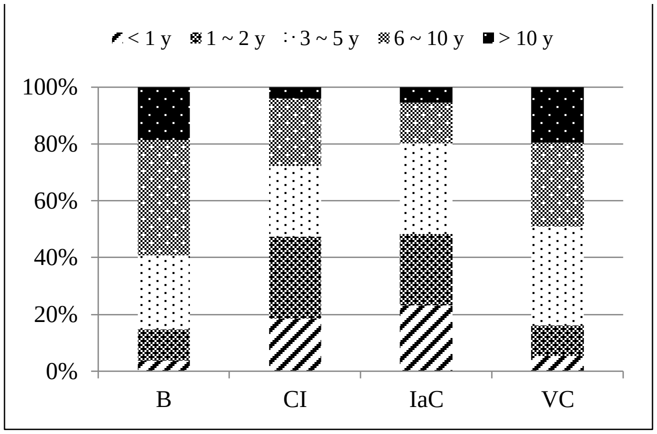

Figure 2: Summary of tool usage duration amongst survey participants.

A. *Answer to RQ-1*

We present our findings related to RQ-1 in Table I. In Table I the 'Factor' column presents the adoption factors followed by the index of the factor. The 'Group' column presents the factor group to which the adoption factor belongs. The 'Tool' column presents the tool type(s) for which the adoption factor was determined as influential, along with the AIC score and p-values recorded for that particular factor. The p-values are represented in symbols decoded in the table footer, whereas, the AIC score is enclosed within squared brackets. If an adoption factor is not influential for any of the four tool types then the corresponding row in Table I is marked in italic.

Let us use the adoption factor 'Use of <TOOL X> improves the quality of work I do (AD1)' as an example for interpreting Table I. The index of this factor is AD1, and is identified as an influential adoption factor for B tools. The corresponding AIC for this factor is 88.0 for B tools. The recorded p-value for AD1 is < 0.001. This adoption factor belongs to the factor group 'Advantages'.

Recall from Section III-D that we applied adjusted p-value using Benjamini-Hochberg correction. We use these p-values to determine which of the 26 adoption factors influence usage of B, CI, IaC, and VC tools. The adjusted p-value for B, CI, IaC, and VC tools were respectively, 0.025, 0.017, 0.009 and 0.030. As shown in Table I, 24 of the 26 adoption factors are influential for at least one type of build automation tool.

TABLE I: ADOPTION FACTORS THAT INFLUENCE USAGE

Factor	Group	Tool
Use of <TOOL X> improves the quality of work I do (AD1)	Advantages	B** [88.0]
Use of <TOOL X> make my job easier (AD2)	Advantages	B** [72.4]
Use of <TOOL X> improve my performance (AD3)	Advantages	B** [78.2]
Use of <TOOL X> is cost-effective (AD4)	*Advantages*	*B$^{!}$ [77.3]* *CI^{Ŧ} [147.3]* *IaC$^{!}$ [106.1]* *VC$^{!}$ [127.3]*
I think that the use of <TOOL X> fits well with the way I work (CP1)	Compatibility	B** [89.9] VC** [110.7]
<TOOL X> is highly configurable (CP2)	Compatibility	B** [63.6] VC** [126.8]
I had to adjust my workflow to use <TOOL X> (CP3)	Compatibility	B** [78.0] CI** [151.1] IaC** [103.1]
<TOOL X> is compatible with the technologies that I use (CP4)	Compatibility	CI** [139.1] IaC** [99.8] VC^{Ŧ} [118.7]
My use of <TOOL X> require a lot of mental effort (CX1)	Complexity	B** [78.9] VC** [116.0]
Use of <TOOL X> requires deep knowledge of <TOOL X> (CX2)	Complexity	B** [74.6] VC** [128.2]
The internal workings of <TOOL X> are complex (CX3)	Complexity	B** [86.1] VC** [125.5]
<TOOL X> present their analysis in understandable ways (CX4)	Complexity	CI** [148.0] VC** [120.3]
My organization holds frequent training on <TOOL X> (ED1)	Education	VC** [127.2]
I learned about <TOOL X> as part of my university courses (ED2)	Education	CI** [148.1]
I prefer to learn about <TOOL X> from online tutorials (ED3)	Education	B** [89.1] CI** [145.5] VC** [125.3]
I prefer to learn about <TOOL X> from their manual (ED4)	Education	B** [88.9] VC** [131.5]
I learn about <TOOL X> as I perform my professional duties (ED5)	Education	B** [81.8] CI$^{\rho}$ [140.7] VC** [121.5]
I prefer to learn about <TOOL X> from my colleagues (ED6)	*Education*	*B$^{!}$ [85.7]* *CI$^{!}$ [139.7]* *IaC$^{!}$ [106.6]* *VC$^{!}$ [131.1]*
Use of <TOOL X> is visible within the community of <TOOL X> users (OB1)	Observability	B** [77.5] VC** [122.6]
I have seen how my colleagues use <TOOL X> (OB2)	Observability	VC** [122.5]

Use of <TOOL X> is not very visible in my organization (OB3)	Observability	IaC** [99.1]
I can easily observe my colleagues' use of <TOOL X> in my organization (OB4)	Observability	CI** [146.2] IaC** [105.3] VC** [127.7]
I know how I can satisfactorily try out variation of the use of <TOOL X> (TR1)	Trialability	IaC** [105.2] VC** [124.8]
<TOOL X> is available for me to adequately try or not (TR2)	Trialability	VC** [127.8]
I experiment with <TOOL X> whenever necessary (TR3)	Trialability	VC** [127.4]
I did not have to extend very much effort to try out <TOOL X> (TR4)	Trialability	CI** [142.0]

Ŧ indicates a p-value of 0.020 ρ indicates a p-value of 0.010
** indicates a p-value of < 0.001 ! indicates a p-value of > 0.191

B. Answer to RQ-2

In our study, RQ-2 focuses on prioritizing the identified adoption factors that influence usage of B, CI, IaC, and VC tools. We use Table II to present our findings related to RQ-2. In Table II the 'Prioritization' column lists the adoption factors that are influential for B, CI, IaC, and VC tools, and sorted according to their MIL scores. We used the AIC scores presented in Table I to compute the MIL scores.

TABLE II: PRIORITY OF ADOPTION FACTORS

Tool	Prioritization
B	CP2 > AD2 > CX2 > OB1 > CP3 > AD3 > CX1 > ED5 > CX3 > AD1 > ED4 > ED3 > CP1
CI	CP4 > ED5 > TR4 > ED3 > OB4 > CX4 > ED2 > CP3
IaC	OB3 > CP4 > CP3 > TR1 > OB4
VC	CP1 > CX1 > CP4 > CX4 > ED5 > OB2 > OB1 > TR1 > ED3 > CX3 > CP2 > ED1 >TR3 > OB4 > TR2 > CX2 > ED4

We summarize our findings related to RQ-2 as following:

- For **B** tools, the highest priority adoption factor is '<TOOL X> is highly configurable' (**CP2**). Overall, Education related adoption factors have lower priority.
- For **CI** tools, the highest priority factor is '<TOOL X> is compatible with the technologies that I use' (**CP4**).
- For **IaC** tools, the highest priority factor is 'Use of <TOOL X> is not very visible in my organization' (**OB3**). After OB3, the adoption factor **CP4** has higher priority than other adoption factors.
- For **VC** tools, the highest priority factor is 'I think that the use of <TOOL X> fits well with the way I work' (**CP1**).

V. DISCUSSION

In this section we discuss our findings and possible implications for practice.

From our analysis presented in Section IV, we have observed that the ability to customize B tools influence their usage. Furthermore, for CI and VC tools, usage is influenced by how well the tools fit with practitioners' style of work. This finding also indicates that practitioners do not want to change their usual style of work, and might prefer tools that are easy to integrate with their usual style of work. Usage of build automation tools might increase if they are customizable and if they do not hinder practitioners' usual style of work.

> *To increase usage of build automation tools, teams can select build automation tools that fit well with the usual work style of the team members and that can be easily customized to the needs of the team members.*

Findings from Section IV indicate that for B tools usage is influenced by how well B tools are used within the practitioners' community. For CI, IaC, and VC tools usage is dependent on how these tools are used within practitioners' peers and the organizations they work for. These findings imply that generally speaking, practitioners' are more likely to adopt build automation tools that are used by their peers or by their community. Blog posts, conferences, and live demonstrations might help in increased usage of build automation tools.

> *Practitioner-led demonstrations of build automation tools at company events and public events, such as conferences and meetups, might help in increasing the usage of build automation tools.*

Unlike adoption of security tools [8], from our analysis of build automation tools, we observe practitioners' preference of tools that are customizable and can easily be used without hindering their natural style of work. We consider this particular observation as unexpected, yet explainable. Build automation tools are often applied to achieve continuous deployment (CD). One of the core practices of CD is 'shepherding your own changes' that implies a practitioner who makes software changes is responsible to fix the errors induced by those software changes, all the way from development, through testing, finally to deployment [11]. The practice of shepherding software changes implicitly recommends CD practitioners to be familiar with tools that is related to every phase of software deployment such as Git, Jenkins, Maven, and Puppet. These tools have different purposes, yet compatible with each other to facilitate CD [7]. Practitioners might be more willing to use those build automation tools that fits their existing workflow, or for which they have to adjust their workflow with minimum effort. Making build automation tools open source might also help in this regard.

> *Toolsmiths might influence usage of build automation tools by considering the existing workflow of software practitioners' and designing related tools accordingly*.

VI. Limitations

We present the limitations of this paper as following:

Survey response rate: Our overall survey response rate was 9.9%, which is not ideal. Low response rate however is not uncommon in the field of software engineering. Buse and Zimmermann [25] reported a response rate of 6% in their research study.

Factors used in the survey: We include 26 adoption factors in our survey. These factors belong to the five DOI innovation factors and education. We acknowledge the list of adoption factors is not comprehensive.

Factor selection process: Our selection process of identifying relevant factors depends on the judgment of two individuals. We acknowledge that this part of our research methodology is subjective.

VII. Conclusion

In this research study, we use a quantitative survey analysis to identify the adoption factors that influence usages of build automation tools. We collected responses from practitioners, and conducted analysis on the collected survey responses using logistic regression. Our analysis indicates that compatibility and observability-related factors have relatively more influence on build automation tool usage. We hope that findings from this study will help practitioners in executing the appropriate steps necessary to increase usage of build automation tools.

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