.375,0.545,0.710)	(0.400,0.560,0.720)	(0.460,0.605,0.750)	(0.440,0.590,0.740)
A7	(0.645,0.770,0.880)	(0.620,0.755,0.870)	(0.660,0.785,0.890)	(0.665,0.785,0.890)
A8	(0.320,0.500,0.595)	(0.280,0.470,0.575)	(0.290,0.485,0.595)	(0.360,0.530,0.615)
A9	(0.585,0.710,0.830)	(0.535,0.665,0.790)	(0.565,0.695,0.820)	(0.485,0.635,0.780)
A10	(0.560,0.695,0.830)	(0.500,0.650,0.800)	(0.615,0.740,0.860)	(0.580,0.710,0.840)
A11	(0.350,0.500,0.650)	(0.250,0.425,0.600)	(0.270,0.440,0.610)	(0.240,0.395,0.550)
A12	(0.550,0.680,0.790)	(0.515,0.650,0.780)	(0.485,0.635,0.780)	(0.490,0.620,0.750)
A13	(0.370,0.545,0.635)	(0.320,0.515,0.625)	(0.480,0.605,0.730)	(0.320,0.515,0.625)

**Appendix I**

The Fuzzy Theoretical Evaluation Matrix ( $\tilde{T}_p$ )

	C11	C12	C13	C14	C21
A1	(0.016,0.016,0.016)	(0.008,0.008,0.008)	(0.007,0.007,0.007)	(0.005,0.005,0.005)	(0.003,0.003,0.003)
A2	(0.016,0.016,0.016)	(0.008,0.008,0.008)	(0.007,0.007,0.007)	(0.005,0.005,0.005)	(0.003,0.003,0.003)
A3	(0.016,0.016,0.016)	(0.008,0.008,0.008)	(0.007,0.007,0.007)	(0.005,0.005,0.005)	(0.003,0.003,0.003)
A4	(0.016,0.016,0.016)	(0.008,0.008,0.008)	(0.007,0.007,0.007)	(0.005,0.005,0.005)	(0.003,0.003,0.003)
A5	(0.016,0.016,0.016)	(0.008,0.008,0.008)	(0.007,0.007,0.007)	(0.005,0.005,0.005)	(0.003,0.003,0.003)
A6	(0.016,0.016,0.016)	(0.008,0.008,0.008)	(0.007,0.007,0.007)	(0.005,0.005,0.005)	(0.003,0.003,0.003)
A7	(0.016,0.016,0.016)	(0.008,0.008,0.008)	(0.007,0.007,0.007)	(0.005,0.005,0.005)	(0.003,0.003,0.003)
A8	(0.016,0.016,0.016)	(0.008,0.008,0.008)	(0.007,0.007,0.007)	(0.005,0.005,0.005)	(0.003,0.003,0.003)
A9	(0.016,0.016,0.016)	(0.008,0.008,0.008)	(0.007,0.007,0.007)	(0.005,0.005,0.005)	(0.003,0.003,0.003)
A10	(0.016,0.016,0.016)	(0.008,0.008,0.008)	(0.007,0.007,0.007)	(0.005,0.005,0.005)	(0.003,0.003,0.003)
A11	(0.016,0.016,0.016)	(0.008,0.008,0.008)	(0.007,0.007,0.007)	(0.005,0.005,0.005)	(0.003,0.003,0.003)
A12	(0.016,0.016,0.016)	(0.008,0.008,0.008)	(0.007,0.007,0.007)	(0.005,0.005,0.005)	(0.003,0.003,0.003)
A13	(0.016,0.016,0.016)	(0.008,0.008,0.008)	(0.007,0.007,0.007)	(0.005,0.005,0.005)	(0.003,0.003,0.003)

	C22	C23	C24	C25	C31
A1	(0.003,0.003,0.003)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.010,0.010,0.010)
A2	(0.003,0.003,0.003)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.010,0.010,0.010)
A3	(0.003,0.003,0.003)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.010,0.010,0.010)
A4	(0.003,0.003,0.003)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.010,0.010,0.010)
A5	(0.003,0.003,0.003)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.010,0.010,0.010)
A6	(0.003,0.003,0.003)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.010,0.010,0.010)
A7	(0.003,0.003,0.003)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.010,0.010,0.010)
A8	(0.003,0.003,0.003)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.010,0.010,0.010)
A9	(0.003,0.003,0.003)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.010,0.010,0.010)
A10	(0.003,0.003,0.003)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.010,0.010,0.010)

	C22	C23	C24	C25	C31
A11	(0.003,0.003,0.003)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.010,0.010,0.010)
A12	(0.003,0.003,0.003)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.010,0.010,0.010)
A13	(0.003,0.003,0.003)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.010,0.010,0.010)

	C32	C33	C41	C42	C43
A1	(0.004,0.004,0.004)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)
A2	(0.004,0.004,0.004)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)
A3	(0.004,0.004,0.004)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)
A4	(0.004,0.004,0.004)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)
A5	(0.004,0.004,0.004)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)
A6	(0.004,0.004,0.004)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)
A7	(0.004,0.004,0.004)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)
A8	(0.004,0.004,0.004)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)
A9	(0.004,0.004,0.004)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)
A10	(0.004,0.004,0.004)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)
A11	(0.004,0.004,0.004)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)
A12	(0.004,0.004,0.004)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)
A13	(0.004,0.004,0.004)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)	(0.002,0.002,0.002)

	C44	C51	C52	C53
A1	(0.002,0.002,0.002)	(0.003,0.003,0.003)	(0.001,0.001,0.001)	(0.001,0.001,0.001)
A2	(0.002,0.002,0.002)	(0.003,0.003,0.003)	(0.001,0.001,0.001)	(0.001,0.001,0.001)
A3	(0.002,0.002,0.002)	(0.003,0.003,0.003)	(0.001,0.001,0.001)	(0.001,0.001,0.001)
A4	(0.002,0.002,0.002)	(0.003,0.003,0.003)	(0.001,0.001,0.001)	(0.001,0.001,0.001)
A5	(0.002,0.002,0.002)	(0.003,0.003,0.003)	(0.001,0.001,0.001)	(0.001,0.001,0.001)
A6	(0.002,0.002,0.002)	(0.003,0.003,0.003)	(0.001,0.001,0.001)	(0.001,0.001,0.001)
A7	(0.002,0.002,0.002)	(0.003,0.003,0.003)	(0.001,0.001,0.001)	(0.001,0.001,0.001)
A8	(0.002,0.002,0.002)	(0.003,0.003,0.003)	(0.001,0.001,0.001)	(0.001,0.001,0.001)
A9	(0.002,0.002,0.002)	(0.003,0.003,0.003)	(0.001,0.001,0.001)	(0.001,0.001,0.001)
A10	(0.002,0.002,0.002)	(0.003,0.003,0.003)	(0.001,0.001,0.001)	(0.001,0.001,0.001)
A11	(0.002,0.002,0.002)	(0.003,0.003,0.003)	(0.001,0.001,0.001)	(0.001,0.001,0.001)
A12	(0.002,0.002,0.002)	(0.003,0.003,0.003)	(0.001,0.001,0.001)	(0.001,0.001,0.001)
A13	(0.002,0.002,0.002)	(0.003,0.003,0.003)	(0.001,0.001,0.001)	(0.001,0.001,0.001)

**Appendix J**

Normalized Matrix

	C11	C12	C13	C14
A1	(0.165, 0.197, 0.225)	(0.172, 0.203, 0.228)	(0.152, 0.186, 0.218)	(0.187, 0.216, 0.238)
A2	(0.110, 0.147, 0.184)	(0.106, 0.146, 0.185)	(0.128, 0.163, 0.197)	(0.120, 0.159, 0.197)
A3	(0.066, 0.116, 0.144)	(0.068, 0.119, 0.148)	(0.092, 0.143, 0.173)	(0.092, 0.143, 0.173)

	<b>C11</b>	<b>C12</b>	<b>C13</b>	<b>C14</b>
<b>A4</b>	(0.097, 0.143, 0.167)	(0.081, 0.130, 0.158)	(0.077, 0.128, 0.157)	(0.072, 0.124, 0.155)
<b>A5</b>	(0.149, 0.181, 0.209)	(0.136, 0.168, 0.200)	(0.122, 0.159, 0.195)	(0.122, 0.159, 0.195)
<b>A6</b>	(0.142, 0.177, 0.209)	(0.137, 0.172, 0.205)	(0.136, 0.170, 0.202)	(0.129, 0.166, 0.202)
<b>A7</b>	(0.171, 0.200, 0.227)	(0.155, 0.187, 0.218)	(0.180, 0.209, 0.233)	(0.131, 0.170, 0.207)
<b>A8</b>	(0.059, 0.120, 0.138)	(0.063, 0.123, 0.139)	(0.049, 0.109, 0.125)	(0.054, 0.113, 0.128)
<b>A9</b>	(0.168, 0.200, 0.227)	(0.175, 0.206, 0.230)	(0.165, 0.197, 0.225)	(0.165, 0.197, 0.225)
<b>A10</b>	(0.140, 0.174, 0.207)	(0.153, 0.184, 0.210)	(0.136, 0.170, 0.205)	(0.146, 0.178, 0.210)
<b>A11</b>	(0.043, 0.078, 0.112)	(0.061, 0.096, 0.132)	(0.087, 0.124, 0.161)	(0.082, 0.120, 0.159)
<b>A12</b>	(0.142, 0.185, 0.203)	(0.146, 0.180, 0.210)	(0.124, 0.163, 0.200)	(0.143, 0.178, 0.210)
<b>A13</b>	(0.064, 0.116, 0.147)	(0.073, 0.123, 0.151)	(0.074, 0.124, 0.152)	(0.064, 0.116, 0.147)

	<b>C21</b>	<b>C22</b>	<b>C23</b>	<b>C24</b>
<b>A1</b>	(0.181, 0.210, 0.235)	(0.155, 0.188, 0.218)	(0.167, 0.201, 0.232)	(0.149, 0.183, 0.216)
<b>A2</b>	(0.114, 0.152, 0.191)	(0.142, 0.177, 0.210)	(0.133, 0.169, 0.205)	(0.124, 0.160, 0.196)
<b>A3</b>	(0.103, 0.152, 0.179)	(0.114, 0.161, 0.186)	(0.123, 0.169, 0.193)	(0.116, 0.152, 0.188)
<b>A4</b>	(0.072, 0.125, 0.156)	(0.083, 0.134, 0.162)	(0.072, 0.117, 0.140)	(0.059, 0.098, 0.136)
<b>A5</b>	(0.128, 0.164, 0.199)	(0.123, 0.161, 0.197)	(0.136, 0.173, 0.208)	(0.147, 0.179, 0.208)
<b>A6</b>	(0.135, 0.172, 0.206)	(0.142, 0.173, 0.203)	(0.131, 0.165, 0.200)	(0.136, 0.171, 0.206)
<b>A7</b>	(0.154, 0.187, 0.219)	(0.123, 0.165, 0.205)	(0.136, 0.177, 0.216)	(0.167, 0.198, 0.226)
<b>A8</b>	(0.065, 0.125, 0.142)	(0.055, 0.114, 0.130)	(0.043, 0.089, 0.113)	(0.046, 0.094, 0.120)
<b>A9</b>	(0.148, 0.183, 0.217)	(0.143, 0.180, 0.216)	(0.141, 0.177, 0.211)	(0.152, 0.187, 0.219)
<b>A10</b>	(0.143, 0.175, 0.206)	(0.149, 0.180, 0.210)	(0.149, 0.181, 0.213)	(0.153, 0.183, 0.211)
<b>A11</b>	(0.057, 0.094, 0.132)	(0.060, 0.095, 0.130)	(0.056, 0.105, 0.132)	(0.067, 0.109, 0.152)
<b>A12</b>	(0.147, 0.183, 0.217)	(0.164, 0.196, 0.226)	(0.155, 0.189, 0.221)	(0.145, 0.179, 0.211)
<b>A13</b>	(0.067, 0.114, 0.138)	(0.065, 0.118, 0.149)	(0.067, 0.113, 0.137)	(0.064, 0.117, 0.148)

	<b>C25</b>	<b>C31</b>	<b>C32</b>	<b>C33</b>
<b>A1</b>	(0.159, 0.189, 0.220)	(0.090, 0.233, 0.187)	(0.121, 0.175, 0.182)	(0.118, 0.175, 0.184)
<b>A2</b>	(0.130, 0.166, 0.202)	(0.070, 0.141, 0.174)	(0.121, 0.163, 0.184)	(0.118, 0.163, 0.185)
<b>A3</b>	(0.107, 0.155, 0.180)	(0.075, 0.134, 0.194)	(0.105, 0.148, 0.190)	(0.100, 0.143, 0.187)
<b>A4</b>	(0.064, 0.116, 0.147)	(0.070, 0.128, 0.185)	(0.082, 0.121, 0.159)	(0.084, 0.124, 0.163)
<b>A5</b>	(0.121, 0.159, 0.194)	(0.090, 0.141, 0.189)	(0.147, 0.179, 0.208)	(0.154, 0.187, 0.216)
<b>A6</b>	(0.128, 0.162, 0.197)	(0.088, 0.147, 0.207)	(0.127, 0.163, 0.198)	(0.132, 0.167, 0.203)
<b>A7</b>	(0.166, 0.197, 0.225)	(0.152, 0.207, 0.260)	(0.181, 0.209, 0.234)	(0.174, 0.206, 0.234)
<b>A8</b>	(0.077, 0.124, 0.150)	(0.035, 0.174, 0.125)	(0.075, 0.125, 0.153)	(0.089, 0.139, 0.167)
<b>A9</b>	(0.151, 0.185, 0.217)	(0.062, 0.220, 0.154)	(0.165, 0.198, 0.224)	(0.149, 0.183, 0.216)
<b>A10</b>	(0.152, 0.182, 0.210)	(0.101, 0.161, 0.220)	(0.150, 0.182, 0.213)	(0.145, 0.187, 0.206)
<b>A11</b>	(0.061, 0.113, 0.142)	(0.088, 0.147, 0.207)	(0.062, 0.105, 0.149)	(0.058, 0.112, 0.143)
<b>A12</b>	(0.136, 0.170, 0.202)	(0.112, 0.187, 0.222)	(0.132, 0.163, 0.193)	(0.128, 0.171, 0.191)
<b>A13</b>	(0.084, 0.132, 0.157)	(0.101, 0.161, 0.220)	(0.064, 0.109, 0.154)	(0.060, 0.116, 0.149)

	<b>C41</b>	<b>C42</b>	<b>C43</b>	<b>C44</b>
<b>A1</b>	(0.137, 0.183, 0.204)	(0.129, 0.167, 0.203)	(0.142, 0.176, 0.207)	(0.148, 0.186, 0.220)
<b>A2</b>	(0.102, 0.151, 0.177)	(0.137, 0.171, 0.206)	(0.116, 0.156, 0.196)	(0.094, 0.139, 0.183)
<b>A3</b>	(0.084, 0.127, 0.171)	(0.098, 0.136, 0.174)	(0.083, 0.125, 0.168)	(0.105, 0.146, 0.188)
<b>A4</b>	(0.087, 0.127, 0.168)	(0.082, 0.124, 0.166)	(0.085, 0.125, 0.165)	(0.089, 0.131, 0.173)
<b>A5</b>	(0.146, 0.183, 0.218)	(0.150, 0.187, 0.222)	(0.154, 0.187, 0.220)	(0.143, 0.178, 0.212)
<b>A6</b>	(0.126, 0.163, 0.200)	(0.116, 0.156, 0.195)	(0.097, 0.141, 0.184)	(0.105, 0.146, 0.188)
<b>A7</b>	(0.185, 0.214, 0.239)	(0.165, 0.199, 0.229)	(0.182, 0.211, 0.235)	(0.169, 0.201, 0.230)
<b>A8</b>	(0.095, 0.139, 0.162)	(0.098, 0.144, 0.167)	(0.083, 0.129, 0.154)	(0.073, 0.123, 0.150)
<b>A9</b>	(0.148, 0.183, 0.215)	(0.137, 0.175, 0.211)	(0.146, 0.180, 0.212)	(0.153, 0.186, 0.217)
<b>A10</b>	(0.131, 0.167, 0.202)	(0.103, 0.148, 0.193)	(0.145, 0.180, 0.215)	(0.131, 0.170, 0.209)
<b>A11</b>	(0.060, 0.104, 0.147)	(0.092, 0.132, 0.171)	(0.065, 0.110, 0.155)	(0.071, 0.115, 0.160)
<b>A12</b>	(0.137, 0.171, 0.202)	(0.137, 0.171, 0.203)	(0.142, 0.176, 0.204)	(0.135, 0.170, 0.204)
<b>A13</b>	(0.081, 0.131, 0.159)	(0.076, 0.128, 0.157)	(0.080, 0.129, 0.156)	(0.094, 0.131, 0.167)

	<b>C51</b>	<b>C52</b>	<b>C53</b>
<b>A1</b>	(0.102, 0.148, 0.193)	(0.143, 0.181, 0.216)	(0.102, 0.144, 0.186)
<b>A2</b>	(0.116, 0.160, 0.204)	(0.141, 0.177, 0.213)	(0.085, 0.129, 0.172)
<b>A3</b>	(0.074, 0.120, 0.167)	(0.109, 0.146, 0.182)	(0.085, 0.129, 0.172)
<b>A4</b>	(0.103, 0.144, 0.185)	(0.081, 0.122, 0.164)	(0.101, 0.140, 0.180)
<b>A5</b>	(0.114, 0.156, 0.198)	(0.143, 0.177, 0.211)	(0.140, 0.176, 0.212)
<b>A6</b>	(0.122, 0.160, 0.198)	(0.115, 0.154, 0.193)	(0.119, 0.160, 0.199)
<b>A7</b>	(0.164, 0.200, 0.230)	(0.172, 0.204, 0.232)	(0.176, 0.208, 0.236)
<b>A8</b>	(0.077, 0.128, 0.157)	(0.094, 0.138, 0.160)	(0.090, 0.140, 0.168)
<b>A9</b>	(0.141, 0.176, 0.209)	(0.147, 0.181, 0.213)	(0.129, 0.168, 0.207)
<b>A10</b>	(0.163, 0.196, 0.227)	(0.107, 0.157, 0.186)	(0.154, 0.188, 0.223)
<b>A11</b>	(0.063, 0.104, 0.145)	(0.057, 0.099, 0.141)	(0.080, 0.125, 0.170)
<b>A12</b>	(0.128, 0.168, 0.206)	(0.128, 0.161, 0.195)	(0.147, 0.184, 0.220)
<b>A13</b>	(0.127, 0.160, 0.193)	(0.096, 0.142, 0.165)	(0.085, 0.136, 0.166)

## Appendix K

Real Evaluation Matrix ( $\tilde{T}_r$ ).

	<b>C11</b>	<b>C12</b>	<b>C13</b>	<b>C14</b>
<b>A1</b>	(0.003, 0.003, 0.003)	(0.001, 0.002, 0.002)	(0.001, 0.001, 0.001)	(0.001, 0.001, 0.001)
<b>A2</b>	(0.002, 0.002, 0.003)	(0.001, 0.001, 0.001)	(0.001, 0.001, 0.001)	(0.001, 0.001, 0.001)
<b>A3</b>	(0.001, 0.002, 0.002)	(0.001, 0.001, 0.001)	(0.001, 0.001, 0.001)	(0.000, 0.001, 0.001)
<b>A4</b>	(0.002, 0.002, 0.003)	(0.001, 0.001, 0.001)	(0.001, 0.001, 0.001)	(0.000, 0.001, 0.001)
<b>A5</b>	(0.002, 0.003, 0.003)	(0.001, 0.001, 0.002)	(0.001, 0.001, 0.001)	(0.001, 0.001, 0.001)
<b>A6</b>	(0.002, 0.003, 0.003)	(0.001, 0.001, 0.002)	(0.001, 0.001, 0.001)	(0.001, 0.001, 0.001)

	<b>C11</b>	<b>C12</b>	<b>C13</b>	<b>C14</b>
<b>A7</b>	(0.003, 0.003, 0.004)	(0.001, 0.002, 0.002)	(0.001, 0.001, 0.002)	(0.001, 0.001, 0.001)
<b>A8</b>	(0.001, 0.002, 0.002)	(0.001, 0.001, 0.001)	(0.000, 0.001, 0.001)	(0.000, 0.001, 0.001)
<b>A9</b>	(0.003, 0.003, 0.004)	(0.001, 0.002, 0.002)	(0.001, 0.001, 0.002)	(0.001, 0.001, 0.001)
<b>A10</b>	(0.002, 0.003, 0.003)	(0.001, 0.001, 0.002)	(0.001, 0.001, 0.001)	(0.001, 0.001, 0.001)
<b>A11</b>	(0.001, 0.001, 0.002)	(0.000, 0.001, 0.001)	(0.001, 0.001, 0.001)	(0.000, 0.001, 0.001)
<b>A12</b>	(0.002, 0.003, 0.003)	(0.001, 0.001, 0.002)	(0.001, 0.001, 0.001)	(0.001, 0.001, 0.001)
<b>A13</b>	(0.001, 0.002, 0.002)	(0.001, 0.001, 0.001)	(0.001, 0.001, 0.001)	(0.000, 0.001, 0.001)

	<b>C21</b>	<b>C22</b>	<b>C23</b>	<b>C24</b>
<b>A1</b>	(0.000, 0.001, 0.001)	(0.000, 0.001, 0.001)	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)
<b>A2</b>	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.001)	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)
<b>A3</b>	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.001)	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)
<b>A4</b>	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)
<b>A5</b>	(0.000, 0.000, 0.001)	(0.000, 0.000, 0.001)	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)
<b>A6</b>	(0.000, 0.000, 0.001)	(0.000, 0.000, 0.001)	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)
<b>A7</b>	(0.000, 0.000, 0.001)	(0.000, 0.000, 0.001)	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)
<b>A8</b>	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)
<b>A9</b>	(0.000, 0.000, 0.001)	(0.000, 0.001, 0.001)	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)
<b>A10</b>	(0.000, 0.000, 0.001)	(0.000, 0.001, 0.001)	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)
<b>A11</b>	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)
<b>A12</b>	(0.000, 0.000, 0.001)	(0.000, 0.001, 0.001)	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)
<b>A13</b>	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)	(0.000, 0.000, 0.000)

	<b>C25</b>	<b>C31</b>	<b>C32</b>	<b>C33</b>
<b>A1</b>	(0.000, 0.000, 0.000)	(0.001, 0.002, 0.002)	(0.001, 0.001, 0.001)	(0.000, 0.000, 0.000)
<b>A2</b>	(0.000, 0.000, 0.000)	(0.001, 0.001, 0.002)	(0.001, 0.001, 0.001)	(0.000, 0.000, 0.000)
<b>A3</b>	(0.000, 0.000, 0.000)	(0.001, 0.001, 0.002)	(0.000, 0.001, 0.001)	(0.000, 0.000, 0.000)
<b>A4</b>	(0.000, 0.000, 0.000)	(0.001, 0.001, 0.002)	(0.000, 0.001, 0.001)	(0.000, 0.000, 0.000)
<b>A5</b>	(0.000, 0.000, 0.000)	(0.001, 0.001, 0.002)	(0.001, 0.001, 0.001)	(0.000, 0.000, 0.001)
<b>A6</b>	(0.000, 0.000, 0.000)	(0.001, 0.001, 0.002)	(0.001, 0.001, 0.001)	(0.000, 0.000, 0.000)
<b>A7</b>	(0.000, 0.000, 0.000)	(0.002, 0.002, 0.003)	(0.001, 0.001, 0.001)	(0.000, 0.000, 0.001)
<b>A8</b>	(0.000, 0.000, 0.000)	(0.000, 0.002, 0.001)	(0.000, 0.001, 0.001)	(0.000, 0.000, 0.000)
<b>A9</b>	(0.000, 0.000, 0.000)	(0.001, 0.002, 0.002)	(0.001, 0.001, 0.001)	(0.000, 0.000, 0.001)
<b>A10</b>	(0.000, 0.000, 0.000)	(0.001, 0.002, 0.002)	(0.001, 0.001, 0.001)	(0.000, 0.000, 0.000)
<b>A11</b>	(0.000, 0.000, 0.000)	(0.001, 0.001, 0.002)	(0.000, 0.000, 0.001)	(0.000, 0.000, 0.000)
<b>A12</b>	(0.000, 0.000, 0.000)	(0.001, 0.002, 0.002)	(0.001, 0.001, 0.001)	(0.000, 0.000, 0.000)
<b>A13</b>	(0.000, 0.000, 0.000)	(0.001, 0.002, 0.002)	(0.000, 0.000, 0.001)	(0.000, 0.000, 0.000)

	C41	C42	C43	C44
A1	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A2	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A3	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A4	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A5	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A6	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A7	(0.000,0.000,0.001)	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A8	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A9	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A10	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A11	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A12	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A13	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)	(0.000,0.000,0.000)

	C51	C52	C53
A1	(0.000,0.001,0.001)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A2	(0.000,0.001,0.001)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A3	(0.000,0.000,0.001)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A4	(0.000,0.001,0.001)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A5	(0.000,0.001,0.001)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A6	(0.000,0.001,0.001)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A7	(0.001,0.001,0.001)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A8	(0.000,0.001,0.001)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A9	(0.000,0.001,0.001)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A10	(0.001,0.001,0.001)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A11	(0.000,0.001,0.001)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A12	(0.000,0.001,0.001)	(0.000,0.000,0.000)	(0.000,0.000,0.000)
A13	(0.000,0.001,0.001)	(0.000,0.000,0.000)	(0.000,0.000,0.000)

## Appendix L

### Total Gap Matrix

	C11	C12	C13	C14	C21	C22	C23	C24	C25	C31	C32	C33
A1	0,013	0,007	0,006	0,004	0,002	0,002	0,002	0,001	0,001	0,009	0,004	0,002
A2	0,014	0,007	0,006	0,005	0,002	0,002	0,002	0,001	0,001	0,009	0,004	0,002
A3	0,014	0,007	0,006	0,005	0,002	0,002	0,002	0,001	0,002	0,009	0,004	0,002
A4	0,014	0,007	0,006	0,005	0,002	0,003	0,002	0,001	0,002	0,009	0,004	0,002
A5	0,013	0,007	0,006	0,005	0,002	0,002	0,002	0,001	0,002	0,009	0,004	0,002
A6	0,013	0,007	0,006	0,005	0,002	0,002	0,002	0,001	0,001	0,009	0,004	0,002
A7	0,013	0,007	0,006	0,005	0,002	0,002	0,002	0,001	0,001	0,008	0,003	0,002

<b>A8</b>	0,014	0,007	0,006	0,005	0,002	0,003	0,002	0,001	0,002	0,009	0,004	0,002
<b>A9</b>	0,013	0,007	0,006	0,004	0,002	0,002	0,002	0,001	0,001	0,009	0,004	0,002
<b>A10</b>	0,013	0,007	0,006	0,005	0,002	0,002	0,002	0,001	0,001	0,009	0,004	0,002
<b>A11</b>	0,015	0,007	0,006	0,005	0,002	0,003	0,002	0,001	0,002	0,009	0,004	0,002
<b>A12</b>	0,013	0,007	0,006	0,005	0,002	0,002	0,002	0,001	0,001	0,009	0,004	0,002
<b>A13</b>	0,014	0,007	0,006	0,005	0,002	0,003	0,002	0,001	0,002	0,009	0,004	0,002

	<b>C41</b>	<b>C42</b>	<b>C43</b>	<b>C44</b>	<b>C51</b>	<b>C52</b>	<b>C53</b>
<b>A1</b>	0,002	0,002	0,001	0,002	0,002	0,001	0,001
<b>A2</b>	0,002	0,002	0,002	0,002	0,002	0,001	0,001
<b>A3</b>	0,002	0,002	0,002	0,002	0,002	0,001	0,001
<b>A4</b>	0,002	0,002	0,002	0,002	0,002	0,001	0,001
<b>A5</b>	0,002	0,002	0,001	0,002	0,002	0,001	0,001
<b>A6</b>	0,002	0,002	0,002	0,002	0,002	0,001	0,001
<b>A7</b>	0,002	0,002	0,001	0,002	0,002	0,001	0,001
<b>A8</b>	0,002	0,002	0,002	0,002	0,002	0,001	0,001
<b>A9</b>	0,002	0,002	0,001	0,002	0,002	0,001	0,001
<b>A10</b>	0,002	0,002	0,001	0,002	0,002	0,001	0,001
<b>A11</b>	0,002	0,002	0,002	0,002	0,002	0,001	0,001
<b>A12</b>	0,002	0,002	0,001	0,002	0,002	0,001	0,001
<b>A13</b>	0,002	0,002	0,002	0,002	0,002	0,001	0,001

### Appendix M

Sensitivity Analysis Scenarios: Alternative School Scores Calculated According to the F-MAIRCA Method

	<b>OR</b>	<b>S1</b>	<b>S2</b>	<b>S3</b>	<b>S4</b>	<b>S5</b>	<b>S6</b>	<b>S7</b>	<b>S8</b>	<b>S9</b>
<b>A1</b>	0,0626	0,0628	0,0629	0,0629	0,0629	0,0630	0,0630	0,0627	0,0627	0,0626
<b>A2</b>	0,0652	0,0653	0,0653	0,0653	0,0653	0,0653	0,0653	0,0653	0,0653	0,0653
<b>A3</b>	0,0668	0,0669	0,0669	0,0669	0,0668	0,0668	0,0667	0,0670	0,0670	0,0671
<b>A4</b>	0,0671	0,0673	0,0673	0,0673	0,0673	0,0673	0,0673	0,0673	0,0673	0,0673
<b>A5</b>	0,0640	0,0641	0,0641	0,0641	0,0641	0,0641	0,0641	0,0641	0,0641	0,0641
<b>A6</b>	0,0641	0,0643	0,0643	0,0644	0,0644	0,0644	0,0644	0,0643	0,0642	0,0642
<b>A7</b>	0,0617	0,0618	0,0618	0,0618	0,0618	0,0618	0,0618	0,0618	0,0618	0,0619
<b>A8</b>	0,0684	0,0685	0,0685	0,0685	0,0684	0,0684	0,0684	0,0686	0,0686	0,0686
<b>A9</b>	0,0626	0,0628	0,0628	0,0629	0,0629	0,0630	0,0630	0,0627	0,0626	0,0626
<b>A10</b>	0,0634	0,0635	0,0635	0,0635	0,0636	0,0636	0,0636	0,0635	0,0635	0,0635
<b>A11</b>	0,0686	0,0687	0,0686	0,0686	0,0686	0,0685	0,0685	0,0687	0,0688	0,0688
<b>A12</b>	0,0634	0,0636	0,0636	0,0636	0,0636	0,0636	0,0636	0,0636	0,0636	0,0636
<b>A13</b>	0,0674	0,0675	0,0675	0,0675	0,0674	0,0674	0,0674	0,0676	0,0676	0,0677
	<b>S10</b>	<b>S11</b>	<b>S12</b>	<b>S13</b>	<b>S14</b>	<b>S15</b>	<b>S16</b>	<b>S17</b>	<b>S18</b>	<b>S19</b>
<b>A1</b>	0,0628	0,0628	0,0628	0,0628	0,0629	0,0632	0,0633	0,0628	0,0628	0,0628
<b>A2</b>	0,0653	0,0653	0,0652	0,0653	0,0653	0,0653	0,0652	0,0653	0,0653	0,0653
<b>A3</b>	0,0669	0,0669	0,0668	0,0670	0,0670	0,0666	0,0666	0,0670	0,0669	0,0670
<b>A4</b>	0,0673	0,0673	0,0673	0,0672	0,0672	0,0673	0,0672	0,0673	0,0673	0,0673

<b>A5</b>	0,0641	0,0641	0,0640	0,0640	0,0640	0,0642	0,0640	0,0641	0,0641	0,0641
<b>A6</b>	0,0643	0,0643	0,0643	0,0643	0,0644	0,0645	0,0646	0,0643	0,0643	0,0643
<b>A7</b>	0,0618	0,0618	0,0619	0,0618	0,0618	0,0617	0,0617	0,0619	0,0619	0,0618
<b>A8</b>	0,0685	0,0685	0,0685	0,0685	0,0684	0,0683	0,0682	0,0686	0,0686	0,0685
<b>A9</b>	0,0627	0,0628	0,0628	0,0628	0,0628	0,0632	0,0631	0,0627	0,0628	0,0627
<b>A10</b>	0,0635	0,0635	0,0635	0,0635	0,0635	0,0636	0,0635	0,0636	0,0635	0,0635
<b>A11</b>	0,0687	0,0687	0,0687	0,0687	0,0687	0,0684	0,0685	0,0687	0,0688	0,0687
<b>A12</b>	0,0636	0,0635	0,0635	0,0636	0,0636	0,0636	0,0636	0,0636	0,0636	0,0636
<b>A13</b>	0,0676	0,0676	0,0675	0,0675	0,0675	0,0672	0,0672	0,0676	0,0676	0,0676
	<b>S20</b>	<b>S21</b>	<b>S22</b>	<b>S23</b>	<b>S24</b>	<b>S25</b>	<b>S26</b>	<b>S27</b>	<b>S28</b>	<b>S29</b>
<b>A1</b>	0,0629	0,0628	0,0628	0,0628	0,0630	0,0628	0,0628	0,0627	0,0626	0,0628
<b>A2</b>	0,0654	0,0653	0,0653	0,0653	0,0655	0,0653	0,0654	0,0653	0,0653	0,0653
<b>A3</b>	0,0669	0,0670	0,0670	0,0670	0,0671	0,0670	0,0670	0,0670	0,0670	0,0670
<b>A4</b>	0,0673	0,0673	0,0673	0,0673	0,0674	0,0673	0,0672	0,0673	0,0673	0,0673
<b>A5</b>	0,0641	0,0641	0,0640	0,0641	0,0642	0,0641	0,0641	0,0641	0,0640	0,0641
<b>A6</b>	0,0643	0,0643	0,0643	0,0643	0,0644	0,0643	0,0643	0,0643	0,0642	0,0643
<b>A7</b>	0,0618	0,0618	0,0618	0,0618	0,0620	0,0618	0,0618	0,0618	0,0619	0,0618
<b>A8</b>	0,0685	0,0685	0,0685	0,0685	0,0687	0,0685	0,0685	0,0685	0,0686	0,0685
<b>A9</b>	0,0629	0,0627	0,0627	0,0627	0,0629	0,0627	0,0627	0,0627	0,0626	0,0627
<b>A10</b>	0,0636	0,0635	0,0636	0,0635	0,0637	0,0635	0,0636	0,0635	0,0635	0,0635
<b>A11</b>	0,0686	0,0687	0,0687	0,0687	0,0689	0,0687	0,0687	0,0687	0,0688	0,0687
<b>A12</b>	0,0636	0,0636	0,0636	0,0636	0,0637	0,0636	0,0636	0,0636	0,0635	0,0636
<b>A13</b>	0,0675	0,0676	0,0676	0,0676	0,0677	0,0676	0,0675	0,0676	0,0677	0,0676
	<b>S30</b>	<b>S31</b>	<b>S32</b>							
<b>A1</b>	0,0627	0,0628	0,0627							
<b>A2</b>	0,0653	0,0653	0,0653							
<b>A3</b>	0,0670	0,0670	0,0670							
<b>A4</b>	0,0673	0,0673	0,0673							
<b>A5</b>	0,0641	0,0641	0,0641							
<b>A6</b>	0,0642	0,0643	0,0643							
<b>A7</b>	0,0618	0,0618	0,0618							
<b>A8</b>	0,0686	0,0685	0,0686							
<b>A9</b>	0,0627	0,0627	0,0627							
<b>A10</b>	0,0635	0,0635	0,0635							
<b>A11</b>	0,0687	0,0687	0,0687							
<b>A12</b>	0,0636	0,0636	0,0636							
<b>A13</b>	0,0676	0,0676	0,0676							