STATE OF CONTINUOUS DELIVERY REPORT

The Evolution of Software Delivery Performance

Created by

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KEY INSIGHTS

- The adoption of DevOps practices continues to increase, with 84% of developers in DevOps-related activities as of Q1 2023. →

- Testing applications for security measures has become the second most popular DevOps-related activity, with 37% of developers including it as an activity they are involved in. →

- There is no clear indication that the velocity for code changes has increased over the last two and a half years among the general developer population. Despite the ubiquity of DevOps practices, the increase in complexity of projects may be counteracting the benefits to development velocity. →

- The correlation between speed and stability metrics remains strong, where 30% of high performers for code changes lead time are also high performers for service restoration. →

- The average number of DevOps-related technologies used by developers has remained stable over the last year at 4.5 technologies. →

- There is a strong correlation between the number of DevOps technologies used by developers and their likelihood of being a top performer across all three performance metrics tracked: lead time for code changes, deployment frequency, and time to restore service. →

- Using CI/CD tools is correlated with better software delivery performance across all metrics. →

- While application security testing can improve development velocity, the way it is implemented is crucial. Automated and continuous testing can be more effective than manual testing, but it is not a universal case. →

- While using CI/CD tools can improve development performance, an increasing number of self-hosted CI/CD tools used by DevOps practitioners does not lead to greater performance, possibly due to interoperability issues. →

INTRODUCTION

01

Continuous Delivery (CD) is a software development practice that enables developers to release small but frequent software updates reliably and safely. Closely linked to the broader DevOps cultural movement, CD consists of a set of practices that aim to automate and streamline the software delivery process. These practices, in turn, allow developer teams to innovate faster by collecting regular user feedback and prioritise the product features and fixes that matter. To what extent, really, have developers embraced CD practices and the DevOps culture to increase the effectiveness of their software development and release process?

In this report, commissioned by the Continuous Delivery Foundation (CDF) and authored by SlashData, we explore the current state of the CD developer ecosystem and how this has evolved over the past two and half years. We will look at what proportion of developers are involved in the broader DevOps space and how many work with CD technologies in particular.

Moreover, we will see how developers' software delivery performance has changed over time. Finally, we will explore how developers' usage of multiple continuous integration and continuous delivery (CI/CD) tools contribute to software delivery performance, as well as how approaches to application security testing change delivery performance.

The findings in this report are based on data from SlashData's past six Developer Nation surveys, which reached more than 125,000 respondents worldwide over two and half years, from Q3 2020 to Q1 2023.

WHO IS INTO DEVOPS?

02

2. Who is into DevOps?

For the sixth consecutive iteration of SlashData's biannual Developer Nation survey, we asked developers where they are involved in any of the activities that commonly fall under the DevOps spectrum, such as Continuous Integration (CI), CD, and infrastructure monitoring.

As of Q1 2023, only 16% of developers are not involved in any DevOps-related activities. This represents a 7 percentage point decrease from Q1 2022, indicating a continual increase in the adoption of practices that aim to increase an organisation's ability to deliver software at high velocity. Despite the increase in developers involved in DevOps, only 7% describe their role as 'DevOps engineer/specialist', the same percentage as in Q1 2022. This highlights that even as more developers adopt DevOps practices, they do so without necessarily self-identifying as 'specialists'.

In the last year, we added an additional option for developers to include testing their applications for security measures among their DevOps activities. This immediately rose to the second most popular activity, with 37% of developers including it as an activity they are involved in. Outside of this new practice, the relative ranking of activities has remained consistent, but with an increase in adoption across the board.

Monitoring software and infrastructure saw the largest increase in relative adoption, rising by 4 percentage points in the last year, to 40%. With this, monitoring software and infrastructure performance remains as the most popular DevOps-related activity, with testing applications for security measures close behind. Using CI to build and test code changes is now the third most popular activity, with 37% of developers involved. Nearly half (49%) of developers use either CI or CD, up from 47% in Q1 2022, but only a little more than one in five (22%) developers are using CI and CD approaches to automate all building, testing, and deployment of code to production. This corresponds to a small increase of 2 percentage points over the past 12 months, which continues the trend of a gradual increase in the adoption of CI/CD.

2. Who is into DevOps?

As noted in previous reports, DevOps practices have been broadly adopted across all sectors of the software economy. In fact, all regions have seen an increased adoption within their sectors. The sectors that had the lowest adoption of DevOps-related activities in Q1 2022, games and desktop apps, have seen large increases in their usage. 81% of those involved in game development are using DevOps practices currently, compared to 73% in Q1 2022. Meanwhile, the desktop apps sector (85%) has overtaken mobile apps (84%), a 7 percentage point increase since Q1 2022.

In terms of organisation sizes, our data reveal that medium-sized businesses have the highest involvement in DevOps practices (94%). However, organisations of other sizes have seen significant growth in terms of the proportion of developers undertaking DevOps activities. Both small businesses and large enterprises now have more than 90% of their developers involved in DevOps-related activities, up by 6 and 5 percentage points, respectively, from Q1 2022. Further, 79% of freelancers are now using DevOps practices, up from 71% last year.

More than 80% of developers are now involved in DevOps activities

% of developers (n=23,387)

Which of the following development activities are you involved in?

Activity	%
I monitor software and/or infrastructure performance	40%
I test my applications for security vulnerabilities	37%
I use continuous integration to automatically build and test my code changes	37%
I approve code deployments to production	36%
I use continuous delivery/deployment to automate my code deployments	34%
I programmatically provision and manage IT infrastructures	29%
I create automated regression tests and/or validation checks	27%
I build CI/CD pipelines	23%
Other DevOps related activities	1%
None of the above	16%

More than 90% of developers in industrial IoT are involved in DevOps
% of developers involved in DevOps activities by software sector (n=23,387)

Involvement in DevOps by software sector

■ Involved in DevOps   ■ Not involved in DevOps

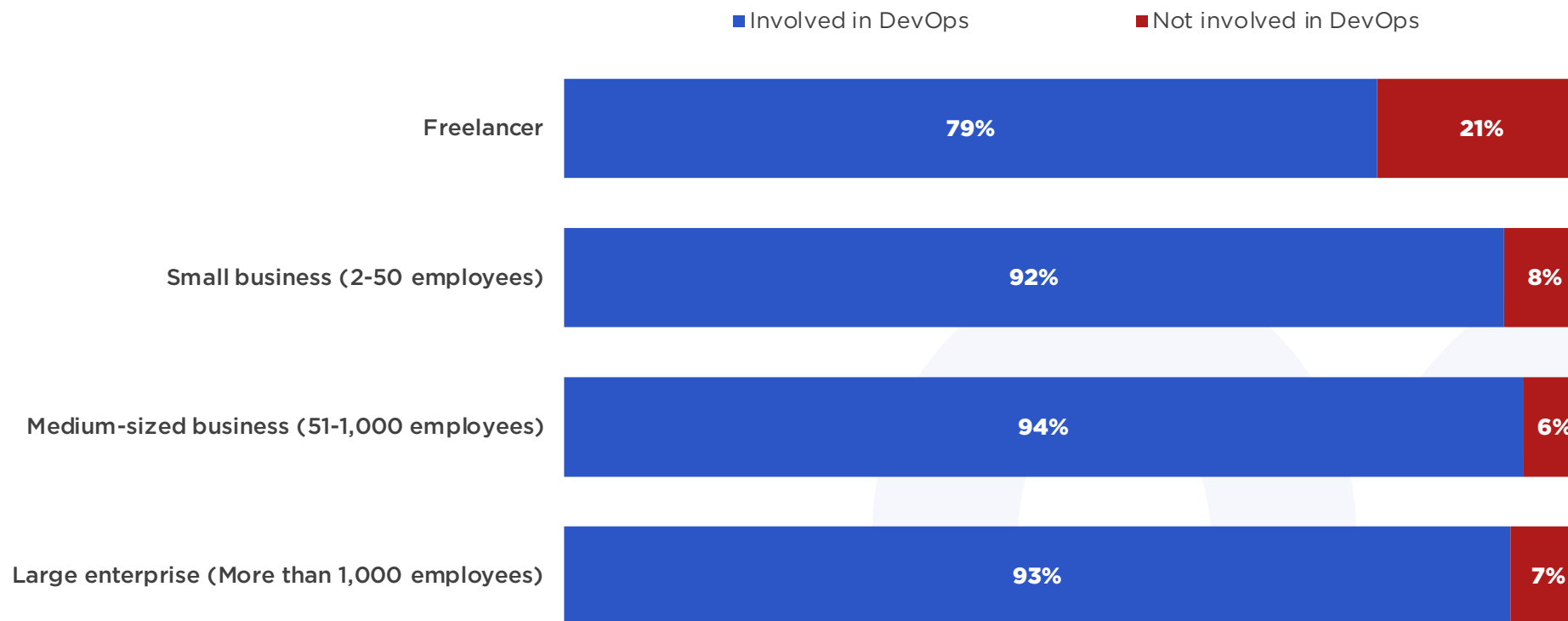| Sector	Not involved	Involved
Industrial IoT	8%	92%
Embedded software	9%	91%
Apps/extensions for 3rd party ecosystems	9%	91%
Consumer electronics devices	10%	90%
Backend services	11%	89%
Augmented reality including non-developers	11%	89%
Virtual reality including non-developers	12%	88%
Data science	12%	88%
Web apps / Software as a Service	13%	87%
Machine learning / AI	15%	85%
Desktop apps	15%	85%
Mobile apps	16%	84%
Games	19%	81%

2. Who is into DevOps?

Developers at medium-sized businesses have embraced DevOps practices

% of developers involved in DevOps activities by company size (n=16,987)

DevOps involvement by organisational size

■ Involved in DevOps   ■ Not involved in DevOps

Company size	Involved in DevOps	Not involved in DevOps
Freelancer	79%	21%
Small business (2-50 employees)	92%	8%
Medium-sized business (51-1,000 employees)	94%	6%
Large enterprise (More than 1,000 employees)	93%	7%

HOW HAS SOFTWARE DELIVERY PERFORMANCE EVOLVED?

03

3. How has software delivery performance evolved?

For individuals and organisations to measure the effectiveness of CD efforts, a set of robust performance metrics are required. In our survey, we ask developers about their performance for three of the four DORA metrics[1]: lead time for changes, deployment frequency, and time to restore service. These are used to measure software delivery performance and are predictive of organisational performance.

Within the general developer population, our data show no clear signs that the velocity for code changes has increased over the last two and a half years. Over this period, the percentage of top performers — those with lead times of less than one day — has fluctuated between 13% and 17% and currently stands at 15% in Q1 2023. It is possible that the increase in DevOps practices has not yet trickled down to positively impact performance. Moreover, the ubiquity of DevOps practices may be increasing the complexity of projects developers are involved in, counteracting the benefits to development velocity.

Among developers at large enterprises (more than 1,000 employees) we began to see an increase in top performers for lead time for code changes to 21% in Q1 2022, which has since decreased to 16%. However, despite the percentage of top performers decreasing, we still see that 40% of developers have lead time changes of less than one week, the second highest since we began asking developers.

For deployment frequency, we have seen a continual decrease in the proportion of developers who are top performers – those with multiple deploys per day. However, this decrease has been small over the scale that we have been monitoring, which, while concerning, does not indicate a huge crisis. We have also seen an increase in those deploying between once per hour and once per week. This suggests that increased DevOps practice adoption may help developers improve their performance, but reaching the highest performance levels is still a greater challenge.

[1] *Forsgren, N., Humble, J., Kim, G. 2018. Accelerate: The Science of Lean Software and DevOps: Building and Scaling High Performing Technology Organizations. IT Revolution Press*

3. How has software delivery performance evolved?

There has been a steady deceleration in the time it takes developers to restore service across the five survey waves from Q3 2020 to Q3 2022. However, in Q1 2023 this trend has abated slightly. With more than a third of all DevOps practitioners (34%) taking longer than a week to restore service, the proportion of low performers has continued to trend upward over the last two and half years. Conversely, the proportion of top performers has continued to decrease. With 12% of DevOps practitioners taking less than an hour to restore service, it is no longer dropping precipitously.
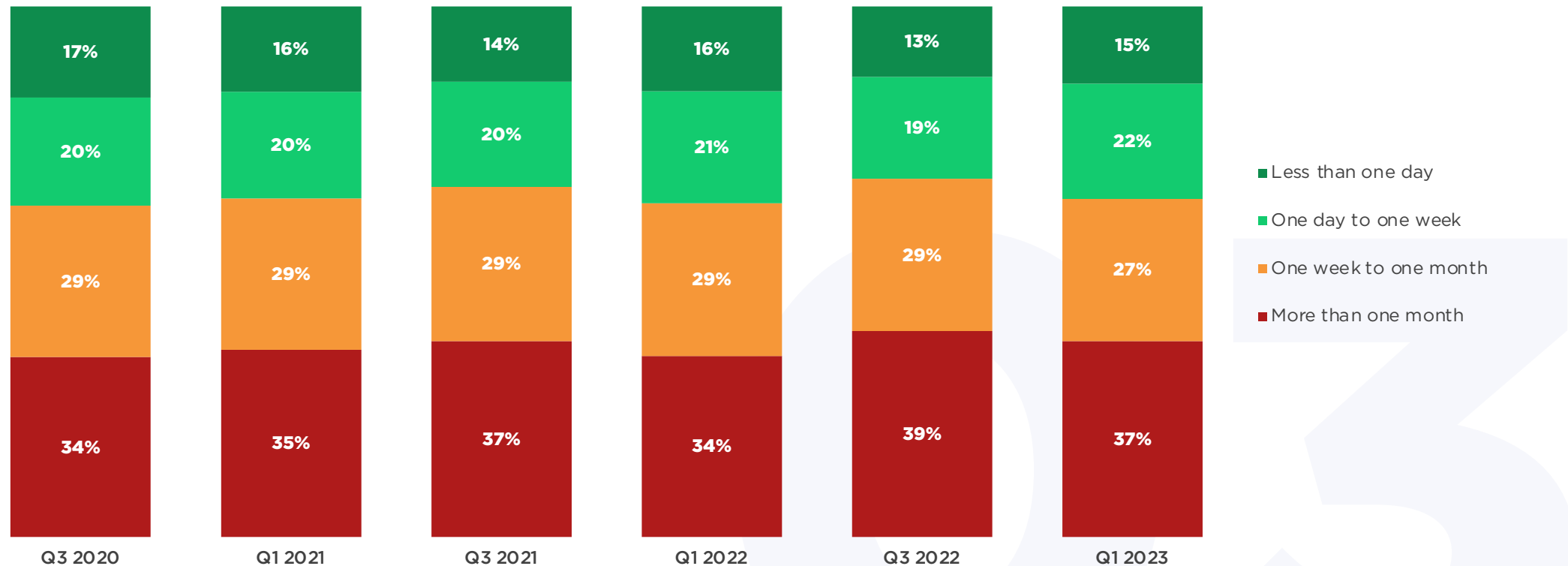
The speed and stability metrics remain strongly correlated, rather than one compromising the other. More than half of developers (56%) who are low performers on lead time for code changes are also low performers for service restoration time. At the other end of the spectrum, 30% of those who are high performers for lead time are also high performers for service restoration. A further 45% of lead-time high performers take between one hour and one day to restore service, indicating good stability, even if these developers are not top performers.

3. How has software delivery performance evolved?

The proportion of top performers for lead time for code changes has returned to levels comparable to a year ago

% of DevOps practitioners (Q3 2020 n=10,252 | Q1 2021 n=7,814 | Q3 2021 n=8,784 | Q1 2022 n=9,640 | Q3 2022 n=13,108 | Q1 2023 n=13,048)

Software delivery performance - Lead time for code changes

	Q3 2020	Q1 2021	Q3 2021	Q1 2022	Q3 2022	Q1 2023
Less than one day	17%	16%	14%	16%	13%	15%
One day to one week	20%	20%	20%	21%	19%	22%
One week to one month	29%	29%	29%	29%	29%	27%
More than one month	34%	35%	37%	34%	39%	37%

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Q3 2021 marked a high point for deployment frequency performance

% of DevOps practitioners (Q3 2020 n=10,119 | Q1 2021 n=7,613 | Q3 2021 n=8,619 | Q1 2022 n=9,473 | Q3 2022 n=12,912 | Q1 2023 n=12,747)
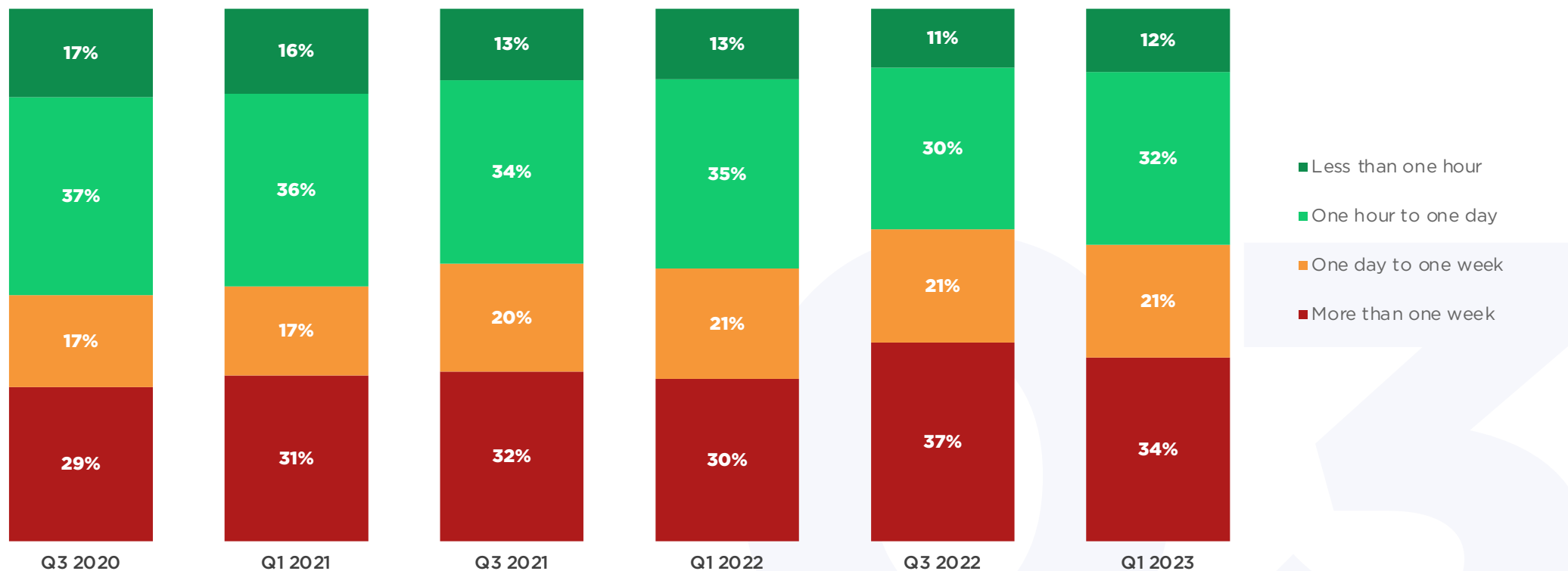
Software delivery performance - Deployment frequency

Legend:
- ■ Multiple deploys per day
- ■ Once per hour to once per week
- ■ Once per week to once per month
- ■ Less frequently than once per month

	Q3 2020	Q1 2021	Q3 2021	Q1 2022	Q3 2022	Q1 2023
Multiple deploys per day	12%	11%	11%	11%	9%	10%
Once per hour to once per week	21%	20%	19%	23%	22%	23%
Once per week to once per month	32%	32%	33%	33%	31%	32%
Less frequently than once per month	35%	37%	37%	33%	37%	35%
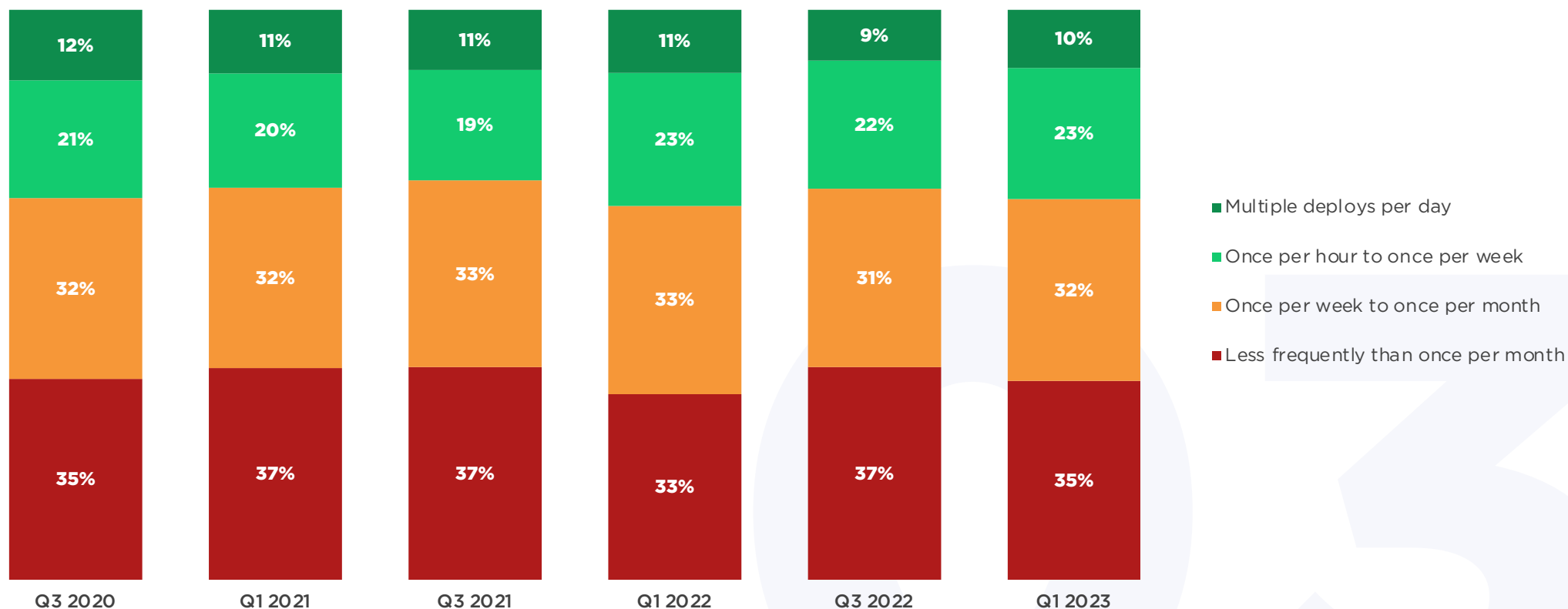
Time to restore service performance has been decreasing over the last two and a half years

% of DevOps practitioners (Q3 2020 n=9,349 | Q1 2021 n=7,221 | Q3 2021 n=8,126 | Q1 2022 n=8,927 | Q3 2022 n=12,385 | Q1 2023 n=12,250)
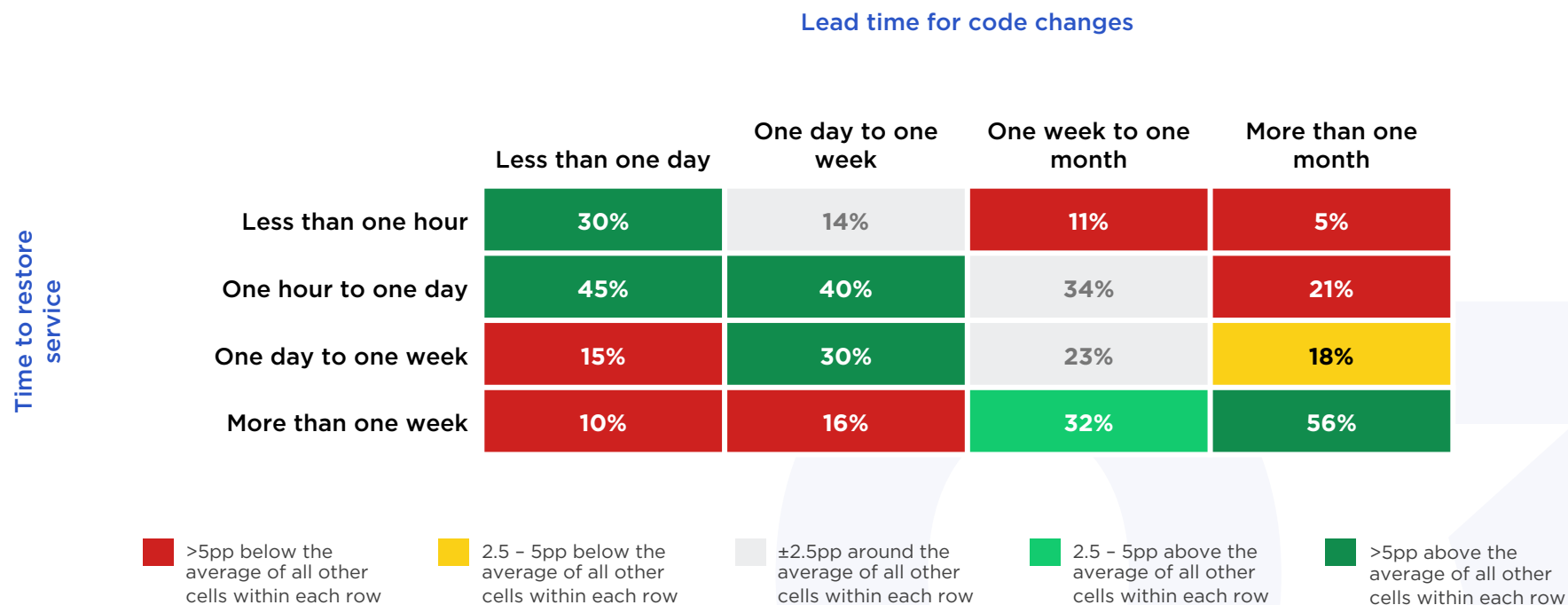
Software delivery performance - Time to restore service

Legend:
- Less than one hour
- One hour to one day
- One day to one week
- More than one week

	Q3 2020	Q1 2021	Q3 2021	Q1 2022	Q3 2022	Q1 2023
Less than one hour	17%	16%	13%	13%	11%	12%
One hour to one day	37%	36%	34%	35%	30%	32%
One day to one week	17%	17%	20%	21%	21%	21%
More than one week	29%	31%	32%	30%	37%	34%

Lead time for code changes and time to restore service are closely linked

% of DevOps practitioners (n=11,616)

Lead time for code changes

Time to restore service	Less than one day	One day to one week	One week to one month	More than one month
Less than one hour	30%	14%	11%	5%
One hour to one day	45%	40%	34%	21%
One day to one week	15%	30%	23%	18%
More than one week	10%	16%	32%	56%

Legend:
- 🟥 >5pp below the average of all other cells within each row
- 🟨 2.5 – 5pp below the average of all other cells within each row
- ⬜ ±2.5pp around the average of all other cells within each row
- 🟩 2.5 – 5pp above the average of all other cells within each row
- 🟩 >5pp above the average of all other cells within each row

WHAT DRIVES SOFTWARE DELIVERY PERFORMANCE

04

4.1 DevOps technology usage

In our survey, we capture information on a broad range of DevOps-related technologies that developers use, ranging from tools for managing source code to tools for monitoring application performance. The average number of technologies that DevOps practitioners use, of those listed, has remained stable over the last year, at 4.5 technologies, on average.

No technology has seen significant growth in the proportion of developers using them. The largest increase was observed for those using application security testing technologies, growing by 3 percentage points to 28% over the last year. However, some technologies have seen a drop in their usage rates. Notably, the use of self-hosted CI/CD tools has dropped from 32% in Q1 2022 to 23% in Q1 2023.

Next, we analyse if the number of these DevOps technologies used by developers correlates with improved software delivery performance. Our motivation is to examine whether having developers with a greater breadth of exposure to different aspects of DevOps and technologies to support them helps to collectively drive performance. On the contrary, it may be beneficial for developers to have a narrow and specific focus or responsibility and therefore have fewer tools or technologies to manage.

4. What drives software delivery performance

The results of this analysis resoundingly support the breadth of developers' involvement with DevOps technologies being highly beneficial to development velocity. There is a strong correlation between the number of technologies used and their likelihood to be a top performer. Even more important is that this finding is true across all three metrics we track, indicating that the benefit of utilising a breadth of technologies benefits DevOps practitioners across all areas of development velocity.

According to our data, 47% of practitioners using a single technology belong to the low-performing groups for lead time for code changes, 44% to low performance of deployment frequency, and 55% to the time to restore service low-performance group. On the contrary, those who are using 10 or more technologies are more likely to be in the top-performing group than the low-performing group for lead time and restoration time, with deployment frequency being roughly equal.

The usage rate of self-hosted CI/CD tools has seen a significant decrease in the last 12 months

% of DevOps practitioners (Q1 2022 n=14,176 | Q1 2023 n=19,774)

DevOps technologies used in the past 12 months

Technology	Q1 2023	Q1 2022
Issue tracking	39%	38%
Source control management	38%	41%
Test automation/management	34%	34%
Collaboration / knowledge-sharing tools	32%	35%
Application performance monitoring/observability	31%	37%
Agile project management tools	31%	34%
Application security testing	28%	25%
Infrastructure as Code	27%	27%
Infrastructure monitoring	26%	26%
Configuration management	26%	26%
Managed CI/CD services (e.g. Azure Pipelines, AWS CodePipeline)	25%	26%
Self-hosted CI/CD tools (e.g. Jenkins, TeamCity)	23%	32%
Cloud-based IDEs	23%	23%
Incident management	20%	20%
Artifact repositories	20%	19%
Feature flagging	15%	12%
GitOps	14%	
None of the above	5%	5%

Practitioners using more DevOps technologies are increasingly likely to be top performers in lead time for code changes

% of DevOps practitioners by number of DevOps technologies used (n=13,048)

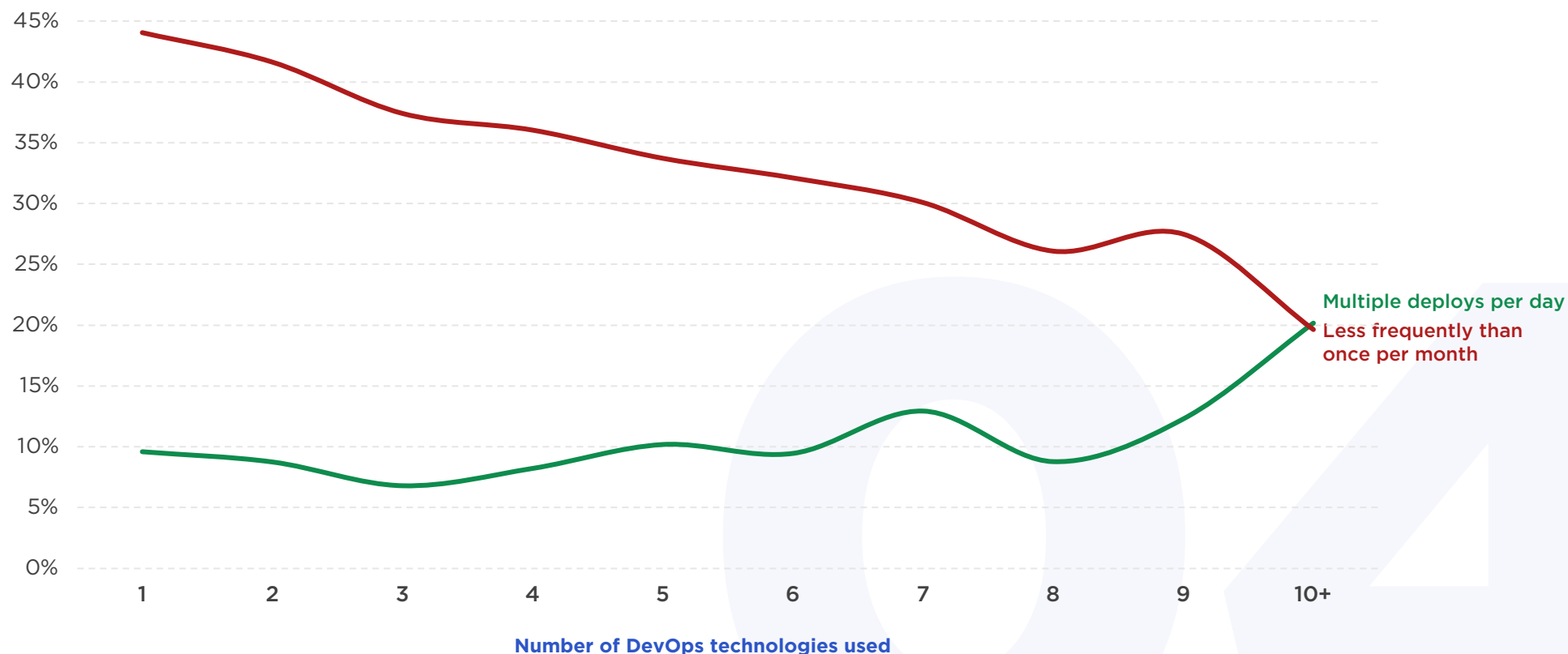**Code lead time for changes against number of DevOps technologies used**

Less than one day

More than one month

Number of DevOps technologies used
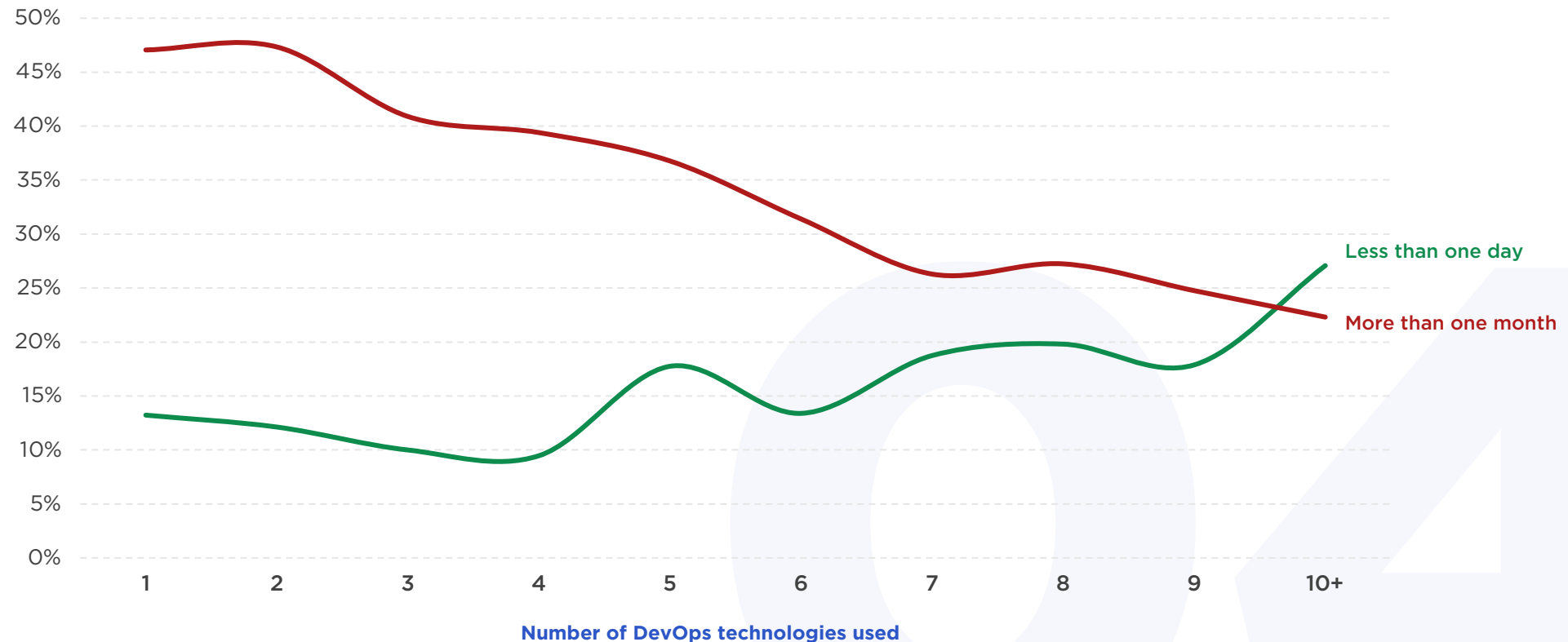
4. What drives software delivery performance

Those using 10 or more tools are more than twice as likely to be high performers than those only using a single technology

% of DevOps practitioners by number of DevOps technologies used (n=12,746)

Deployment frequency against number of DevOps technologies used

Multiple deploys per day

Less frequently than once per month

Number of DevOps technologies used

A greater breadth of DevOps tools used is associated with dramatically fewer low performers for service restoration

% of DevOps practitioners by number of DevOps technologies used (n=12,249)

Time to restore service against number of DevOps technologies used

Less than one hour

More than one week

Number of DevOps technologies used
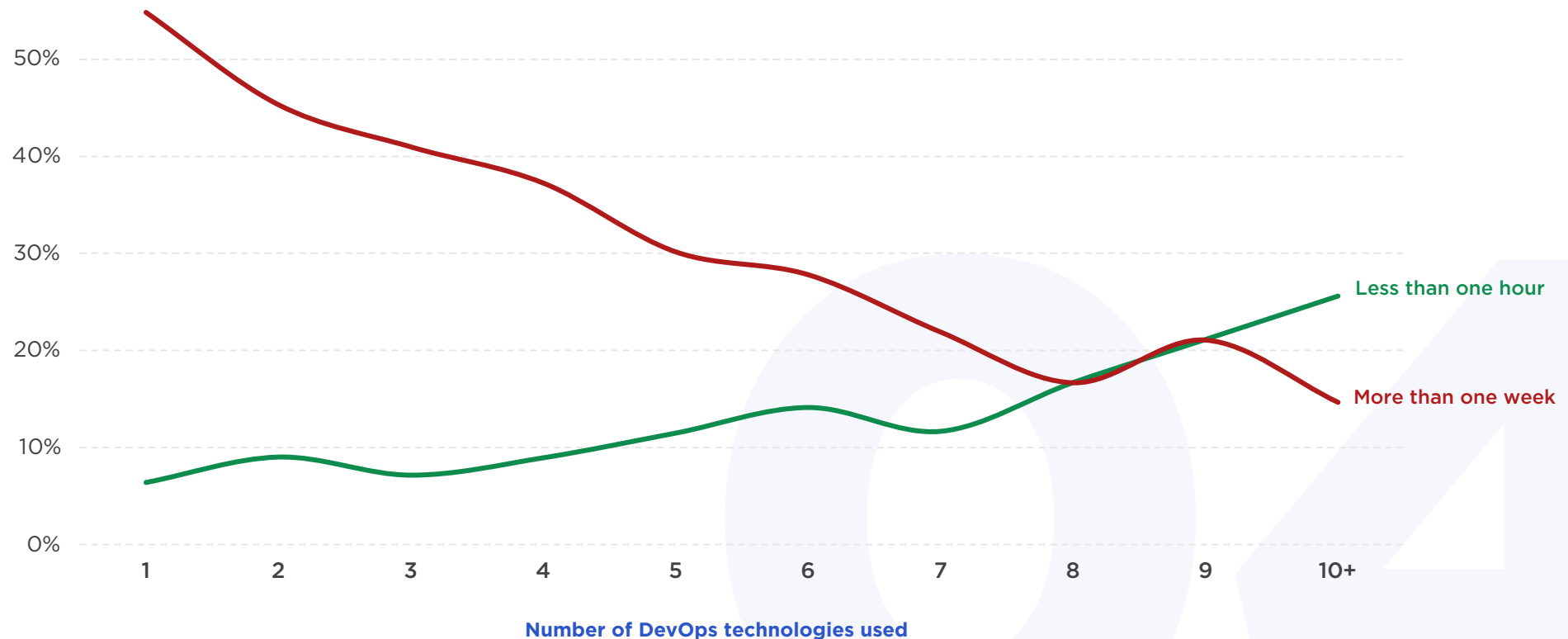
4.2 CI/CD and application security testing

While the breadth of technology usage has been shown to be beneficial to development velocity, certain tools are found to be more impactful than others. When comparing DevOps practitioners who use CI/CD tools – managed or self-hosted – against those who do not, we can see a distinct difference in performance across all three development metrics.

Developers who use CI/CD tools are more likely to be top performers compared to those who do not. This is particularly stark for top performers in time to restore service, where those who use CI/CD tools (17%) are more than twice as likely to be top performers than those who do not (8%). However, what may be of more importance is the likelihood that a practitioner will be in the low-performing groups. For those not using CI/CD tools, the low-performing groups are the largest proportion of developers for all metrics. The reverse is true for those using CI/CD tools, where the low-performing group is not the largest group for any of the metrics and is substantially smaller than those who do not use CI/CD tools.

4. What drives software delivery performance

The way various DevOps tools are used also has an impact on performance. In our Q3 2022 survey, we asked DevOps practitioners who practise application security testing what kind of testing they did. Further, we asked them if it was automated and continuous, manual, or ad-hoc. In the three examples shown, we can see different effects of this in practice.

Developers who perform build-time security checks in an automated and continuous fashion are the most likely to be top performers, and the least likely to be low performers, across all three metrics, of the types shown. Contrast this against those who perform this testing manually, who are the worst performers across the three metrics. Similarly, for developers performing test-time security checks, those using automated testing are slightly more likely to be top performers than those doing so manually. However, they are several percentage points less likely to be in the low-performing groups.
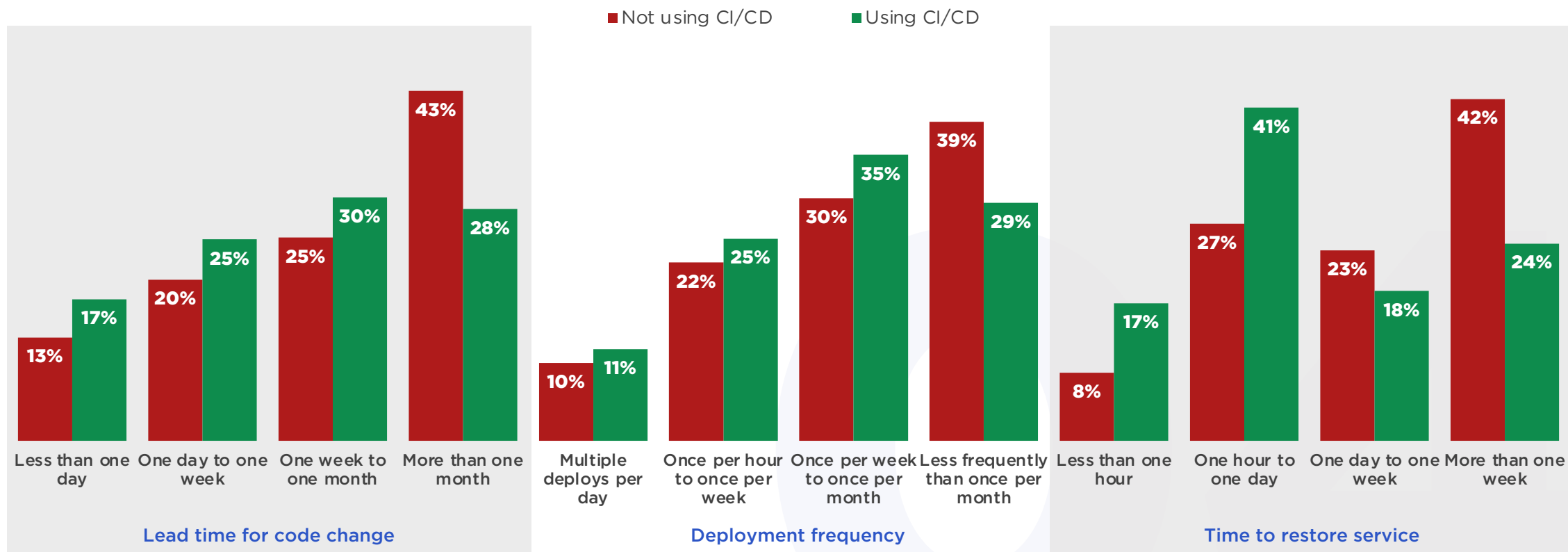
While application security testing can be associated with increased development velocity, it is not a simple binary switch, nor does automating the processes universally help developers. Those who are introducing application security testing measures should carefully consider their uses and ensure they operate well within their current processes, otherwise they may not benefit from development velocity as intended.

Those who use CI/CD tools are significantly less likely to be low performers than those who do not

% of DevOps practitioners for each performance metric (Lead time for code change n=13,048 | Deployment frequency n=12,747 | Time to restore service n=12,250)
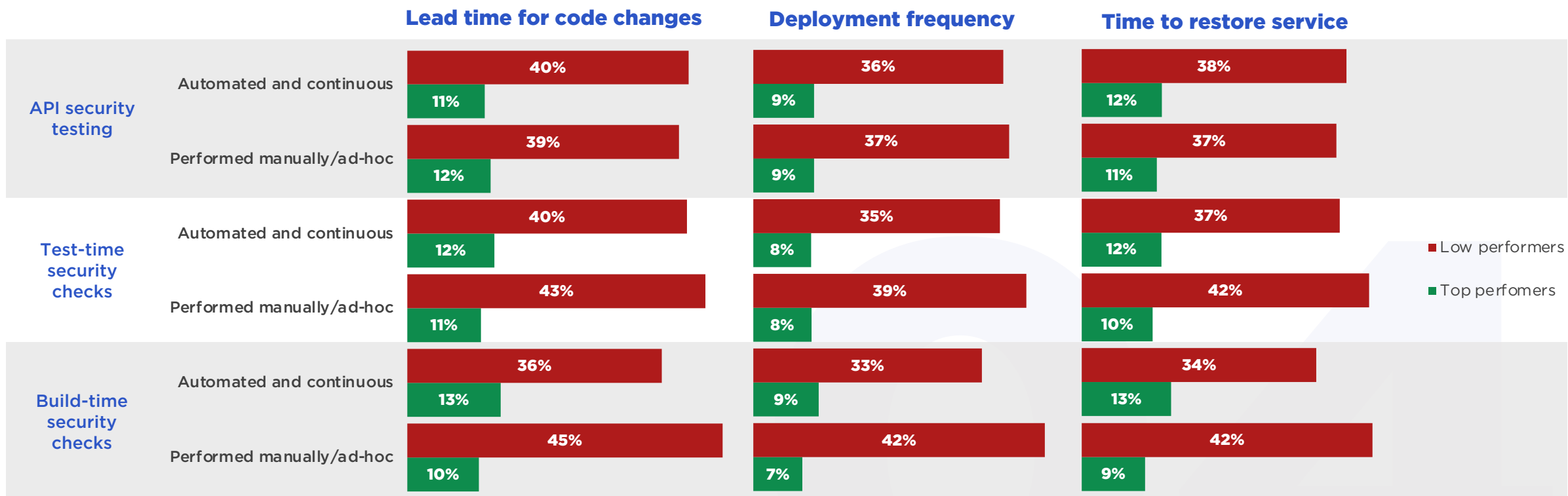
Performance against CI/CD usage

■ Not using CI/CD   ■ Using CI/CD

Lead time for code change

	Not using CI/CD	Using CI/CD
Less than one day	13%	17%
One day to one week	20%	25%
One week to one month	25%	30%
More than one month	43%	28%

Deployment frequency

	Not using CI/CD	Using CI/CD
Multiple deploys per day	10%	11%
Once per hour to once per week	22%	25%
Once per week to once per month	30%	35%
Less frequently than once per month	39%	29%

Time to restore service

	Not using CI/CD	Using CI/CD
Less than one hour	8%	17%
One hour to one day	27%	41%
One day to one week	23%	18%
More than one week	42%	24%

4.3 Interoperability of CI/CD tools

We have previously shown that using CI/CD tools increases the likelihood of DevOps practitioners being top performers across lead time for code changes, deployment frequency, and time to restore service. However, there are noted concerns that interoperability issues may emerge when multiple CI/CD tools are used in conjunction with one another.

Across all three of the development performance metrics used, we can see that an increased number of self-hosted CI/CD tools used is not associated with greater performance. For lead time for code changes and deployment, we see minimal increases in the likelihood of DevOps practitioners being high performers as they increase the number of CI/CD tools used. For both, those using five CI/CD tools see the lowest percentage of top performers, uplifting for those using six or more, but not to levels above those using fewer CI/CD tools.

We note that the proportion of top performers remains flat while that of low performers increases dramatically, with an increasing number of self-hosted CI/CD tools used. This suggests that there is a diminishing return from increasing the number of CI/CD tools a developer uses. The usage of an increasing number of tools may also be a response to increased complexity, which is having negative impacts on the performance of these developers. Similarly, the integration of multiple tools may not be optimally implemented, leading to function overlap that is impacting performance.

The time to restore service metric sees the most dramatic increase in low performers from the increased number of self-hosted CI/CD tools used. Among those using one self-hosted CI/CD tool, the likelihood of being a top performer is greater than being a low performer. However, once a practitioner passes two or three CI/CD tools, this reverses dramatically. Among developers who use more than five tools, more than half are low performers, and less than 10% are top performers.

An increasing number of tools used having such a strongly negative impact on service restoration time has multiple possible explanations. However, interoperability issues may be at the centre of many of them. Multiple tools may make it challenging to integrate all of them well, leading to a greater challenge to isolate the service-impacting issue at hand. Further, a lack of standardisation between tools may make it more difficult for all tools to work together well, which also increases the challenge of addressing service failure.

Using multiple self-hosted CI/CD tools can lead to long response times to service failure

% of DevOps practitioners for each performance metric (Lead time for code change n=13,048 | Deployment frequency n=12,746 | Time to restore service n=12,249)

Lead time for code changes performance against the number of CI/CD self-hosted tools used

More than one month

Less than one day

Deployment frequency performance against the number of CI/CD self-hosted tools used

Less frequently than once per month

Multiple deploys per day

Number of CI/CD self-hosted tools used
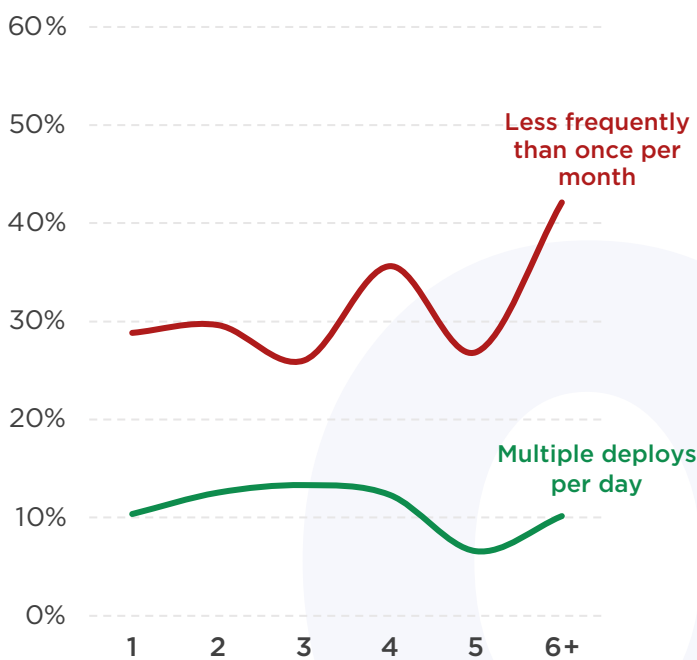
Time to restore service performance against the number of CI/CD self-hosted tools used

More than one week

Less than one hour
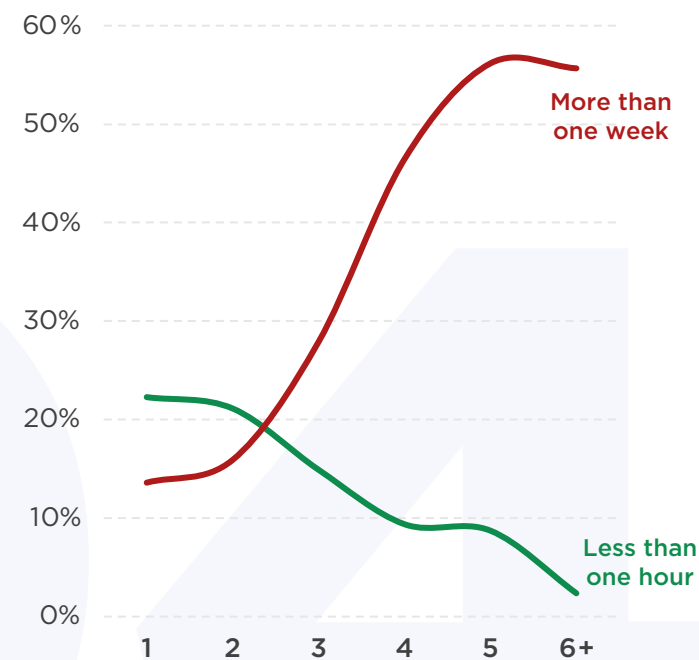
METHODOLOGY

The Developer Nation Survey

The 24th edition of the Developer Nation survey reached nearly 26,000 respondents from 166 countries around the world. As such, the Developer Nation series of surveys continues to be the most global independent research on mobile, desktop, industrial IoT, consumer electronics, embedded, third-party app ecosystems, cloud, web, game, augmented and virtual reality, and machine learning developers and data scientists combined, ever conducted. The report is based on a large-scale, online developer survey designed, produced, and carried out by SlashData over a period of ten weeks between December 2022 and February 2023.

Respondents to the online survey came from 166 countries, including major app and machine learning development hotspots such as the US, China, India, Israel, the UK, and Russia, even stretching all the way to Kenya, Brazil, and Jordan. The geographic reach of this survey is truly reflective of the global scale of the developer economy. The online survey was translated into eight languages in addition to English, namely simplified Chinese, traditional Chinese, Spanish, Portuguese, Vietnamese, Russian, Japanese, and Korean, and was promoted by more than 100 leading community and media partners within the software development industry. The regional distribution of responses is shown in the following chart.

To eliminate the effect of regional sampling biases, we first weighted to correct for over-represented individual countries within regions. We then weighted the regional distribution across nine regions by a factor that was determined by the regional distribution and growth trends identified in our Developer Nation research. Each of the separate branches: mobile, desktop, Industrial IoT, consumer electronics, embedded software, third-party app ecosystems, cloud, web, games, augmented and virtual reality, and data science and machine learning were weighted independently and then combined.

To minimise other important sampling biases across our outreach channels, we weighted the responses to derive a representative distribution for technologies used and developer segments. Using ensemble modelling methods, we derived a weighted distribution based on data from independent, representative channels, excluding the channels of our research partners, to eliminate sampling bias due to respondents who were recruited via these channels. Again, this was performed separately for each of mobile, industrial IoT, consumer electronics, embedded software, third-party app ecosystems, desktop, cloud, web, games, augmented and virtual reality, and data science and machine learning.

For more information on our methodology please visit
SlashData Website: Our methodology page
A short video explaining our methodology

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We help the world understand developers

We survey 30,000+ developers annually – across Web, Desktop, Cloud, Mobile, Industrial IoT, AR/VR, Machine Learning and Data Science, Games, Consumer Electronics and Apps/Extensions for 3rd party ecosystems - to help companies understand who developers are, what they buy and where they are going next.
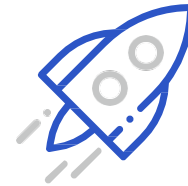
WHO DEVELOPERS ARE
Developer population sizing
Developer segmentation

WHAT THEY BUY
Why developers are adopting competitor products – and how you can fix that
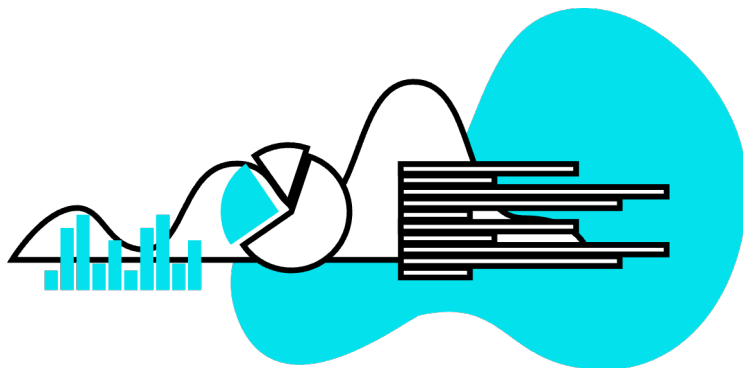
WHERE THEY ARE GOING
Emerging platforms – augmented & virtual reality, machine learning

TRUSTED BY

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