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Journal of Adolescence

journal homepage: www.elsevier.com/locate/adolescence

Brief report

Applying elastic-net regression to identify the best models predicting changes in civic purpose during the emerging adulthood

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ARTICLE INFO

Keywords:

Civic purpose
Emerging adulthood
Elastic-net regression
Positive youth development
Data science

ABSTRACT

Introduction: Changes in civic purpose during the emerging adulthood has been a significant research topic since it is closely associated with active civic engagement later in human lives. While standard regression methods have been used in previous studies to predict civic purpose development, they have limitations that may not always lead to best prediction models. We aimed to address these limitations by utilizing elastic-net multinomial logistic regression, which favors models with the least number of necessary predictors, in exploration of predictors for civic purpose development in a data-driven manner.

Methods: We analyzed data from the longitudinal Civic Purpose Project while focusing on the model that best predicted civic purpose from Wave 1 (12th grade before high school graduation) to Wave 2 (two years after Wave 1). The reanalyzed data included responses from 476 participants (60.29% females, 39.08% males) who were recruited from Californian high schools in the United States and completed the survey at both Waves. The elastic-net regression was performed 5000 times for predicting three dependent variables, Wave 2 political purpose, community service purpose, and expressive activity purpose, with Wave 1 predictors. We identified which predictors were selected as the constituents of the best regression models during the elastic-net regression process.

Results: Results showed that civic purpose, moral and political identity, and external supports (e.g., parental and peer involvement, school civic opportunities, etc.) in Wave 1 significantly predicted civic purpose in Wave 2. Several predictors were excluded from the regression models during the elastic-net regression process.

Conclusion: We found that the elastic-net regression was able to present the more regularized model for prediction. Implications for promoting civic purpose are discussed as well as utilizing the elastic-net regression method.

Promoting civic engagement during adolescence and emerging adulthood is important in human flourishing because experiences of early civic engagement enable youths to develop and practice skills to continue civic engagement through adulthood (Youniss et al., 2002). Previous research has reported that civic purpose, one's purpose to engage in civic activities, contributes to maintaining civic engagement during adolescence and early adulthood, which are significant transitional periods in a person's life (Malin, Ballard, & Damon, 2015; Malin, Han, & Liauw, 2017). This research has found that civic purpose is constituted by three components, long-term

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<https://doi.org/10.1016/j.adolescence.2021.09.011>

Received 25 June 2020; Received in revised form 4 August 2021; Accepted 29 September 2021

Available online 8 October 2021

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intention to engage in civic activities, actual civic engagement, and motivation to contribute to beyond-the-self beings (Malin, Ballard, & Damon, 2015). Several factors including identity style (Crocetti, Erentaitė, & Žukauskienė, 2014), moral and political identity (Han, Ballard, & Choi, 2021), parental and peer civic attitude and engagement (Duke, Skay, Pettingell, & Borowsky, 2009; Moran, Bundick, Malin, & Reilly, 2013; Zaff, Malanchuk, & Eccles, 2008), and school atmosphere and support (Andolina, Jenkins, Zukin, & Keeter, 2003; Ballard, Caccavale, & Buchanan, 2015; Keating & Janmaat, 2016) have been found to be conducive to the formation of civic purpose and engagement.

Previous studies have tested which factors would significantly predict civic purpose with standard regression, such as ordinary linear regression. However, due to the methodological limitations of standard regression, they could not examine which regression model is the best model among all possible candidate models consisting of combinations of candidate predictors (Kim, Banerjee, Park, & Pathak, 2016, pp. 1860–1869). First, epistemologically, ordinary regression analysis based on null hypothesis significant testing with *p*-values can only reject a null hypothesis (e.g., coefficients with a zero effect size) within the one model that is being tested each time (Han, Park, & Thoma, 2018). It is not suitable to examine which predictors (independent variables) are meaningful and should be included in a model (Harrell, 2015; Walter & Tiemeier, 2009). Second, model selection methods based on standard regression, such as the stepwise method, are likely to inflate estimated coefficients associated with smaller *p*-values, while they could not address issues related to collinearity and correlation among predictors (Hammami, Lee, Ouarda, & Lee, 2012; Harrell, 2015; Tibshirani, 1997). Third, when standard regression is performed, only one model, which was set by a researcher, can be tested (Han & Dawson, 2021). So, if the researcher wants to explore the best model among all possible models in terms of combinations of candidate predictors in a hypothesis-free, data-driven manner, such standard regression could not be an ideal method.

Thus, we intend to analyze the civic purpose project (CPP) dataset with elastic-net regression to explore the best model and predictors in a data-driven manner without setting any a priori hypotheses. In the data-driven model exploration, we examined what would be the best regression models predicting changes in civic purpose during emerging adulthood. As candidate predictors to be examined, we employed variables regarding the baseline civic purpose (Malin, Ballard, & Damon, 2015), civic identity (Han et al., 2021; Malin et al., 2017; Porter, 2013), attitudes and supports regarding civic engagement among peers and parents (Duke et al., 2009; Moran et al., 2013; Zaff et al., 2008), and school environment (Andolina et al., 2003; Ballard, Caccavale, & Buchanan, 2015; Keating & Janmaat, 2016) from the CPP dataset based on prior research. Although each individual cited prior study examined several aspects of civic purpose development, the prior studies have not been able to consider diverse person-level and environmental factors in a simultaneous manner, due to the methodological limitations. Hence, we decided to examine how such diverse factors contributed to prediction of civic purpose development in a data-driven manner for better understanding of the developmental process.

While addressing this question, we were also interested in presenting methodological benefits of elastic-net regression in research on adolescence by demonstrating its superiority to standard regression. We decided to employ elastic-net regression because it prefers the simplest model with the least necessary predictors and penalizes the inclusion of unnecessary predictors (see “Analysis” section in supplementary methods for the model estimation mechanism). Although no previous studies using elastic-net have been published in journals for research on adolescence (e.g., *Journal of Adolescence*, *Journal of Youth and Adolescence*, *Journal of Research on Adolescence*), statisticians have demonstrated that elastic-net can produce better outcomes in terms of the accuracy and simplicity of regression models (Grave, Obozinski, & Bach, 2011; Zou & Hastie, 2005). For instance, in epidemiology, when a prediction is made with numerous candidate predictors, elastic-net regression contributes to the estimation of the most stringent model with improved prediction accuracy (Kim et al., 2016, pp. 1860–1869).

In addition, we also examined whether the model identified by elastic-net regression can better predict outcomes outside of the boundary of data used for regression compared with standard regression through cross-validation (McNeish, 2015). Previous studies reported when the best regression model with parsimony was identified in a data-driven manner, such a model could more accurately predict outcomes even beyond the data used for regression compared with the model from standard regression and was less susceptible to over-fitting (Han & Dawson, 2021). Given attrition is a significant issue in research on adolescence (Jeličić, Phelps, & Lerner, 2009), by demonstrating that the result from elastic-net regression can accurately predict developmental outcomes outside of the boundary of data used for regression, we would be able to present another significant practical benefit of this method in research on adolescence.

1. Methods¹

1.1. Materials

We downloaded and analyzed files containing two-wave survey data from the CPP dataset that is available for public via the Inter-university Consortium for Political and Social Research (<https://www.icpsr.umich.edu/icpsrweb/civicleads/studies/36561>). The CPP researchers collected Wave 1 data before participants' high school graduation at California high schools, which resulted in 1578 participants completing the survey. Wave 2 data was collected two years later via Qualtrics and 480 participants completed the survey (see “Materials” section in supplementary methods for further details about the nature of the dataset). After filtering out redundant responses, data collected from 476 participants were used for our analyses. We found that the attrition rate was significantly different across different gender and ethnicity groups (see “Materials” section in supplementary methods for additional information).

¹ Technical further details regarding the methods used in the present study are elaborated in Supplementary Methods

1.2. Measures

Participants' civic purpose and variables that have been found to be associated with civic purpose (e.g., moral and political identity; supports from parents, peers, and schools) were analyzed. We used three civic purpose statuses as categorical variables, political, community service, and expressive activity purpose statuses, as dependent variables. Further details regarding each measure are available in "Measures" section in supplementary materials.

1.2.1. Civic purpose

For dependent variables, civic purpose was measured in three domains: political, community service, and expressive activities. We classified each participant's political, community service, and expressive activity purpose at Waves 1 and 2 into five categories, i.e., drifting, dreamers, dabblers, self-oriented, and purposeful, with three variables, civic intent, civic engagement, and beyond-the-self motivation (see Table 1 for the classification criteria). Civic intent was intent to engage in civic activities in general. For civic engagement, three different types of engagement, i.e., political, community service, and expressive activity engagement, were measured independently. Beyond-the-self motivation was measured in two domains, political activity and volunteering. The numbers of participants classified into the civic purpose status categories are summarized in Table S1. Some participants did not respond to all civic purpose-related items, so the summed numbers in Table S1 were smaller than 1578 and 476, the total sample size at Wave 1 and 2, respectively.

1.2.2. Moral and political identity

Moral and political identity were measured at Wave 1 to indicate whether a participant regarded moral and political values as central to his/her self-concept. Participants were presented with items representing different values (either moral, political, or neutral) and asked to score to what extent each value was central to themselves. As one reported more moral and political values as central to him/herself, he/she received the higher moral and political identity score, respectively.

1.2.3. Parental, peer, and school supports

We used four variables that quantify supports from parents, peers, and schools in civic activities at Wave 1 for analysis. These variables were parental civic involvement, peer civic involvement, perceived importance of civic and academic values among peers, and opportunities for involvement in civic activities at school.

1.2.4. Demographics

We used seven demographical variables in this study following prior purpose studies. The variables include gender, college boundedness, ethnicity, participants' place of birth, mother's place of birth, father's place of birth, and socioeconomic status.

1.3. Analysis

First, we conducted correlation analysis to examine the relationship between civic purpose-related variables. We focused on Pearson correlation among continuous variables, i.e., civic intent and engagement at both waves, moral and political identity, and variables about parental, peer, and school supports.

Second, we performed multinomial elastic-net multinomial regression to search for the best prediction model for each dependent variable, i.e., Wave 2 political, community service, or expressive activity purpose statuses as categorical variables. For this analysis, we composed our customized R script with *glmnet* package (Friedman et al., 2021). The dependent variables were treated as categorical variables. We entered candidate predictors (i.e., Wave 1 purpose status; moral and political identity; four variables about parental, peer, and school supports; seven demographics variables) to the model.

For each dependent variable, we repeated the aforementioned process for elastic-net regression 5000 times. Elastic-net regression was repeated multiple times because the dataset was shuffled for cross-validation in a random manner, so we wanted to minimize any random error that could originate from random data shuffling by averaging results across the repetitions (see "Notes on glmnet" subsection in supplementary methods for further details about the cross-validation and random data shuffling). Previous studies that conducted the similar procedure for model exploration with cross-validation repeated model exploration 1000 to 10,000 times (Han & Dawson, 2021; Han, Lee, & Soylu, 2020). We determined the number of repetitions in our study, 5,000, to compromise required computation time and prediction performance based on the range of the repetition numbers in the previous studies. The repeated cross-validation processes were performed with multiple processors to save computation time (Friedman et al., 2021; Han, 2021).

Table 1

Classifying civic purpose statuses.

Category	Civic intention	Civic engagement	Possession of beyond-the-self motivation
Drifting	Low	Low	–
Dreamer	High	Low	–
Dabbler	Low	High	–
Self-oriented	High	High	No
Purposeful	High	High	Yes

We counted how many times each candidate predictor was included in the resultant model out of 5000 repetitions. We also calculated the mean of each coefficient. According to prior research in computational methods, this procedure was employed and suggested as a way to integrate results from multiple repetitions of elastic-net regression with cross-validation and to improve prediction performance (Boulesteix, De Bin, Jiang, & Fuchs, 2017). Further details regarding elastic-net regression are explained in “Notes on elastic net” subsection in supplementary methods.

Furthermore, we examined whether elastic-net regression better predicted outcomes outside of the boundary of data used for regression and, thus, was less susceptible to over-fitting and able to address attrition better compared with standard regression. For this examination, we compared the validation dataset prediction accuracy between the two methods, multinomial elastic-net regression and conventional multinomial regression. Methodological details about this comparison are explained in “Notes on validation dataset prediction accuracy test” subsection in supplementary methods.

The analyzed data file and all source code files are available for public via the Open Science Framework (<https://osf.io/zb7um/>).

2. Results

Brief descriptive statistics of analyzed variables were presented in Table S2. The result of correlation analysis is reported in Fig. 1. We found significant association among civic purpose-related variables both in Waves 1 and 2. Table 2 presents how many times each predictor showed a non-zero coefficient for each dependent variable among 5000 trials. Figs. 2–4 show the mean value of each coefficient when Wave 2 political, community service, and expressive activity purpose was predicted, respectively. Only the predictors that showed non-zero coefficients at least once out of 5000 iterations are presented. For better representation of effect sizes, all reported coefficients were standardized. Exact estimated coefficient values are presented in Tables S3–5. Furthermore, when the validation dataset was examined, elastic-net regression significantly better predicted outcomes than standard regression. The comparison results are presented in Table S6.

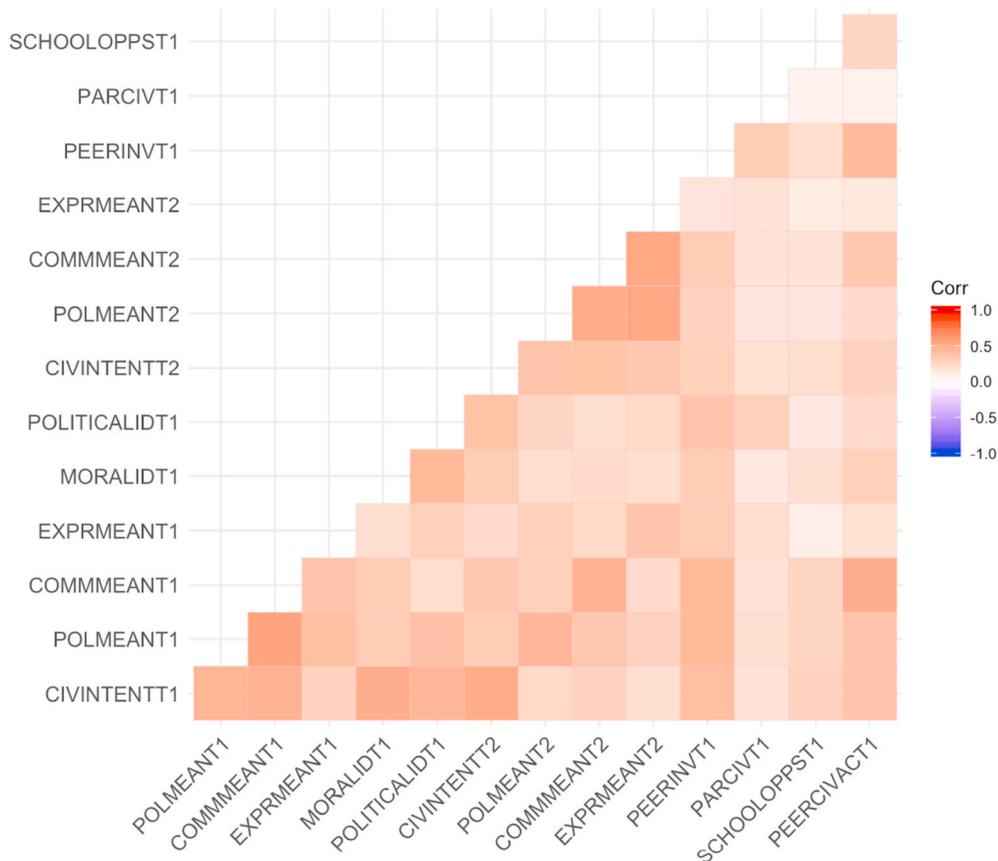


Fig. 1. Correlation table. All colored cells represent at least $p < .05$. CIVINTENT: T1 or T2 civic intention. POLMEAN: T1 or T2 political engagement. COMMMEAN: T1 or T2 community service engagement. EXPRMEAN: T1 or T2 expressive activity engagement. MORALIDT1: T1 moral identity. POLITICALIDT1: T1 political identity. PEERINVT1: T1 peer civic involvement. PARCIVT1: T1 parental civic involvement. SCHOOLOPPST1: T1 school opportunity. PEERCIVACT1: T1 peer civic-academic value.

Table 2
 Number of iterations where each predictor reported non-zero coefficient out of 5000 iterations.

	Wave 1 drifting	Wave 1 dreamers	Wave 1 dabblers	Wave 1 self-oriented	Wave 1 purposeful	Moral identity	Political identity	Parental involvement	Peer involvement	Peer values	SES
Wave 2 Political	5000	4999	3994	–	5000	4996	5000	264	4732	4732	–
Wave 2 Community service	5000	105	1	5000	4912	4998	5000	–	2750	4984	1
Wave 2 Expressive activity	5000	4999	3919	11	4999	4999	5000	347	–	66	–
	School opportunities	Gender (female)	Asian	Black	Latino	White	US born	Mother US born	Mother out of US born	College	
Wave 2 Political	2604	–	5	–	–	–	–	–	–	–	–
Wave 2 Community service	2750	–	105	–	1	38	11	38	1	299	–
Wave 2 Expressive activity	3919	11	4654	347	66	–	–	–	–	–	–

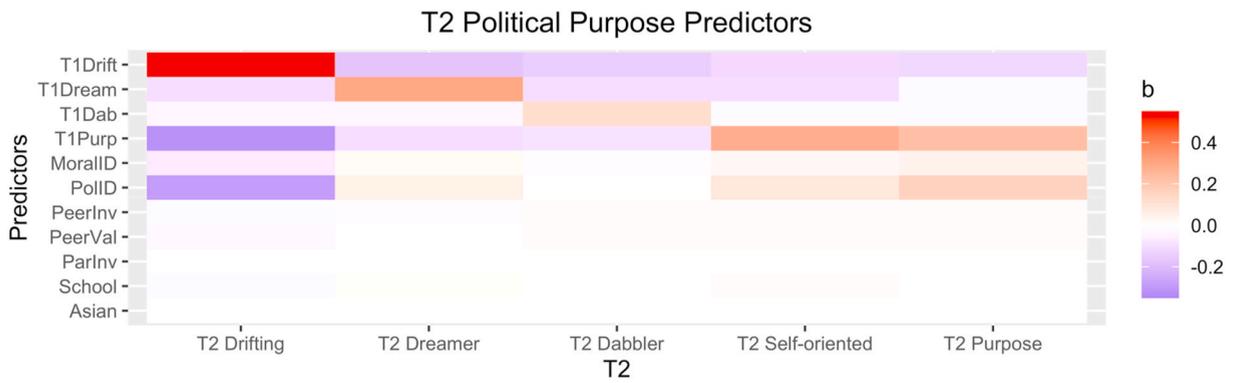


Fig. 2. Estimated coefficients in T2 political purpose status prediction averaged over 5000 iterations. MoralID: T1 moral identity. PolID: T1 political identity. PeerInv: T1 peer civic involvement. PeerVal: T1 peer civic-academic value. School: T1 school opportunity.

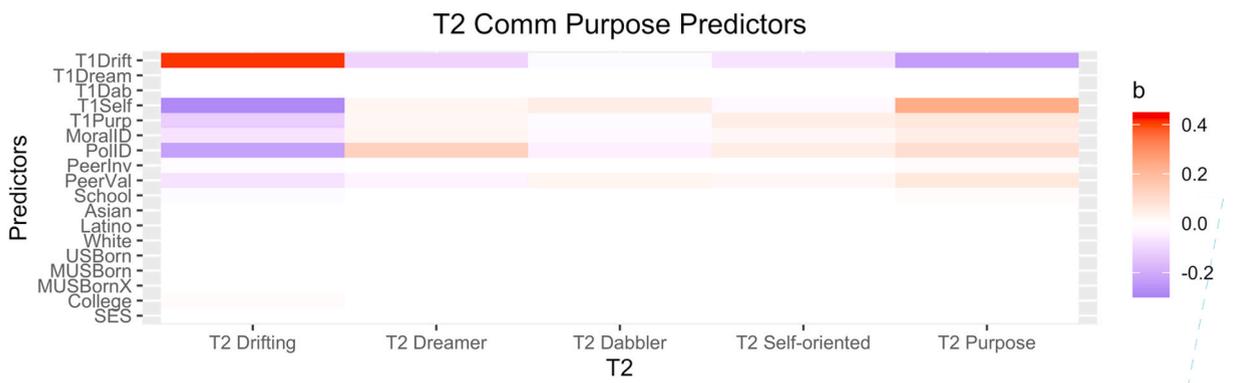


Fig. 3. Estimated coefficients in T2 community service purpose status prediction averaged over 5000 iterations. USBorn: Born in the USA. MUSBorn: Mother born in the USA. MUSBornX: Mother not born in the USA. College: T2 college boundedness.

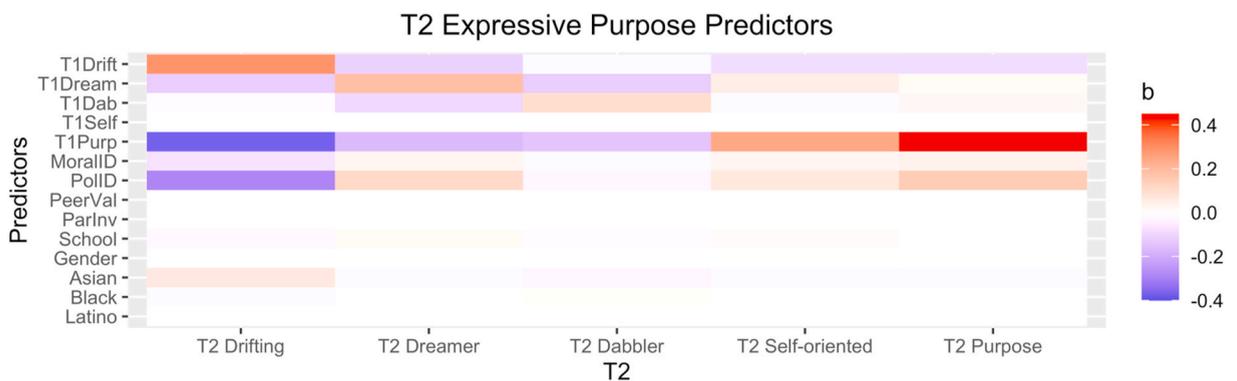


Fig. 4. Estimated coefficients in T2 expressive activity purpose status prediction averaged over 5000 iterations.

3. Discussion

In this study, we used multinomial elastic-net to explore the best prediction model with the most significant predictors for changes in civic purpose statuses in three domains: political, community service, and expressive activities. The results showed that first, as shown in prior research, Wave 1 purpose status significantly predicted Wave 2 purpose status. Second, both moral and political identity were found to be significant predictors for most of the 5000 iterations in all three domains. Participants who maintained civic purpose were likely to possess strong moral and political identity in Wave 1. Moreover, in general, external supports, including parental and peer involvement, peer civic and academic values, and school civic opportunities were positively associated with Wave 2 civic purpose.

In general, these findings are consistent with what has been reported in previous studies examining civic purpose. The importance of the baseline civic purpose statuses, and moral and political identity in predicting civic purpose development was originally reported in Han et al. (2021) and Malin, Ballard, and Damon (2015). The association between demographical and environmental factors (e.g., supports from peers, parents, and schools) and civic purpose was demonstrated by Ballard, Malin, Porter, Colby, and Damon (2015), Malin et al. (2017), and Malin, Tirri, and Liauw (2015). Despite the aforementioned consistency between findings from ours and previous studies, we were able to examine more diverse candidate predictors in predicting civic purpose changes, which could not be examined in the previous studies, with a data-driven analysis method, multinomial elastic-net regression. The relationship between candidate predictors and civic purpose changes could be tested partially in each study as the previous studies employed standard regression based on a priori hypotheses. Unlike the previous studies, we were able to identify the best prediction models among all possible candidate models.

Interestingly, supports from parents, peers, and school differently predicted changes in different domains of civic purpose when standardized coefficients were compared. Compared with other supports, parental supports did not seem to strongly predict civic purpose transitions during emerging adulthood (standardized coefficients $\ll .01$). This result is consistent with the existing literature that underscores the role of non-familial mentors in purpose development during adolescence and early adulthood (Damon, 2008). Also, the significant association between peer involvement and values, and civic purpose, might support previous research that reported that motivational influences of modeling can be strengthened when peers who are perceived to be relevant are presented as models (Han, Kim, Jeong, & Cohen, 2017; Lockwood & Kunda, 1997). Compared with the two other domains, the change in expressive activity purpose was not strongly predicted by external support factors except presence of school opportunities. Expressive activities are somehow more individualistic than traditional political activities (Stanyer, 2005), so influences from others might not significantly predict purpose in this domain.

Regarding the treatment of attrition, the results from the validation dataset prediction accuracy test may suggest that elastic-net regression would be one of possible solutions to address the issue. As shown, the regression models generated by elastic-net regression significantly more accurately predicted outcomes outside of the boundary of the training dataset used for regression. The reported superiority of elastic-net regression in validation dataset prediction accuracy might support the point that the method would possibly better predict outcomes in the cases where missing occurred due to attrition or withdrawal. This is because a regression model based on elastic-net regression is more parsimonious and less likely to be overfitted and biased compared with a regression model from standard regression (Han & Dawson, 2021).

In our study, we explored the best model to predict changes in civic purpose in three different domains with elastic-net multinomial logistic regression. The results will provide information regarding factors that most significantly predict changes in civic purpose during emerging adulthood. Furthermore, we were able to search for the simplest prediction model that could not be feasibly identified with classical regression methods (Walter & Tiemeier, 2009). Previous studies were able to test their own hypotheses focusing on different individual predictors. However, they could not examine which predictors should be used to constitute the best prediction model due to the methodological limitations. Thus, our study will provide researchers in the field with insights about how to use the novel method in data science for their future research, particularly that aim at exploring data without established hypotheses.

However, there are several limitations warranting further investigation. First, the significant gender and ethnicity-related bias in attrition could be further examined. Of course, as discussed, elastic-net regression might potentially be a viable way to address attrition given the result from the validation dataset prediction accuracy test and its tendency to regularize coefficients. However, we could not test other conventional methods to address the issue, such as imputation and inverse probability weighting (Seaman & White, 2013). Second, we focused on only one type of regularized regression, elastic-net regression. Two other more specific types of regularized regression methods, LASSO and ridge regression (Zou & Hastie, 2005), may need to be examined in future studies. Third, regarding interpretation of resultant standardized coefficients, several predictors, particularly those related to external supports and demographics, were non-zero but their effect sizes were very small (<0.01). Follow-up confirmatory studies that utilize the reported regression models as sources for a priori hypotheses shall be conducted to examine the effect sizes of such predictors with additional data.

Declaration of competing interest

The authors report no conflicting interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.adolescence.2021.09.011>.

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