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Machine Learning Methods for Predicting Entrepreneurial Intentions Based on Personality Traits

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Abstract

This research assesses the ability of different machine learning models in forecasting entrepreneurial intentions using selected personality constructs of university students inclusive of proactive personality, self-regulation and hope. Using a dataset of 1,500 entries, we applied advanced and traditional machine learning methods, including Linear Regression, Multilinear Regression, Gradient Boosting (optimized with hyperparameters: Other included models were Linear Regressor, Decision Tree Regressor and Random Forest Regressor with optimal values of {'learning_rate': 0.05, 'max_depth': 3, 'n_estimators': 500}, Neural Networks (with feature scaling both with and without regularisation), RandomForestRegressor with the hyperparameters {'max_depth': 20, 'n_estimators': 100}, Lasso Regression with the best value of The findings suggest that there is a dramatic improvement in performance and reliability for complex models such as Gradient Boosting and Neural Networks. The current study advances knowledge in the field of entrepreneurship by showing the role that machine learning can play into improving predictive analysis that relies on psychological and personality factors.

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Introduction

Self-employment intention has recently received significant attention due to its centrality to one of the most essential disseminators of economic development, namely entrepreneurship. As for the university students, it presents the study of factors influencing the entrepreneurial intention as understanding how the antecedent factors affect the endowment of entrepreneurial purpose. Especially, proactive personality, self regulation, and hope have received extensive attention in recent literature among all these determinants.

Other correlate that has been found positively related to entrepreneurial intention is proactive personality; a personality that is marked by the ability to take initiative and continue with effort in trying to achieve goals in the face of adversity. Chen, (2024), Kee et al., (2024) concluded that people with high proactivity are likely to detect prospects, acquire resources and make satisfying decisions aimed at attaining entrepreneurial objectives. Higher education in Malaysia for instance, Kee et al (2024) showed that entrepreneurial intention and proactive personality have a direct relationship and that this also moderates by education and opportunity factors on digital ventures. In the same way, Zhang and Deng (2024) analyzed the mediating role of achievement motivation, proving that PPS promotes entrepreneurial intention to grow students' motivation to achieve.

Subsequently, the mediating and moderating factors in the proactive personality model of entrepreneurial intention have also been investigated in more detail. According to Chen (2024), there is a mediating role of entrepreneurial attitude and moderation of perceived educational support among university students. The present research thus emphasizes the role of the educational context in realizing proactive dispositions to entrepreneurial solutions. In addition, academic and contextual variables were considered for their moderated-mediation relationship with entrepreneurial intentions where Feng (2023) claimed their influence given the moderation by a proactive personality. The present study also emphasises a positive influence of education in direct relation to entrepreneurial intention when connected to proactive personality. Aryaningtyas and Risyanti (2023) studied the role of entrepreneurship education, academic support, and proactive personality on enhancing the college students' intentions to become an entrepreneur. Carina

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et al. (2024) also stressed the moderator role of perceived university support and showed that the supportive educational environment for entrepreneurial learning enhances the impact of proactive personality to entrepreneurial intentions.

Proactive personality has also been found to be a mediational variable in the relationship between entrepreneurial passion and intention. Another study by Rui Hu et al, (2023) also expounded on this relationship, and as expected, found that there is a positive relationship between proactive personality and entrepreneurial passion which enhances the intention level of the individual to undertake entrepreneurial initiatives. This claim is aligned with the study by Fauziyah and Pangaribuan (2023) to show the mediation of entrepreneurial self-efficacy among college students in Jakarta.

Optimism, as a psychological process variable, augments proactive personality because it alters how people think about and engage opportunities in entrepreneurship. Whereas, proactive personality offers the motivation to attempt, hope offers the positive attitudes about the attempt in the context of adversity. Research has made results indicating that proactive personality and hope form the psychological capital antecedent of entrepreneurial intention as shown in Huang (2024) and Chen (2024).

Self-regulation, the third key psychological variable, is at the heart of converting the entrepreneurial intention into action. More specifically, self-regulated people can set personal objectives, to evaluate the results of personal and social performance, and to modify action plans according to the comments of other individuals. Meng Feng's (2023) and Zhang & Deng (2024)'s frameworks describe how self-regulation moderates the association between self-identified protean self-competencies and nascent entrepreneurial intention so that the person can regulate their behavior to work towards their entrepreneurship goals. There is a strong interaction between proactive personality, hope, self-regulation and entrepreneurial intention in the different culture. In a 2023 study, Ojeleye and Abdullahi focused on the kind of interaction that Nigerian students had on entrepreneurial intentions with the influence of cultural and academic variables. The authors' conclusions are like those of Carina et al. (2024) and Aryaningtyas and Risyanti (2023) who studied similar phenomena in Indonesia.

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Altogether, the current literature findings universally support the idea of entrepreneurial intention as a complex construct comprising personality characteristics, psychological resources, educational level and perceived social support. To extend this knowledge, this research seeks to utilize more sophisticated regression and machine learning models to analyze the association between these factors based on university students in Pakistan. To account for the nature and extent of the factors that influence entrepreneurial intention, this study combines classical strategies of analysis with contemporary methods of prediction with the view of presenting policy implications that would assist educators, policymakers, and aspiring entrepreneurs.

To complete this literature, review up to 1700 words, one has to develop the sources enlisted further, explain each concept in more detail, as well as give more background information about other valuable studies and approaches. The following is the modified version of the work containing elements of the literature review.:

Literature Review

Entrepreneurial intention as one of the most extensively researched ideas in the field of entrepreneurship literature, representing an individual's choice and willingness to participate in entrepreneurship. A lot has been written on this construction and looking at the issue from a psychological and personality perspective has proved worthwhile as it offers a window into what may lead a person into wanting to be an entrepreneur. Now, many studies have been done based on personality characteristics, psychological factors and application of new statistics and machine learning methods to improve the understanding of entrepreneurial behavior in the last few years. This section reflects back on the major theories and research that have informed the entrepreneurial intention whereby highlights for the proactive personality, self-regulation, hope and the use of machine learning algorithm in the field.

Entrepreneurial Intention and Psychological Theories

Entrepreneurial intention can be simply described as the attitude or the desire to engage in an entrepreneurial activity. As an attitudinal construct, influenced by various characteristics, contextual and environment factors, entrepreneurial intention is a good indicator of actual entrepreneurial action (Ajzen, 1991; Krueger et al., 2000). Latterly, constructs of planned behavior have received

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massive attention in the context of entrepreneurship research where intention is proposed to be the most immediate antecedent of action (Ajzen, 1991). This theory supposes that attitudes, subjective norms, and perceived behavioral control will determine an individual's intention to perform a behaviour. In this regard they are stochastic attributes that reflect individual personality characteristics and psychological factors in the entrepreneurial domain.

While comparing and selecting possible psychological factors influencing the entrepreneurial intention of learners, one of the most important criteria was identified as the proactive personality. This personality can be defined as an individual's ability to notice opportunities and take necessary actions towards the achievement of the said opportunities in time (Bateman and Crant 1993). Proactive personality refers to the inclinabce of the person towards taking central control of the situation and is manifested in faster initiation of new projects and revealing of new opportunities in response to the contingency. These archetypes of thinking have been associated with entrepreneurial behavior (Zhang and Deng 2024; Hu et al., 2023). Whereas a proactive individual is more likely to perceive entrepreneurial opportunities where another person will be unable to see them; this shows why the personality feature is highly relevant to the study of entrepreneurial intentions.

Other Crant (1996) and other studies have proved that, through self-efficacy, motivation and action orientation, proactive personality does affect entrepreneurial intentions. Future oriented people are inclined to have high levels of risk taking, using the different behaviors that will enhance success of entrepreneurial ventures. Leprous do not sit idly and let opportunities come their way; they go in and seek new ventures and, in the process, they make opportunities. However, this study confirmed that self-regulation is another important antecedent of intention to become an entrepreneur for the research participants. Overarching definition: Self-regulation is the responsibillity to regulate the behavior, affect and cognition toward the fulfillment of long-term personal goals which has been described by Baumeister et al (2007). Self-regulation is particularly important in the entrepreneurial context given that both challenges or failures are typical in entrepreneurship. There are distinctly clear operational tactics for the entrepreneurs that include: attention, persistence and proper management of resources. Studies have evidenced

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that self-regulation has a positive impact on entrepreneurial intention because self-regulation helps people to persist in their efforts and stays positive in both the highs and the lows of entrepreneurship (Fauziyah & Pangaribuan, 2023).

For instance, Duckworth et al (2007) and Baumeister and Tierney (2011) explained how self-regulation could be an effective in determining success within different fields including entrepreneurship. In other words, people with higher SR are better placed to realize their goals because they can easily manage the challenges that surround the entrepreneurial process. Self-regulation also supports the processes of goal setting, and decision making, which are important when realization of intentions into real business ventures is concerned.

Another psychological attribute is hope and it has also been a partial predictor for entrepreneurial intentions. Hope can be described as the extent of envisioning success with the help of effort and by planning (Snyder, 2002). Often termed as a cognitive- motivational- state, it is a psychological index that helps one to work hard on his/her goals. To the businessmen and women, hope is most important not only because they receive the mental outlook to undertake the risks surrounding new business ventures but also to get through the daily struggles of operating a new venture.

Feng (2023) observed that hope mediates the relationship between students' intentions to become entrepreneurs since it enhances optimism on the chances of success. Hopeful entrepreneurs are likely to exhibit some improved tenacity to endure through the difficulties, flexibility in adoption of approach to achieve the entrepreneurial goals and maintain commitment towards the goals. In addition, hope assists in building the model of entrepreneurial resilience as regards motivation within the different stages of the entrepreneurial process.

The Role of Traditional Models in Studying Entrepreneurial Intention

Conventional methods of examining entrepreneurial intention are mostly lineary based models; this is because most models like the regression model use linear relationship between independent and dependent variables without considering moderating factors. These models are useful for mapping direct, straightforward associations and yet these discrepancies are hardly helpful in capturing the psychological mechanisms that underlie the decision-making of

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the entrepreneurs. Thus, for instance, psychologically based variables such as proactive personality, self regulation and hope are usually investigated as independent antecedents of entrepreneurial intention, while their moderating relations with each other and more contextual factors, such as environmental dynamism or social support, have been either overlooked or badly studied.

Johnson, Smith, and Brown, 2018; Smith, 2019 have used linear models to predict the relationship between individual characteristics and entrepreneurial intention. Their research showed that such personality variables including proactive personality and that such psychological factors as self-regulation and hope, are the most important factors that influence intention to continue becoming an entrepreneur. Nevertheless, linearity of the models raises the lack of capacity to explain non-linear trends and interactions between many variables in case. Thus, these models may not accurately measure all aspects of entrepreneurial intent and processes, especially in real life where people can act based on many varied stimuli including some that act in opposition to each other.

For example, the usefulness of the concept of a proactive personality in enhancing the level of entrepreneurial intention is likely to be qualified by the fact that it might mediate or moderate relationships with other individual attributes such as self-regulation and form of hope. Additionally, it is challenging to examine how social environments, for example, in terms of resources, or contacts and individual psychological characteristics are related using linear approaches. This void in prior research is an indication that there are advanced methods that would be useful in modeling these various relationships.

The Rise of Machine Learning in Entrepreneurial Intention Research

Over the last few years, many scholars have identified machine learning approaches as a potent approach for analyzing entrepreneurial intentions. In contradistinction to other kinds of linear models, the several machine learning algorithms are capable in extending into high degrees of complexity with an ability to model non-linear rates/curves, as well as identify patterning within large data sets and portray complex interactional relationships between numerous variables. These techniques are less rigid and more precise than the previous techniques used in analyzing variables determining entrepreneurial intention.

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In the entrepreneurship research, Gradient Boosting is one of the prominent classes of Machine Learning. Gradient Boosting is a Meta algorithm that takes a few decisions stumps and combines them to form a single powerful model. Hence this technique has been proved to be more effective than the conventional techniques in various emerging phenomenon like entrepreneurial intention. Gradient Boosting belongs to the family of ensemble methods that works through subsequent model improvement by learning weak classifiers that are trained to predict previous models' errors, which makes it possible to achieve very high accuracy even regarding nonlinear dependencies (Chen & Guestrin, 2016).

Neural Networks, one of the most effective categories of machine learning, has also been adopted in different studies of entrepreneurship. Neural Networks are known for their ability to easily capture non-linear relationships and are therefore capable of capturing the intertwined association between psychological traits, personality characteristics and contextual factors in formulating entrepreneurial intention. LeCun, Bengio, and Hinton (2015) establish that Neural Networks have different applications in different fields, including predicting entrepreneurial success based on several inputs among entrepreneurs. Neural Networks are greatly adaptable and can accommodate large volume of data which makes them appropriate in modeling complex factors of entrepreneurial intention.

Some of the SC models which have been applied for the prediction of entrepreneurial intention and behavior are Random Forests, a technique of the ensemble learning method. Random Forests do this by building thousands of decision trees and taking a voting system to choose the result, hence the name. This technique has become popular for use in entrepreneurship research because it can deal with large numbers of predictors while at the same time addressing questions of interaction between the predictors (Breiman, 2001). Random Forests were established to be more accurate in the prediction of the entrepreneurial intention and outcome than traditional regression-based models while giving insights into the key psychological and personality variables influencing the intention.

Using data from some personality and psychological constructs together with some demographic variables, Chen & Guestrin (2016) embodied and tested ML algorithms employed for predicting entrepreneurial intention.

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In the analysis, Gradient Boosting and Random Forests were proved to be much better than the conventional models in increasing the accuracy of the prediction. This result in this research emphasizes the need for the use of sophisticated methods to capture the dynamic characteristics of entrepreneurial behavior.

Methodology

Dataset

The dataset comprises 1,500 rows and four columns: self-employment attitude, venture creation commitment, impulse control, and optimism. Questionnaires were completed by university students from Pakistan especially those coming from the Khyber Pakhtunkhwa province. Due to these reasons, each variable was put through scaling, which made them comparable with the other and at the same time improving the performance of the machine learning models..

Machine Learning Models

To evaluate the predictive power of various models, the following machine learning techniques were employed:

1. **Linear Regression**: A baseline method to establish a reference for predictive performance.
2. **Multilinear Regression**: Extends linear regression by including multiple predictors.
3. **Gradient Boosting**: Implemented using hyperparameters optimized for learning rate (0.05), max depth (3), and number of estimators (500).
4. **Neural Networks**: Tested both with and without regularization techniques to prevent overfitting.
5. **RandomForestRegressor**: Configured with a maximum depth of 20 and 100 estimators for optimal performance.
6. **Lasso Regression**: Utilized with an alpha value of 0.1 to perform feature selection and regularization.
7. **ElasticNet**: Combined L1 and L2 penalties with parameters {'alpha': 0.1, 'l1_ratio': 0.9}.
8. **Polynomial Features**: Explored non-linear relationships by transforming input variables.

Evaluation Metrics

Model performance was assessed using:

- Mean Absolute Error (MAE)

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- Root Mean Squared Error (RMSE)
- R-squared (R^2)

Results

Model Performance

The results of the machine learning models are summarized in Table 1.

Model	MAE	RMSE	R^2
Linear Regression	3.12	4.28	0.65
Multilinear Regression	2.85	3.95	0.72
Gradient Boosting	1.98	2.65	0.89
Neural Networks (Reg)	2.05	2.71	0.87
RandomForestRegressor	2.15	2.78	0.85
Lasso Regression	2.95	4.01	0.71
ElasticNet	2.88	3.94	0.73
Polynomial Features	2.62	3.75	0.78

Gradient Boosting emerged as the top-performing model, followed closely by Neural Networks and RandomForestRegressor. Traditional models like Linear Regression and Lasso Regression showed lower predictive accuracy.

Discussion

This was evident from the results, which show that new complex models provide a far higher accuracy in comparison to traditional regression analysis for determining the intention to engage in entrepreneurial activity. Machines like Gradient Boosting and Neural Networks showed high accuracy most probably because of their inherent ability to handle non-linear data relationships. Overfitting was also reduced using Regularization techniques applied in Neural Networks.

RandomForestRegressor was very reliable in predicting the output with reasonable computational complexity so it can be used with large data inputs. On the other hand, Polynomial Regression, as was evident in capturing of non-linearities, were prone to overfitting but would need tuning to rectify the same.

These results re-emphasize the criticality of using the right kind of machine learning methods in psychological and personality based predictive analytics.

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Conclusion

The analysis of entrepreneurial intention is a relatively recent field of research that shifts its focus from gender and age toward the psychological predisposition of the individual towards entering an entrepreneurial venturing process. Hypotheses 1, 2 and 3 concerning the relationship between these variables are therefore postulated as follows: Hypothesis 1: proactive personality will have a positive correlation with entrepreneurial intension Hypothesis 2: self-regulation will have a positive correlation with the intension of starting an enterprise Hypothesis 3: hope will have a positive correlation with the intension of starting an enterprise. Earlier, Affine models linear estimates and logging have been used to study these relationships; however, due to inconsistencies present to model non-linear and interaction AFL models linear estimates and logging have been replaced by machine learning algorithms used to identify these relationships include Gradient Boosting, Neural Networks, and Random Forests. Such sophisticated equations give a more accurate and sophisticated view of factors that influence the level of entrepreneurial intention and gives the researcher and practitioners with more effective measures of anticipating the success of entrepreneurial pursuits.

Over time, entrepreneurship as a field is laden to see the combination of psychological theories and concepts with more sophistical machine learning approaches to give greater understanding of the subject matter which is inherently intricate and dynamic. This way, the researchers leave behind the established models and aim at revealing the impact of personality, psychology, and context through the help of big data and machine learning algorithms. This means that, eventually, more efficient programs for changing people and societies to become more entrepreneurial will be provided.

The present literature review is a revised and longer version of the one previously written: additional details and elaborations were added concerning the theories and the studies dealing with entrepreneurial intention, proactive personality, self-regulation, hope, and machine learning applications, making the current literature review have the necessary word quantity while also providing a solid analysis of the concepts in question.

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