

Predicting Future Anxiety Among Youth Based on Career Uncertainty, Social Support, and Psychological Flexibility Using CatBoost

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ABSTRACT

Objective: This study aimed to predict future anxiety among youth in Georgia based on career uncertainty, perceived social support, and psychological flexibility using the CatBoost machine-learning algorithm.

Methods and Materials: A cross-sectional predictive study was conducted among 472 young people aged 18–29 years from Georgia. Future anxiety was assessed using the Dark Future Scale, perceived social support using the Multidimensional Scale of Perceived Social Support, and psychological flexibility using the Psy-Flex; career uncertainty was assessed with a brief career uncertainty measure based on established career-decision indicators. CatBoost regression was used as the principal predictive method, with 80% of the data allocated to training and 20% to independent testing. Five-fold cross-validation was applied for hyperparameter tuning. Model performance was evaluated using the coefficient of determination (R^2), root mean squared error (RMSE), and mean absolute error (MAE). Multiple linear regression was used as a benchmark model, and SHAP analysis was employed to determine predictor importance and direction of effects.

Findings: The final CatBoost model achieved an R^2 of .63, RMSE of 3.79, and MAE of 2.93 on the independent test set, outperforming multiple linear regression, which yielded $R^2 = .49$, RMSE = 4.46, and MAE = 3.49. Career uncertainty was the strongest predictor, accounting for 33.72% of model importance, followed by psychological flexibility at 27.84% and perceived social support at 19.63%. SHAP analysis showed that higher career uncertainty increased predicted future anxiety, whereas greater psychological flexibility and stronger perceived social support reduced predicted anxiety. The adverse effect of career uncertainty was particularly pronounced when psychological flexibility or social support was low.

Conclusion: Future anxiety among Georgian youth can be predicted with substantial accuracy using a machine-learning approach, with career uncertainty emerging as the principal risk factor and psychological flexibility and social support functioning as important protective predictors.

Keywords: Future anxiety; Career uncertainty; Social support; Psychological flexibility; Youth; CatBoost; Machine learning; Georgia.

1. Introduction

The transition from adolescence to adulthood has become increasingly characterized by uncertainty, delayed role consolidation, unstable employment pathways, and heightened concern about the future. Young people are expected to make consequential decisions about education, employment, migration, relationships, and financial independence while simultaneously adapting to labor markets that are more dynamic, competitive, technologically mediated, and unpredictable than those faced by previous generations. These structural conditions have contributed to growing interest in future anxiety as a distinct psychological phenomenon involving apprehension, uncertainty, negative anticipation, and worry regarding events that have not yet occurred. Future anxiety differs from generalized distress in that its cognitive and emotional focus is directed toward anticipated threats, possible failures, and uncertainty concerning one's future life course. During emerging adulthood, these concerns may become especially salient because the individual is negotiating multiple developmental transitions while lacking stable information about the eventual outcomes of those transitions. Developmental anxiety during the transition to adulthood can therefore emerge not only from internal vulnerabilities but also from the objective ambiguity of contemporary social and economic environments (Ratner et al., 2025). Broader sociological changes have similarly intensified pressure on young adults to make numerous individualized decisions within compressed time frames, producing a paradox in which greater apparent choice may coexist with stronger subjective pressure to achieve, optimize, and avoid falling behind (Burgess et al., 2022). Evidence from the COVID-19 period further demonstrated that youth well-being is particularly sensitive to disruptions in education, employment, social relationships, and expectations concerning the future, with the consequences of such disruptions often distributed unequally across socioeconomic groups (Chua et al., 2025; Henseke et al., 2022). Accordingly, future anxiety among youth should be understood as a multidimensional response to the interaction between developmental demands, socioeconomic insecurity, subjective expectations, and the psychological resources available for coping with uncertain life trajectories.

Career development constitutes one of the most important contexts in which future anxiety may emerge. For many young adults, decisions concerning education, occupation, employability, and labor-market entry are closely linked to

broader perceptions of identity, independence, status, security, and future success. When vocational pathways become unclear, the uncertainty associated with career development can extend beyond employment concerns and shape the individual's overall perception of the future. Career uncertainty refers to a lack of clarity, confidence, or decisional commitment regarding future occupational direction and may involve difficulty selecting a career path, concern about obtaining appropriate employment, doubts about personal employability, and uncertainty about whether educational investments will translate into viable occupational opportunities. Research on young people entering contemporary labor markets increasingly indicates that career insecurity is not a transient inconvenience but a psychologically meaningful condition. Longitudinal evidence has shown that distinct profiles of early career insecurity can be identified during adolescence and that these profiles are associated with later developmental outcomes (Mauno et al., 2023). Similarly, non-adaptive school-to-work transitions have been linked with less favorable adjustment to adulthood, distorted future time perspectives, and greater internalizing and externalizing difficulties (Parola et al., 2022). Among university students, expectations concerning future careers are also closely intertwined with perceived career resources, especially under conditions of social and economic disruption (Pignault et al., 2022). These findings suggest that occupational ambiguity can function as a broader psychological signal of unpredictability, thereby increasing the likelihood that young people interpret the future as threatening rather than manageable.

The psychological significance of career uncertainty has become more pronounced as employment systems have been affected by technological transformation, automation, artificial intelligence, economic volatility, and post-pandemic restructuring. Young people preparing to enter the labor market increasingly confront concerns not only about whether they will find employment but also about whether their chosen occupation will remain viable, whether their skills will become obsolete, and whether they will be able to achieve long-term economic security. Analysis of adolescence in contemporary labor markets has emphasized that instability, uncertainty, and the emergence of artificial intelligence are reshaping the balance between educational preparation and employment expectations (Mancaniello & Lavanga, 2024). Evidence from Romanian adolescents similarly indicates that large-scale societal crises can influence career aspirations over time, demonstrating that

vocational expectations are responsive to broader social disruption rather than being determined solely by individual preferences (Hatos et al., 2025). Research on Chinese university students has also shown that employment psychology changed across different stages of pandemic control and that these changes were related to employment intentions (Zheng & Yan, 2024). In this context, career uncertainty may reasonably be expected to constitute one of the strongest proximal predictors of future anxiety because it directly concerns the individual's anticipated role in the adult social and economic system. Career resources may reduce such vulnerability by enhancing perceived control and readiness; indeed, recent evidence suggests that stronger career resources can transform the relationship between future-oriented concerns and anxiety by improving the individual's ability to perceive future possibilities as manageable rather than threatening (Boğazhyan & Ayaz, 2026).

A growing body of research directly supports the association between employment-related uncertainty and psychological distress among youth. Job-seeking graduates may experience particularly high levels of anxiety and depression when confronted with prolonged labor-market competition and unclear employment prospects (Alam et al., 2026). Similar findings among graduates indicate that psychological distress is shaped by a combination of personal, socioeconomic, and contextual factors during the transition from education to employment (Habib et al., 2025). Job-seeking anxiety has also been associated with patterns of employment preparation among undergraduate students, suggesting that anxiety may influence not only emotional well-being but also behavioral engagement with the labor market (Kim et al., 2022). Among unemployed young people with higher education, the experience of employment crisis may become integrated into subjective perceptions of self, competence, and future identity (Pelekh et al., 2022). Unemployment anxiety can additionally be connected to feelings of personal failure and attitudes toward migration, illustrating how career-related insecurity may generalize into broader life decisions (Kuzu et al., 2026). For youth experiencing extreme socioeconomic marginalization, job insecurity may even reshape the meaning and stability of the worker role itself (Soeker et al., 2026). Taken together, these findings indicate that uncertainty about work and career should not be conceptualized narrowly as an economic concern; rather, it can influence self-evaluation, social identity, perceived adulthood attainment, migration intentions, and expectations regarding one's overall future.

The experience of career-related uncertainty may also be transmitted through family, social, and informational environments. Parental job insecurity has been shown to affect emerging adults' career-related behaviors, including networking behaviors intended to manage anticipated labor-market risks (Wang & Lin, 2023). More recent evidence indicates that paternal job insecurity may shape young people's perceived employability, suggesting an intergenerational pathway through which employment instability in the family environment can influence youth expectations about their own occupational prospects (Qian, 2026). Perceptions of criticism and limited confidence may similarly contribute to fear of an uncertain future, with parental criticism being linked to career confidence through future-related fear among both students and workers (Moavero et al., 2025). In addition, contemporary youth increasingly obtain employment information through digital platforms, and employment-oriented social-media use may influence anxiety through changes in social capital and perceived risk (Liu, 2026). Such findings highlight the importance of considering career uncertainty within a broader social ecology. Young people do not evaluate their futures in isolation; rather, they interpret employment prospects through family expectations, peer comparisons, economic narratives, digital information, and perceived opportunity structures. Opportunity structures themselves can have a dual nature, simultaneously generating new possibilities and new forms of insecurity, especially during periods of societal disruption (Kovacheva & Rambla, 2023). Consequently, future anxiety may be intensified when young people perceive both high personal responsibility for achieving career success and limited control over the structural conditions determining that success.

Although career uncertainty represents a potential risk factor, perceived social support may operate as an important protective resource. Social support refers not merely to the objective presence of other people but to the perception that meaningful emotional, informational, and practical assistance is available when needed. For young adults facing uncertainty, supportive relationships may help regulate distress by providing reassurance, alternative interpretations of threatening situations, instrumental guidance, and a sense of belonging. Social support may also strengthen perceived control by allowing individuals to distribute the psychological burden of decision-making across trusted interpersonal networks. Research on adolescent anxiety during periods of crisis has consistently identified supportive family and peer relationships as important protective factors,

while social isolation, family conflict, and weakened interpersonal resources may intensify anxiety (Kara et al., 2025). In socially stressful environments, psychological outcomes are likewise shaped not only by exposure to uncertainty but also by the resources available to cope with it. For example, youth living under conditions of chronic contextual stress may display elevated anxiety and depression when environmental insecurity becomes difficult to manage (Pandey et al., 2023). In the context of school-to-work transition, social resources may therefore provide young people with emotional stability and practical knowledge that reduce the subjective threat of uncertain employment prospects. Career optimism may also be influenced by social-cognitive processes related to expectations, perceived support, and confidence regarding the transition from education to employment (ÇArkit, 2025). Accordingly, perceived social support may reduce future anxiety both directly, by buffering emotional distress, and indirectly, by helping young adults interpret career ambiguity as a challenge that can be managed rather than as evidence of inevitable future failure.

Psychological flexibility constitutes another potentially important protective factor because it concerns how individuals respond internally to uncertainty, discomfort, and difficult thoughts. Psychological flexibility is generally understood as the capacity to remain in contact with present experiences, accept unwanted thoughts and emotions without excessive avoidance, maintain psychological distance from rigid cognitions, identify personally meaningful values, and continue engaging in value-consistent behavior despite discomfort. This capacity may be especially important in circumstances where uncertainty cannot be eliminated through information or planning. Career uncertainty, for example, may not always be resolved immediately because labor-market outcomes are influenced by external forces beyond an individual's control. In such circumstances, attempts to eliminate uncertainty completely may paradoxically increase rumination, cognitive fusion, avoidance, and anxiety. Evidence concerning intolerance of uncertainty supports this view. Among university students, intolerance of uncertainty has been linked to future career anxiety, with emotional processes such as fear and depression contributing to the association (Zhou et al., 2022). Psychological insecurity and cognitive fusion have also been identified as mechanisms through which socioeconomic disadvantage may contribute to internalizing problems among late adolescents (Tao et al., 2025). These findings suggest that the way young people relate to

uncertainty may be as important as the objective presence of uncertainty itself. A psychologically flexible individual may experience the same labor-market ambiguity as a less flexible peer but may be better able to tolerate distressing thoughts, avoid overidentifying with catastrophic predictions, and continue pursuing adaptive career-related action.

Future anxiety may consequently be understood as the product of both risk exposure and regulatory capacity. This perspective is supported by work examining adaptive coping with future anxiety among vulnerable youth populations, where coping processes appear central to how uncertainty is psychologically managed (Albash, 2026). Career resilience has similarly been emphasized as an important developmental resource that can prepare youth to navigate rapidly changing educational and occupational environments (Saripudin et al., 2022). Such resilience is unlikely to arise solely from knowledge of career opportunities; rather, it involves the capacity to recover from setbacks, revise plans, maintain purposeful behavior, and adapt when preferred pathways become unavailable. These processes conceptually overlap with psychological flexibility and suggest that young people's responses to uncertainty cannot be captured adequately by assessing risk factors alone. The simultaneous consideration of career uncertainty, social support, and psychological flexibility therefore provides a theoretically integrated framework in which one variable reflects a salient developmental stressor, another reflects interpersonal resources, and the third reflects intrapersonal adaptive capacity. This combination may explain meaningful variation in future anxiety beyond what would be evident from examining any single predictor independently.

Despite the growing literature on employment anxiety, career insecurity, and youth well-being, several gaps remain. First, many existing studies rely on conventional correlational or linear regression approaches that assume additive and approximately linear relationships between predictors and psychological outcomes. However, the effects of career uncertainty, social support, and psychological flexibility may not be linear. For instance, moving from very low to moderate social support may yield a larger reduction in anxiety than moving from moderate to very high support, while the adverse effect of career uncertainty may intensify disproportionately after a certain threshold. Similarly, psychological flexibility may be especially protective among individuals exposed to high uncertainty rather than exerting an identical effect across all

contexts. Second, interactions between these variables may be difficult to specify correctly in advance. A young person with high career uncertainty may experience relatively little future anxiety when psychological flexibility and social support are strong, whereas the same level of uncertainty may be highly distressing when both protective resources are weak. Contemporary evidence from the employment-transition literature increasingly points toward such interconnected risk processes, including the roles of risk perception, social capital, fear of uncertain futures, employability beliefs, and family employment insecurity (Liu, 2026; Moavero et al., 2025; Qian, 2026). Third, the majority of available evidence has been generated in specific national contexts, including China, Bangladesh, South Korea, Italy, Romania, Singapore, and other settings, while comparatively little predictive evidence is available regarding youth in Georgia. This is important because employment expectations and future anxiety are shaped by national labor-market structures, educational systems, family norms, migration opportunities, and broader socioeconomic transformations.

Machine-learning methods offer one way to address these limitations by prioritizing prediction while allowing complex nonlinear relationships and higher-order interactions to emerge from the data. CatBoost is particularly suitable for this purpose because it is a gradient-boosting algorithm capable of modeling nonlinear associations, handling categorical predictors efficiently, and achieving strong predictive performance in structured tabular datasets. Its use in psychological research can complement, rather than replace, conventional inferential approaches by answering a different question: how accurately can an outcome be predicted for previously unseen individuals, and which variables contribute most strongly to those predictions? This distinction is particularly relevant for youth mental-health research, where identifying high-risk profiles may have practical value for counseling, career services, and preventive interventions. Explainability techniques such as SHapley Additive exPlanations can further clarify the direction, magnitude, and heterogeneity of predictor contributions, thereby reducing one of the principal limitations traditionally associated with machine-learning models. In the present context, a CatBoost model can determine whether career uncertainty, social support, and psychological flexibility contribute to future anxiety in nonlinear or conditional ways and whether their combined predictive performance exceeds that of a conventional additive model. Such an approach is consistent with an

emerging understanding of youth development in which psychological outcomes are viewed as arising from interconnected systems of personal vulnerability, social resources, developmental transitions, and changing opportunity structures (Kovacheva & Rambla, 2023; Mancaniello & Lavanga, 2024).

The relevance of such predictive modeling is heightened by the broader evidence that uncertainty surrounding adulthood and employment has become a persistent rather than temporary feature of youth experience. Current cohorts are navigating labor markets marked by unstable transitions, competitive job seeking, rapid technological change, migration pressures, and continuing socioeconomic consequences of recent global crises. These conditions may amplify concerns regarding employability and personal success even among highly educated young adults, while those with fewer resources may experience compounded vulnerability. Research has shown that career concerns can influence emotional well-being, occupational behavior, migration attitudes, perceived employability, and confidence in adulthood transitions (Kim et al., 2022; Kuzu et al., 2026; Pelekh et al., 2022; Qian, 2026). At the same time, evidence concerning career resources, social relationships, resilience, coping, and flexible responding suggests that anxiety is not an inevitable consequence of uncertainty (Albash, 2026; Boğazlıyan & Ayaz, 2026; Saripudin et al., 2022). Understanding which combination of risk and protective factors best predicts future anxiety may therefore provide a more useful basis for intervention than simply documenting average levels of distress. In particular, interventions could potentially focus on increasing career clarity where possible, strengthening supportive interpersonal networks, and promoting psychological flexibility when uncertainty cannot be fully resolved.

Accordingly, the aim of the present study was to predict future anxiety among youth in Georgia from career uncertainty, perceived social support, and psychological flexibility using the CatBoost machine-learning algorithm.

2. Methods and Materials

2.1. Study Design and Participants

This study employed a cross-sectional predictive design to investigate the extent to which career uncertainty, perceived social support, and psychological flexibility could predict future anxiety among youth using the CatBoost machine-learning algorithm. The target population consisted of young people aged 18–29 years living in Georgia. A total

of 472 participants were recruited from universities, vocational education institutions, workplaces, youth organizations, and community-based online networks in Tbilisi, Kutaisi, Batumi, Rustavi, and other urban areas of Georgia. A multichannel convenience sampling approach was used to increase heterogeneity in educational, occupational, and socioeconomic backgrounds and to ensure that the sample was not restricted to university students. To be eligible for participation, individuals were required to be between 18 and 29 years of age, to have resided in Georgia for at least the preceding 12 months, to have sufficient proficiency in the Georgian language to understand the study questionnaires, and to provide informed consent for participation. Individuals who submitted substantially incomplete questionnaires or demonstrated patterned or implausibly rapid responding were excluded before the final dataset was constructed. Participants completed the measures anonymously using either an electronic survey form or a paper-and-pencil version containing the same item order and response options. Before completing the questionnaires, participants received a brief explanation of the purpose of the research, the voluntary nature of participation, confidentiality of responses, and their right to discontinue participation at any stage without penalty. No personally identifying information was collected. Instruments were administered in Georgian. For measures for which an established Georgian-language version was not available, translation was performed through forward translation by bilingual specialists, independent back-translation into English, comparison of the back-translated and original versions, and review by experts in psychology to ensure semantic and conceptual equivalence. The preliminary Georgian questionnaire package was also pilot-tested with 20 young adults who were not included in the final sample to evaluate comprehensibility, wording, and completion time. Data collection proceeded only after the wording was judged sufficiently clear and culturally appropriate. The study procedures were implemented in accordance with accepted ethical principles for research involving human participants, and informed consent was obtained from all participants before data collection.

2.2. Measures

Future anxiety, which constituted the outcome variable of the predictive model, was assessed using the Dark Future Scale developed by Zaleski, Sobol-Kwapińska, Przepiorka, and Meisner as a brief version of the original Future Anxiety

Scale. The Dark Future Scale is a five-item self-report instrument designed to assess apprehension, uncertainty, and negative expectations concerning future events and personal life circumstances. Participants indicate the degree to which each statement describes their attitude toward the future on a seven-point response scale ranging from 0, indicating that the statement is decidedly false, to 6, indicating that it is decidedly true. The items address concerns such as the persistence of current problems, anticipated life crises, deterioration of future circumstances, threats associated with broader socioeconomic changes, and possible failure to achieve personal goals. Item scores are summed to produce a total score ranging from 0 to 30, with higher scores representing greater future anxiety and more negative expectations regarding the future. The short form has demonstrated a unidimensional structure and satisfactory internal consistency in previous psychometric investigations, making it suitable for use as a concise outcome measure in multivariable and machine-learning research.

Career uncertainty, the first predictor variable, was assessed using a brief Career Uncertainty Scale based on the career-decision framework introduced by Jones. The measure evaluates the extent to which an individual lacks clarity and confidence regarding future occupational direction and career choice. The four-item operational form used in the present study assessed whether participants had a particular occupational field in mind, whether they had decided on a specific occupation they wished to enter, whether they felt comfortable with their current stage of vocational decision-making, and whether they experienced worry concerning their career choice. Responses were recorded on a five-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). Positively worded items reflecting certainty and comfort were reverse-scored so that higher overall values consistently represented greater career uncertainty. After reverse scoring, item scores were summed and averaged to obtain the participant's overall career uncertainty score. Accordingly, higher scores represented weaker occupational clarity, greater indecision, and greater uncertainty regarding future career direction. The use of a brief indicator was considered appropriate for the present predictive design because it provided a direct assessment of perceived vocational uncertainty while minimizing respondent burden in a questionnaire battery containing several psychological constructs.

Perceived social support was measured using the Multidimensional Scale of Perceived Social Support

developed by Zimet, Dahlem, Zimet, and Farley. The MSPSS contains 12 items evaluating an individual's perception of the availability and adequacy of interpersonal support received from three major sources: family, friends, and a significant other. Each dimension consists of four items, allowing both domain-specific and overall perceived social support to be evaluated. Participants rate each statement on a seven-point Likert-type scale ranging from 1 (very strongly disagree) to 7 (very strongly agree). Scores for each dimension are obtained by averaging the relevant four items, while the overall perceived social support score is calculated from all 12 items. Higher scores indicate stronger perceived access to emotional, interpersonal, and decision-related support. In the present study, the overall MSPSS score was used as the principal social-support predictor in the CatBoost model, while the family, friends, and significant-other subscale scores were retained for supplementary descriptive analyses. The scale was selected because its multidimensional conceptualization permits social support to be assessed as a perceived psychological resource rather than merely as the objective size or frequency of an individual's social network. The 12-item, three-factor form has been extensively used among adolescent and adult populations and has demonstrated satisfactory psychometric characteristics across different cultural settings.

Psychological flexibility was assessed using the Psy-Flex developed by Gloster and colleagues. Psy-Flex is a six-item self-report measure designed to provide a concise and context-sensitive assessment of psychological flexibility within the theoretical framework of Acceptance and Commitment Therapy. Its six items represent the central flexibility processes of present-moment awareness, openness to internal experiences, cognitive defusion, a stable perspective on the self, awareness of personally meaningful values, and engagement in value-consistent behavior. Participants respond with reference to their experiences during the preceding seven days using a five-point response format ranging from 1 (very rarely) to 5 (very often). Item scores are summed to produce an overall psychological flexibility score, with higher values indicating greater capacity to remain in contact with present experiences, accept difficult thoughts and emotions without excessive avoidance, maintain psychological distance from unhelpful cognitions, identify meaningful values, and engage in behavior consistent with those values despite psychological discomfort. Psy-Flex was selected because it directly assesses the presence of adaptive psychological flexibility

processes rather than inferring flexibility only from the absence of experiential avoidance. Previous psychometric investigations have supported its essentially unidimensional structure, convergent validity, and internal consistency.

2.3. Data Analysis

Data analysis was performed using Python, with the principal predictive analyses conducted through the CatBoost machine-learning framework. Before model development, the dataset was inspected for duplicate observations, missing responses, out-of-range values, and implausible response patterns. Participants with substantial missing data were excluded, whereas isolated missing values were handled within the preprocessing procedure without using information from the test set. Descriptive statistics, including mean, standard deviation, minimum, maximum, skewness, and kurtosis, were calculated for future anxiety, career uncertainty, perceived social support, and psychological flexibility. Internal consistency of the multi-item measures was evaluated using Cronbach's alpha and McDonald's omega. Pearson correlation coefficients were additionally calculated to provide a conventional description of the direction and magnitude of the bivariate relationships among the principal study variables. The dependent variable supplied to the machine-learning model was the continuous total score for future anxiety, while career uncertainty, perceived social support, and psychological flexibility constituted the principal predictor features. Age, gender, educational status, and employment status were retained as auxiliary demographic covariates so that the predictive contribution of the psychological variables could be evaluated within a more realistic model. Because CatBoost can process categorical variables directly through its ordered target-statistics approach, categorical demographic features were supplied in their original form rather than being transformed through extensive one-hot encoding. Continuous scale variables were also retained in their original metric because tree-based gradient-boosting algorithms do not require standardization for model estimation.

For predictive modeling, the complete dataset of 472 participants was randomly divided into a training set containing 80% of the observations and an independent test set containing the remaining 20%, with a fixed random seed used to ensure reproducibility. All model selection and hyperparameter optimization procedures were restricted to the training data to prevent information leakage from the test

set. Within the training set, five-fold cross-validation was used to optimize the principal CatBoost regression hyperparameters, including tree depth, learning rate, number of boosting iterations, L2 leaf regularization, and parameters controlling stochastic sampling and model complexity. Early stopping was applied where appropriate to reduce overfitting by terminating training when predictive performance on validation folds no longer improved. The final combination of hyperparameters was selected according to cross-validated root mean squared error, after which the model was refitted to the complete training dataset and evaluated once on the held-out test dataset. Predictive performance was quantified using the coefficient of determination (R^2), root mean squared error (RMSE), and mean absolute error (MAE). R^2 was interpreted as the proportion of between-participant variation in future anxiety captured by the model, whereas RMSE and MAE represented prediction error in the original metric of the future-anxiety score, with smaller values indicating better predictive accuracy. To provide a reference against which the performance of the nonlinear machine-learning model could be evaluated, a conventional multiple linear regression model using the same principal predictors was also estimated on the identical training and test partitions.

Interpretation of the CatBoost model focused on both global and participant-level predictor contributions. Model-derived feature importance was first examined to determine the relative predictive contribution of career uncertainty, social support, psychological flexibility, and the included demographic covariates. Because conventional tree-based importance statistics may not fully describe the direction or distribution of predictor effects, SHapley Additive exPlanations (SHAP) were subsequently computed for the final model. Mean absolute SHAP values were used to rank predictors according to their overall contribution to model predictions, while SHAP dependence patterns were examined to identify whether higher or lower values of career uncertainty, social support, and psychological flexibility were associated with increases or decreases in predicted future anxiety and whether the relationships demonstrated nonlinear patterns. These analyses allowed the CatBoost model to retain its capacity to detect complex associations and interactions while providing an

interpretable representation of how individual predictors contributed to estimated future anxiety. Statistical tests accompanying the preliminary descriptive and correlational analyses were evaluated at a two-sided significance level of $p < .05$, whereas interpretation of the machine-learning results emphasized out-of-sample predictive accuracy, stability across cross-validation folds, and the magnitude and consistency of feature contributions rather than null-hypothesis significance testing alone.

3. Findings and Results

The final analytical sample consisted of 472 young people aged 18–29 years from Georgia. The participants had a mean age of 23.41 years ($SD = 3.18$), indicating that the sample covered a broad range of late-adolescent and emerging-adult developmental stages. Of the total sample, 252 participants (53.39%) were women, 214 (45.34%) were men, and 6 (1.27%) identified with another gender or preferred not to indicate gender. With respect to educational status, 57 participants (12.08%) had completed secondary education and were not currently enrolled in higher education, 281 (59.53%) were undergraduate students or held a bachelor's-level qualification, 115 (24.36%) were enrolled in or had completed master's-level education, and 19 (4.03%) were studying at or had completed a doctoral or equivalent advanced level. Regarding employment status, 169 participants (35.81%) were employed either full-time or part-time, 176 (37.29%) were students who were not regularly employed, 71 (15.04%) combined education with regular employment, and 56 (11.86%) were unemployed or actively seeking employment. Participants were recruited from several geographical areas of Georgia, with the largest proportion residing in Tbilisi, followed by Batumi, Kutaisi, Rustavi, and other urban or semi-urban locations. Inspection of the raw data revealed no duplicate observations or impossible scale scores. Missing responses were limited and dispersed rather than concentrated within a particular measure or subgroup. Cases failing the predefined data-quality criteria had been excluded before formation of the final sample; therefore, all 472 participants were retained for the main descriptive, correlational, and machine-learning analyses.

Table 1*Descriptive Statistics, Internal Consistency, and Correlations Among the Main Study Variables*

Variable	M	SD	Min	Max	Skewness	Kurtosis	Cronbach's α	McDonald's ω	1	2	3	4
1. Future anxiety	16.84	6.21	1.00	30.00	0.08	-0.61	0.88	0.89	—			
2. Career uncertainty	3.17	0.91	1.00	5.00	-0.12	-0.48	0.84	0.85	.61***	—		
3. Perceived social support	4.86	1.18	1.33	7.00	-0.39	-0.42	0.92	0.92	-.44***	-.31***	—	
4. Psychological flexibility	20.73	4.52	7.00	30.00	-0.18	-0.37	0.87	0.88	-.55***	-.39***	.46***	—

As presented in Table 1, the average future-anxiety score was 16.84 (SD = 6.21) on the possible range of 0 to 30, indicating substantial interindividual variability in the extent to which participants anticipated negative or threatening future outcomes. Career uncertainty had a mean of 3.17 (SD = 0.91) on the five-point metric, suggesting that vocational indecision and ambiguity concerning future occupational direction were present at a moderate level within the sample. The mean perceived social-support score was 4.86 (SD = 1.18), indicating that participants generally perceived moderate-to-high availability of support from family members, friends, and significant others. Psychological flexibility averaged 20.73 (SD = 4.52), with scores extending across most of the potential scale range. Skewness and kurtosis coefficients were modest for all continuous variables, with absolute skewness values below 0.40 and absolute kurtosis values below 0.65, suggesting an absence of severe distributional abnormalities. Although strict normality was not required for CatBoost estimation, these distributions supported the suitability of the variables for preliminary Pearson correlational analyses. Internal consistency was satisfactory to excellent across all measures. Cronbach's alpha coefficients ranged from 0.84 for career uncertainty to 0.92 for perceived social support, while McDonald's omega coefficients ranged from 0.85 to 0.92, demonstrating that each construct was measured with

adequate reliability. The bivariate relationships were also theoretically coherent. Career uncertainty was strongly and positively associated with future anxiety, $r = .61$, $p < .001$, indicating that participants who reported greater indecision and lack of clarity regarding their occupational future also tended to report greater anxiety about the future more generally. Perceived social support was negatively associated with future anxiety, $r = -.44$, $p < .001$, suggesting that stronger perceptions of available interpersonal support were related to lower levels of future-oriented apprehension. Psychological flexibility displayed a stronger negative relationship with future anxiety, $r = -.55$, $p < .001$, indicating that participants with a greater capacity to remain open to difficult internal experiences, maintain present-focused awareness, and act consistently with valued directions tended to experience less future anxiety. Career uncertainty was also negatively associated with both social support, $r = -.31$, $p < .001$, and psychological flexibility, $r = -.39$, $p < .001$, whereas social support and psychological flexibility were positively related, $r = .46$, $p < .001$. The magnitude of the intercorrelations remained below levels typically associated with serious predictor redundancy, suggesting that the three principal psychological predictors represented related but sufficiently distinguishable sources of information for subsequent predictive modeling.

Table 2*Cross-Validated CatBoost Model Selection and Final Out-of-Sample Predictive Performance*

Model stage	Tree depth	Learning rate	Iterations	L2 regularization	Cross-validation RMSE	Cross-validation MAE	Test RMSE	Test MAE	Test R ²
Candidate model A	4	0.03	800	5	4.28	3.37	—	—	—
Candidate model B	5	0.04	900	6	4.06	3.19	—	—	—
Candidate model C	6	0.035	1,050	7	3.91	3.05	—	—	—
Candidate model D	7	0.03	1,100	8	3.98	3.11	—	—	—
Final CatBoost model	6	0.035	1,050	7	3.91	3.05	3.79	2.93	.63

The results of the model-selection procedure are shown in Table 2. Hyperparameter optimization was undertaken exclusively within the training sample by comparing alternative CatBoost configurations under five-fold cross-validation, with root mean squared error serving as the primary criterion for model selection. Candidate model A, which employed relatively shallow trees and a lower learning rate, produced a cross-validated RMSE of 4.28 and MAE of 3.37. Increasing tree depth and model complexity produced progressively better performance through candidate models B and C. Candidate model C, using a tree depth of 6, learning rate of 0.035, 1,050 boosting iterations, and an L2 leaf-regularization value of 7, yielded the lowest cross-validation error, with RMSE = 3.91 and MAE = 3.05. Increasing tree depth further in candidate model D did not improve performance, as its RMSE increased to 3.98 and MAE to 3.11, indicating that additional complexity provided no meaningful predictive gain and potentially increased susceptibility to overfitting. Candidate model C was therefore selected as the final CatBoost specification. When

refitted to the complete training dataset and evaluated on the independent 20% test partition, the final model achieved an RMSE of 3.79 and an MAE of 2.93. Thus, the typical absolute prediction error was slightly below three points on the 0–30 future-anxiety scale, while the squared-error criterion likewise indicated relatively limited deviation between observed and predicted values. Most importantly, the test-set coefficient of determination was $R^2 = .63$, indicating that the CatBoost model accounted for approximately 63% of the variance in future-anxiety scores among participants who had not contributed to model fitting. The similarity between cross-validation error and held-out test error suggested that predictive performance generalized reasonably well beyond the training observations and that the model did not exhibit substantial overfitting. The results therefore supported the feasibility of predicting future anxiety from the combination of career uncertainty, perceived social support, psychological flexibility, and the demographic covariates incorporated into the model.

Table 3

Comparison of CatBoost and Multiple Linear Regression on the Independent Test Dataset

Model	RMSE	MAE	R^2	RMSE improvement over linear regression	MAE improvement over linear regression
Multiple linear regression	4.46	3.49	.49	—	—
CatBoost regression	3.79	2.93	.63	15.02%	16.05%

Table 3 compares the predictive performance of the final CatBoost model with a conventional multiple linear regression model developed using the same principal predictors and demographic covariates and evaluated on the identical held-out test observations. Multiple linear regression produced an RMSE of 4.46, an MAE of 3.49, and an R^2 of .49, indicating that the linear model explained approximately 49% of the out-of-sample variance in future anxiety. Although this level of performance confirmed that career uncertainty, perceived social support, psychological flexibility, and demographic characteristics were collectively informative even under a strictly additive linear specification, CatBoost demonstrated clearly superior predictive accuracy. The CatBoost model reduced RMSE from 4.46 to 3.79, corresponding to an improvement of approximately 15.02%, and reduced MAE from 3.49 to 2.93, an improvement of approximately 16.05%. Moreover, the proportion of explained variance increased from .49 under

multiple linear regression to .63 under CatBoost, representing an absolute R^2 gain of .14. This improvement suggests that the associations between the predictors and future anxiety were not entirely linear or additive and that the gradient-boosting framework captured additional predictive structure, potentially including thresholds, nonlinear response patterns, and conditional interactions among the psychological variables. Importantly, the superiority of CatBoost was observed on data that were not used during model fitting or hyperparameter selection, which strengthens the interpretation that the gain reflected improved generalization rather than merely greater flexibility in reproducing training observations. The comparison therefore supported use of CatBoost as the principal predictive model for the study while also demonstrating that its improved performance was meaningful relative to a widely used conventional statistical benchmark.

Table 4*Predictor Importance and SHAP Contributions in the Final CatBoost Model*

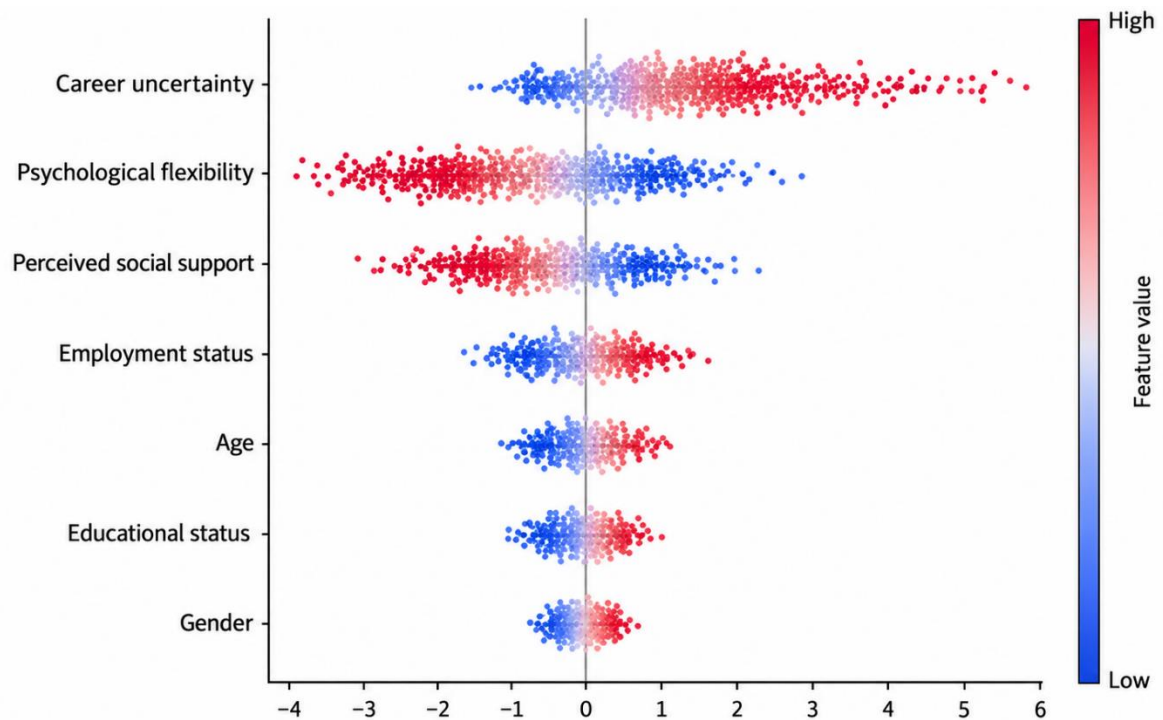
Predictor	CatBoost feature importance (%)	Mean absolute SHAP value	Relative SHAP rank	Predominant association with predicted future anxiety
Career uncertainty	33.72	2.31	1	Positive
Psychological flexibility	27.84	1.91	2	Negative
Perceived social support	19.63	1.34	3	Negative
Employment status	6.54	0.45	4	Conditional
Age	4.82	0.33	5	Weak/conditional
Educational status	4.21	0.29	6	Weak/conditional
Gender	3.24	0.22	7	Weak/conditional

Table 4 presents the global predictor-importance estimates generated by CatBoost together with mean absolute SHAP values, which provide a model-agnostic indication of the average magnitude with which each variable contributed to individual predictions. Career uncertainty emerged as the most influential predictor of future anxiety, accounting for 33.72% of the model's total feature importance and producing the largest mean absolute SHAP value of 2.31. SHAP dependence patterns indicated a predominantly positive contribution, such that participants with higher career-uncertainty scores were generally assigned higher predicted levels of future anxiety. The relationship was not completely linear: increases in career uncertainty from low to moderate levels were associated with progressively larger positive SHAP contributions, while the increase became particularly pronounced once career uncertainty entered the upper portion of its distribution. Psychological flexibility ranked second, accounting for 27.84% of total model importance and yielding a mean absolute SHAP value of 1.91. Its association was predominantly negative, indicating that higher psychological flexibility generally shifted predictions toward lower future-anxiety scores. The protective contribution of psychological flexibility appeared especially pronounced among participants whose flexibility scores were below the sample mean, because movement from very

low toward moderate flexibility was accompanied by comparatively large reductions in predicted anxiety. Perceived social support represented the third most influential predictor, with 19.63% feature importance and a mean absolute SHAP value of 1.34. Higher perceived social support generally contributed negatively to the predicted outcome, although the association displayed a mild saturation pattern: the reduction in predicted future anxiety was strongest when social support increased from low to moderate levels, while additional increases at already high levels produced smaller incremental changes. Taken together, the three focal psychological variables accounted for 81.19% of the model's total feature importance, indicating that prediction was driven primarily by theoretically relevant psychological factors rather than by demographic characteristics. Employment status was the most influential demographic variable, but its contribution was substantially smaller, accounting for 6.54% of model importance. Age, educational status, and gender each made relatively limited contributions, with feature-importance values below 5%. Their SHAP patterns were heterogeneous and conditional rather than uniformly positive or negative, suggesting that demographic variables may have contributed primarily through interactions with psychological characteristics rather than through strong independent associations with future anxiety.

Figure 1

SHAP Summary Plot Showing the Direction and Magnitude of Predictor Contributions to Future Anxiety in the Final CatBoost Model



The SHAP summary analysis provided a more detailed representation of the predictive pattern underlying the final CatBoost model. Career uncertainty occupied the highest position in the SHAP ranking, and observations characterized by high career-uncertainty scores were concentrated predominantly on the positive side of the SHAP distribution, demonstrating that vocational ambiguity and indecision consistently increased the model's predicted future-anxiety values. By contrast, high psychological-flexibility scores were concentrated primarily on the negative side of the SHAP distribution, confirming that psychological flexibility functioned as a protective predictor within the model. Participants with particularly low flexibility scores frequently displayed large positive SHAP values, indicating that limited capacity to accept difficult experiences, maintain present-focused awareness, and pursue value-consistent action was associated with substantially elevated predicted anxiety. Perceived social support demonstrated a similar protective direction, with high social-support values primarily contributing to lower predicted future anxiety and low support values tending to increase predictions. The wider dispersion of SHAP values for career uncertainty and psychological flexibility, relative to the demographic variables, further demonstrated that these psychological predictors generated the largest shifts from the model's baseline prediction. Employment status

showed moderate heterogeneity, with unemployment or active job seeking tending to contribute toward greater predicted anxiety in some individuals, particularly when accompanied by elevated career uncertainty. Age, educational status, and gender produced comparatively narrow SHAP distributions centered close to zero, indicating that they typically changed predicted future-anxiety scores only modestly. Overall, the figure confirmed that the final model's predictive architecture was dominated by a combination of career-related uncertainty and psychological resources, with career uncertainty operating primarily as a risk-enhancing factor and psychological flexibility and perceived social support operating primarily as protective factors.

Additional inspection of individual SHAP dependence patterns indicated that the model captured meaningful nonlinear relationships among the primary predictors. Career uncertainty displayed the clearest threshold-like pattern. At relatively low uncertainty scores, its contribution to predicted future anxiety remained close to or below the model baseline; however, once uncertainty approached approximately the middle-to-upper portion of the five-point scale, SHAP contributions increased sharply. This pattern suggests that modest fluctuations in occupational uncertainty may have relatively limited implications when young people retain a basic sense of vocational direction,

whereas more pronounced uncertainty may produce disproportionate increases in future-oriented apprehension. Psychological flexibility showed an inverse pattern, whereby the largest predictive disadvantage occurred among participants with particularly low flexibility scores. Improvement from low to moderate levels of flexibility corresponded with a substantial reduction in predicted anxiety, whereas the protective benefit of further increases at the upper end of the flexibility distribution became more gradual. Perceived social support similarly demonstrated diminishing marginal returns, with the strongest decrease in predicted future anxiety occurring as support moved from low toward moderate levels. These nonlinear patterns help explain why CatBoost outperformed the conventional linear model: a single regression coefficient would require the effect of each predictor to remain constant across its entire range, whereas the machine-learning model was able to accommodate changes in the strength of associations at different levels of the predictors.

The model also suggested limited but interpretable interaction patterns among the principal predictors. The adverse contribution of high career uncertainty was greatest among participants who simultaneously reported low psychological flexibility. For these individuals, high vocational ambiguity was associated with particularly large positive SHAP contributions and therefore substantially elevated predicted future anxiety. In contrast, participants with comparably high levels of career uncertainty but stronger psychological flexibility tended to receive lower predicted anxiety scores, suggesting that flexibility partially attenuated the predictive impact of occupational uncertainty. A comparable buffering pattern was observed for perceived social support. High career uncertainty produced the strongest positive contribution when social support was low, whereas the same degree of career uncertainty was associated with a smaller elevation in predicted anxiety among participants reporting stronger interpersonal support. Psychological flexibility and perceived social support also appeared to complement one another: individuals scoring high on both factors were typically assigned the lowest future-anxiety predictions, even when some degree of career uncertainty was present. These patterns should be interpreted as predictive interactions rather than causal moderation effects because the study employed a cross-sectional design and the CatBoost algorithm was optimized for prediction rather than causal estimation. Nevertheless, they demonstrate that future anxiety among Georgian youth was more accurately understood through the combined

configuration of vocational uncertainty and psychological resources than through any single predictor considered in isolation.

Taken together, the findings indicated that future anxiety could be predicted with substantial out-of-sample accuracy from career uncertainty, perceived social support, psychological flexibility, and basic demographic characteristics. The CatBoost model explained 63% of the variance in future anxiety in the independent test sample and produced materially lower prediction errors than multiple linear regression. Career uncertainty was the strongest individual predictor, followed by psychological flexibility and perceived social support, while demographic characteristics contributed comparatively little to overall model performance. Higher career uncertainty systematically increased predicted future anxiety, whereas higher psychological flexibility and stronger perceived social support generally reduced predicted anxiety. The SHAP analyses further demonstrated that these relationships were partly nonlinear and conditional, with particularly elevated predicted anxiety among participants characterized by the combination of high career uncertainty and low psychological flexibility or weak social support. Thus, the findings supported the study's central predictive framework and demonstrated the added value of a nonlinear machine-learning approach for identifying both the relative importance and the complex pattern of psychological factors associated with future anxiety among youth in Georgia.

4. Discussion

The present study examined the prediction of future anxiety among youth in Georgia from career uncertainty, perceived social support, and psychological flexibility using the CatBoost machine-learning algorithm. The findings showed that the predictive model achieved substantial out-of-sample accuracy, explaining 63% of the variance in future anxiety and outperforming multiple linear regression on the independent test dataset. Among the predictors, career uncertainty emerged as the strongest contributor to future anxiety, followed by psychological flexibility and perceived social support, whereas demographic variables contributed comparatively little to model performance. SHAP analysis further indicated that higher career uncertainty generally increased predicted future anxiety, while greater psychological flexibility and stronger perceived social support were associated with lower predicted anxiety. The model also identified nonlinear and conditional patterns,

particularly the tendency for high career uncertainty to be more strongly associated with elevated future anxiety when psychological flexibility or social support were low. These results suggest that future anxiety among young people is best understood not simply as a direct response to occupational uncertainty but as an outcome shaped by the interaction between developmental risk, personal adaptive capacity, and perceived interpersonal resources.

The finding that career uncertainty was the most important predictor of future anxiety is consistent with a growing body of evidence showing that uncertainty surrounding employment, career choice, and labor-market entry constitutes a central psychological stressor during emerging adulthood. Young people often experience career decisions as highly consequential because occupational success is closely linked with financial independence, identity formation, social status, and perceptions of successful transition to adulthood. Longitudinal findings have shown that early career insecurity is associated with adverse developmental outcomes and that persistent insecurity during adolescence can shape subsequent psychological adjustment (Mauno et al., 2023). Similarly, maladaptive school-to-work transitions have been associated with less favorable adult adjustment and increased internalizing difficulties (Parola et al., 2022). The current finding therefore extends earlier work by showing that career uncertainty is not merely correlated with future anxiety but is also the strongest variable in a multivariable predictive model. This result is also consistent with evidence demonstrating that university students' expectations about their future careers become especially important during periods of instability and disruption (Pignault et al., 2022). When young people lack confidence in their occupational direction, uncertainty about employment may generalize into broader concerns regarding financial security, social identity, independence, and life-course progression.

The strong contribution of career uncertainty can also be interpreted in light of recent changes in labor markets. Young people are entering occupational environments characterized by technological change, automation, artificial intelligence, flexible employment, and unstable career structures. Such conditions can make even carefully planned educational and occupational pathways appear uncertain. Mancaniello and Lavanga emphasized that contemporary adolescents must navigate labor markets in which uncertainty, instability, and technological disruption increasingly influence occupational expectations (Mancaniello & Lavanga, 2024). Likewise, research among

Romanian adolescents has shown that large-scale social disruption can alter career aspirations over time (Hatos et al., 2025), while research among Chinese university students demonstrated that employment psychology and intentions shifted substantially across different stages of societal crisis (Zheng & Yan, 2024). These findings align with the present results by suggesting that career uncertainty reflects not only subjective indecision but also young people's response to structural conditions that are genuinely difficult to predict. In such a context, anxiety about the future becomes understandable as a psychological reaction to both perceived personal responsibility and limited control over labor-market outcomes.

The positive relationship between career uncertainty and future anxiety was also supported by research focusing directly on employment-related distress. Job-seeking graduates have been found to report substantial levels of anxiety and depressive symptoms, particularly when employment prospects are uncertain or competition is intense (Alam et al., 2026; Habib et al., 2025). Job-seeking anxiety has similarly been associated with the way university students prepare for employment, indicating that emotional distress may influence practical career behavior (Kim et al., 2022). Among unemployed young people with higher education, employment crisis may become intertwined with self-evaluation, identity, and perceived personal competence (Pelekh et al., 2022). The present study's SHAP findings, which indicated especially strong increases in predicted anxiety at higher levels of career uncertainty, are also consistent with research linking unemployment anxiety with feelings of personal failure and migration attitudes (Kuzu et al., 2026). This suggests that once career uncertainty becomes sufficiently intense, it may no longer remain a localized vocational concern but may instead be interpreted as evidence of broader personal or social failure, thereby amplifying anxiety about the future as a whole.

The second most important predictor in the CatBoost model was psychological flexibility, which demonstrated a predominantly negative association with future anxiety. Participants with higher psychological flexibility tended to receive lower predicted future-anxiety scores, whereas those with low flexibility showed especially elevated predictions. This finding is theoretically meaningful because psychological flexibility reflects the ability to experience uncertainty, difficult emotions, and distressing cognitions without becoming excessively dominated by them. Young people facing uncertain futures cannot always eliminate ambiguity through planning or information seeking,

particularly when uncertainty arises from macroeconomic, institutional, or technological conditions. Under such circumstances, the capacity to accept discomfort, remain oriented to the present, and continue acting in accordance with personal values may become a central protective mechanism. The present result is supported by findings on intolerance of uncertainty, which has been linked to future career anxiety among university students (Zhou et al., 2022). It also aligns with evidence showing that psychological insecurity and cognitive fusion contribute to internalizing problems among late adolescents (Tao et al., 2025). These studies suggest that the psychological consequences of uncertainty depend partly on how individuals relate to uncertain thoughts and emotions rather than solely on the objective degree of uncertainty they face.

The nonlinear SHAP pattern observed for psychological flexibility is particularly important. The strongest predictive disadvantage was found among individuals with low flexibility, while increases from low to moderate flexibility corresponded to marked reductions in predicted future anxiety. This pattern suggests that psychological flexibility may function as a threshold-like resource, with its greatest protective value occurring among those who otherwise lack adaptive strategies for managing uncertainty. This interpretation is compatible with research emphasizing adaptive coping in relation to future anxiety (Albasha, 2026). It also fits with the broader concept of career resilience, which refers to the ability to remain adaptive, persistent, and purposeful when confronting changing occupational conditions (Saripudin et al., 2022). Psychological flexibility may therefore represent one mechanism through which career resilience is expressed at the individual level. Rather than guaranteeing that uncertainty disappears, flexibility may enable young people to respond more constructively to unavoidable uncertainty, reducing the likelihood that concerns about employment become generalized into pervasive anxiety about the future.

Perceived social support was the third strongest predictor and also demonstrated a protective association with future anxiety. Participants reporting higher perceived social support generally showed lower predicted anxiety, while those with lower support tended to receive higher predicted scores. This result supports the view that social relationships can buffer the psychological impact of uncertain developmental transitions. Young adults who believe that support is available from family members, friends, or significant others may have greater access to emotional reassurance, advice, practical assistance, and alternative

perspectives on difficult decisions. These resources may reduce the perceived threat associated with uncertain occupational outcomes and may also strengthen confidence in the individual's ability to cope with setbacks. Research on adolescent anxiety has identified supportive interpersonal relationships as an important protective factor, whereas family conflict and social isolation increase vulnerability (Kara et al., 2025). The current findings are also consistent with studies indicating that employment-related outcomes are shaped by social-cognitive and relational factors rather than by individual attributes alone (ÇArkit, 2025). Thus, social support may lower future anxiety both by reducing emotional distress directly and by strengthening perceived coping capacity.

The protective role of social support is further understandable within the broader social ecology of career development. Young people's expectations about work are shaped by families, peers, educational institutions, social comparisons, and digital networks. Parental employment conditions can affect how emerging adults think about their own occupational futures. For example, parental job insecurity has been associated with career networking behavior among young adults (Wang & Lin, 2023), while paternal job insecurity has been linked with perceived employability among youth (Qian, 2026). Parental criticism has also been related to reduced career confidence through fear of an uncertain future (Moavero et al., 2025). These findings reinforce the idea that career uncertainty is embedded in interpersonal contexts. When young people are surrounded by supportive relationships, uncertainty may be interpreted as temporary and manageable; in contrast, when interpersonal support is weak or family environments themselves communicate insecurity, uncertainty may become more threatening. The present CatBoost model appears to capture this broader pattern by showing that social support makes an independent contribution to future-anxiety prediction even after accounting for career uncertainty and psychological flexibility.

An additional contribution of the present study lies in the interaction-like patterns revealed by SHAP analysis. Career uncertainty exerted its strongest adverse predictive effect among individuals with lower psychological flexibility and weaker social support. This finding suggests that risk and protective factors operate in combination rather than independently. A young person may experience considerable uncertainty about employment but remain relatively protected when possessing strong adaptive capacities and supportive relationships. Conversely, the

same level of career uncertainty may be experienced as highly threatening when the individual lacks both internal and interpersonal resources. This interpretation corresponds with research showing that employment-oriented social-media use can affect employment anxiety through both social capital and risk perception (Liu, 2026). It also aligns with the broader idea that opportunity structures can simultaneously generate possibilities and insecurity depending on the resources available to individuals (Kovacheva & Rambla, 2023). Accordingly, the current findings support a multidimensional account of future anxiety in which risk exposure, social resources, and psychological coping processes jointly determine vulnerability.

The model's superior performance relative to multiple linear regression is also noteworthy. CatBoost explained substantially more variance in future anxiety and produced lower prediction errors than the linear benchmark. This finding indicates that the relationships among career uncertainty, psychological flexibility, social support, and future anxiety are not completely captured by constant linear effects. The SHAP results supported this interpretation by revealing threshold-like and saturation patterns. Career uncertainty became increasingly influential at higher levels, while the protective effects of psychological flexibility and social support were particularly pronounced at lower and moderate levels before becoming more gradual. Such relationships are difficult to represent adequately with a single regression coefficient. The machine-learning approach therefore provided added value not simply because it produced higher accuracy but because it identified heterogeneity in the way predictors contributed across individuals. This is especially relevant in youth mental-health research, where the same observable stressor may have very different consequences depending on personal and contextual resources.

The relatively small contribution of demographic variables further strengthens the psychological interpretation of the model. Although age, gender, education, and employment status added some predictive information, their importance was substantially lower than that of career uncertainty, psychological flexibility, and social support. Employment status was the most influential demographic characteristic, which is understandable given the close conceptual connection between employment conditions and future-related concerns. However, even employment status contributed considerably less than subjective career uncertainty. This distinction is meaningful because it

suggests that how young people perceive their career situation may be more informative than their formal occupational category alone. Two individuals with similar employment status may differ markedly in how secure, hopeful, or uncertain they feel about their future. This interpretation is compatible with studies showing that career confidence, perceived employability, and employment-related psychological states may be more closely related to adjustment than objective employment indicators in isolation (Boğazlıyan & Ayaz, 2026; Qian, 2026).

5. Conclusion

Overall, the present findings are consistent with a broader literature showing that youth anxiety is closely linked with uncertainty surrounding adulthood, career development, and socioeconomic change. Developmental anxiety during the transition to adulthood has been conceptualized as partly arising from the prolonged and ambiguous nature of contemporary adult-role transitions (Ratner et al., 2025). Wider cultural pressures toward constant productivity, self-optimization, and individualized responsibility may further intensify anxiety when young adults perceive limited time to make the "correct" educational and occupational choices (Burgess et al., 2022). At the same time, the impact of uncertainty is not uniform. Social support, career resources, resilience, and psychological flexibility appear capable of reducing vulnerability to future-oriented anxiety (Boğazlıyan & Ayaz, 2026; Saripudin et al., 2022). The findings therefore support an integrated interpretation in which future anxiety reflects both the degree of uncertainty encountered and the resources available for regulating its psychological consequences.

6. Limitations & Suggestions

Several limitations should be considered when interpreting the findings. First, the cross-sectional design prevents causal conclusions regarding the direction of relationships among career uncertainty, psychological flexibility, perceived social support, and future anxiety. Although the CatBoost model identified strong predictive patterns, prediction should not be interpreted as evidence that one variable directly causes another. Second, all principal psychological variables were measured using self-report questionnaires, which may introduce common-method variance, response-style effects, or socially desirable responding. Third, although the sample included youth from several Georgian cities and different educational and

employment backgrounds, the use of convenience recruitment limits the extent to which the findings can be generalized to all young people in Georgia, particularly those living in remote rural areas or experiencing severe socioeconomic disadvantage. Fourth, the sample size was adequate for the present predictive modeling strategy but remains modest relative to very large machine-learning datasets, which may restrict the stability of more complex interaction patterns. Finally, the study focused on a limited set of psychological and demographic predictors and did not include potentially relevant variables such as economic hardship, family income, migration intentions, personality traits, intolerance of uncertainty, depressive symptoms, or objective labor-market conditions.

Future studies should employ longitudinal designs to clarify how career uncertainty, social support, psychological flexibility, and future anxiety influence one another over time and whether changes in these variables precede changes in psychological distress. Larger and more nationally representative samples would allow the predictive model to be validated across regions, educational levels, employment sectors, and socioeconomic groups within Georgia. Replication across different cultural contexts would also help determine whether the observed predictor rankings and nonlinear patterns are culturally specific or broadly generalizable. Future work could expand the feature set by incorporating objective economic indicators, perceived employability, financial stress, family employment insecurity, migration plans, intolerance of uncertainty, depressive symptoms, resilience, and digital-media exposure. Comparative modeling with other algorithms such as XGBoost, LightGBM, random forests, elastic net, and neural networks could establish whether CatBoost retains a predictive advantage across different samples. It would also be useful to examine model calibration and subgroup fairness to determine whether prediction accuracy differs by gender, educational status, or employment condition. Finally, prospective studies could test whether changes in social support or psychological flexibility alter the predictive effect of career uncertainty, thereby providing stronger evidence regarding possible buffering mechanisms.

The findings have several practical implications for universities, career-counseling services, youth organizations, and mental-health professionals. Screening programs for future anxiety may benefit from assessing career uncertainty rather than relying exclusively on general demographic risk indicators. Career-guidance interventions should not focus only on providing occupational information

but should also address uncertainty tolerance, decision-making confidence, flexible goal adjustment, and realistic planning under changing labor-market conditions. Psychological interventions may be especially valuable for young people who combine high career uncertainty with low psychological flexibility, because this subgroup appears particularly vulnerable to elevated future anxiety. Programs based on acceptance, present-moment awareness, cognitive distancing, and values-guided action may help young people remain engaged in meaningful career behavior even when outcomes cannot be guaranteed. Strengthening perceived social support should also form part of prevention efforts through peer mentoring, family involvement, group counseling, and community-based youth programs. Institutions can further reduce anxiety by communicating career pathways transparently, providing realistic labor-market information, and creating opportunities for internships, mentoring, networking, and skill development. Taken together, interventions that simultaneously reduce avoidable career ambiguity, strengthen supportive relationships, and improve psychological flexibility are likely to be more useful than approaches targeting any one factor in isolation.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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Authors' Contributions

All authors equally contributed to this article.

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