DEVELOPER NATION

STATE OF THE DEVELOPER NATION

21ST EDITION

The latest trends from our Q3 2021 survey of 19,000+ developers

/DATA

21ST EDITION PUBLISHED OCTOBER 2021

About SlashData

SlashData is the leading analyst company in the developer economy, tracking global software developer trends based on more than 30,000 software developers annually in over 160 countries. Our surveys track the changing landscape of mobile, IoT, desktop, cloud, web, AR, VR, games, machine learning developers, and data scientists. Our mantra:

We help the world understand developers - and developers understand the world.

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About Developer Nation

Developer Nation is a global community engaging thousands of developers of all shapes and sizes across the globe, enabling them to benchmark themselves against the developer nation. We are committed to facilitating community contribution and knowledge sharing, and promoting diversity and inclusion in the developer ecosystem.

Our vision is to empower developers to shape the future!

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ABOUT THIS REPORT

SlashData's Developer Nation survey is the leading research programme on mobile, desktop, industrial IoT, consumer electronics, embedded, third-party app ecosystems, cloud, web, game, AR/VR, and machine learning developers, as well as data scientists, tracking the developer experience across platforms, revenues, apps, languages, tools, APIs, segments, and regions.
The 21st edition of the Developer Nation global survey ran from June to August 2021 and reached more than 19,000 developers in 168 countries. This research report delves into key developer trends for Q3 2021 and beyond.
The report focuses on six major themes - each with its own visualisations - showing how the data lends insight into the developer community.

- **Language communities - An update:** Programming languages are often the kernels of strong communities and the subject of opinionated debate. In this chapter, we provide updated estimates of the number of active software developers using each of the major programming languages, across the globe and across all kinds of programmers.
- **The developers at the heart of the 5G and IoT revolution:** The fifth generation of mobile technology (5G) is upon us - ushering in a new era of hyper-connectivity. In this chapter, we explore how developers are involved in 5G worldwide and across different technology sectors, and we investigate how they are taking advantage of 5G for the rapidly expanding internet of things (IoT).
- **What would make you leave your employer?:** In our most recent survey, we asked professional developers what - if anything - would make them leave their current employer for another. This chapter takes a look at the most important motivations behind developers' decisions to switch employers, including how these decisions are affected by the developers' geographic location and experience level.
- **Stages of the machine learning and data science workflow:** As machine learning models become more complex, so do the infrastructure and working practices that underpin them. From data ingestion through to model deployment and lifecycle management, there are many different stages of the data science and machine learning workflow. In this chapter, we explore the stages which developers are involved in and how their involvement is changing over time.
- **On developers who build apps and extensions for third-party platforms:** Our digital world can be described as a collection of ecosystems filled with applications and services working alongside each other. Some services have evolved into their own platform, serving as a hub of opportunity for developers to build applications and extensions to enhance the platform's functionality. This chapter takes a closer look at the developers who build applications for third-party ecosystems, the types of platforms and audiences they're targeting, and the goals of their development.
- **Technologies used in game development:** Video games can be found everywhere; being sold as physical copies, digitally downloaded versions, or subscription-based access over the cloud. The availability and variety of game-ready devices has impacted the technologies game developers are using today. This chapter focusses on where game developers are deploying the code for their games and the technologies they're leveraging to build their applications.

We hope you will enjoy this report and find the insights useful! If you have any questions or comments, or are looking for additional data, you can get in touch with Viktorija Ignatavičiūtė, Events & PR Lead for SlashData at viktorija@slashdata.co. You can download this report for free at https://www.developereconomics.com/resources/reports.

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PARTNERS

A special thanks to the Meetups participating in our survey including: Hackerspace Mumbai, Hackerspace Singapore and R-Ladies Italy.

Our Developer Committee supported our efforts once more, to create the most up-to-date and detailed survey. Special thanks to our members: Amulya, Baldomero, Dominic, Deborah, Kingsley, Ivan, Girish, and Samuel for your help with reviewing survey content, translations, and suggesting prizes.

Our linguistics partner, Palex Group, supported us to create an inclusive survey, translated into eight different languages - Simplified Chinese, Traditional Chinese, Japanese, Korean, Portuguese, Russian, Spanish, and Vietnamese.

KEY INSIGHTS

Language communities - An update

- JavaScript is the most popular programming language by a wide margin, with nearly 16.5M developers using it globally.
- Since it surpassed Java in popularity at the beginning of 2020, Python has remained the second most widely adopted language behind JavaScript, with 11.3M users.
- Rust has grown faster than any other language in the last 24 months, nearly tripling in size, from just 0.4M developers in Q3 2019 to 1.1M in Q3 2021.
- Kotlin has consistently been identified as a rising star among programming languages, with an audience that has doubled in size over the last three years.

The developers at the heart of the 5G and IoT revolution

- Greater China is the epicentre of the 5G revolution for software developers. In this region, 82% of developers are interested in, learning about, or working with 5G technologies.
- North and South America have the next highest proportion of developers working in 5G, but interest in 5G is much lower among the general developer population in these regions.
- AR/VR, industrial IoT, and consumer electronics are among the sectors in which developers' involvement in 5G has accelerated fastest. Around one in six developers in these areas are now working on 5G technologies.
- Manufacturing, smart cities, and digital twin technology are the IIoT markets in which we find most IIoT professionals working with 5G. Digital twin technology particularly appeals to professional IIoT 5G developers, compared to IIoT developers without interest in 5G.

What would make you leave your employer?

- Many developers know their worth - just one in ten developers say that nothing would make them leave their current employer.
- Around a quarter of developers could be tempted to move by a remote position - software development has historically been a pioneering industry for remote working and the pandemic has likely made this especially salient.
- Developers in Eastern Europe are the most concerned with increasing their salary - nearly seven in ten say that this would make them switch employers and an upgraded benefits package is unlikely to make up for this.
- Developers in Greater China are some of the most likely to select 'softer' benefits such as better company culture, working environments, or shorter commutes.
- Experienced developers are the most content at their jobs - around one in six of those with sixteen or more years of experience say that nothing would make them move.

Stages of the machine learning and data science workflow

- Just one in ten DS/ML developers are involved end-to-end in the DS/ML workflow and end-to-end involvement is decreasing.
- Data exploration and analysis, model development, and visualisation/presentation form the bedrock of DS/ML projects.
- The DS/ML workflow is becoming siloed - developers involved in a particular stage, such as data ingestion, are also often involved in adjacent stages, such as data and feature engineering, but are often less likely to stray further upstream.

On developers who build apps and extensions for third-party platforms

- More than two-thirds (68%) of developers building apps for third-party ecosystems identify as a professional.
- 43% of third-party ecosystem developers are creating applications and extensions for web browsers, making them the most targeted platform type.
- Third-party ecosystem developers have increased their interest by 16% in e-commerce platforms over the last two years, which is now the fastest growing platform type.
- 17% of professional developers building apps for third-party ecosystems are targeting other professionals, which is the second most targeted audience, only behind consumers.

Technologies used in game development

- The percentage of developers deploying their games via the cloud rose by 10% in the last six months, the largest increase of any platform type.
- Of the professional game developers deploying their code to the cloud, 43% are using a multi/hybrid strategy.
- Backend technologies are now the third most used technology in game development, behind only 2D and 3D game engines.
- Professional game development requires more usage of backend technologies, with a majority of developers using storage/database technologies.

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PROGRAMMING LANGUAGE COMMUNITIES - AN UPDATE

The choice of programming language matters deeply to developers because they want to keep their skills up to date and marketable. Languages are a beloved subject of debate and the kernels of some of the strongest developer communities. They matter to toolmakers too, because they want to make sure they provide the most useful SDKs.

01

Size of programming language communities in Q3 2021

Active software developers, globally, in millions (n=12,506)

		Most popular in	Least popular in
Javascript*	16.4 M	Web, backend	DS/ML, embedded
Python	11.3 M	DS/ML, IoT apps	Mobile, AR/VR
Java	9.6 M	Mobile, desktop	DS/ML, web
C/C++	7.5 M	Embedded, IoT apps	Web, mobile
PHP	7.3 M	Web, backend	DS/ML, mobile
C#	7.1 M	AR/VR, desktop, games	DS/ML, mobile
Visual development tools	3.6 M	Desktop, AR/VR	Cloud, web
Kotlin	2.9 M	Mobile, AR/VR	DS/ML, desktop
Swift	2.5 M	Mobile, AR/VR	Backend, desktop
Go	2.0 M	Backend, apps for 3rd-party ecosystems	Games, web
Dart	1.4 M	Mobile	Web
Objective C	1.4 M	AR/VR	Desktop, games
Ruby	1.4 M	IoT, backend	DS/ML, web
Rust	1.1 M	AR/VR, embedded	Mobile, web
Lua	0.8 M	AR/VR, IoT, games	Mobile, desktop

(*) JavaScript includes CoffeeScript and TypeScript

It can be hard to assess how widely used a programming language is. The indices available from players like Tiobe, Redmonk, Stack Overflow's yearly survey, or GitHub's Octoverse are great, but offer mostly relative comparisons between languages, providing no sense of the absolute size of each community. They may also be biased geographically or skewed towards certain fields of software development or open source developers.

The estimates we present here look at active software developers using each programming language; across the globe and across all kinds of programmers. They are based on two pieces of data. First, our independent estimate of the global number of software developers, which we published for the first time in 2017. We estimate that, as of Q3 2021, there are 26.8 million active software developers in the world.

Second, our large-scale, low-bias surveys which reach tens of thousands of developers every six months. In the surveys, we have consistently asked developers about their use of programming languages across ten areas of development, giving us rich and reliable information about who uses each language and in which context.

JavaScript's popularity has skyrocketed

JavaScript is the most popular programming language by a wide margin, with nearly 16.5M developers using it globally. Notably, the JavaScript community has been growing in size consistently for the past several years. 4M developers joined the community in the last year - by far the highest growth in absolute terms across all languages - and upwards of 2.5M developers joined in the past six months alone. Even in software sectors where JavaScript is not among developers' top choices, like data science or embedded development, about a fourth of developers use it in their projects.

Since it surpassed Java in popularity at the beginning of 2020, Python has remained the second most widely adopted language behind JavaScript. Python now counts 11.3M users after adding 2.3M net new developers in the past 12 months. That's a 25% growth rate, one of the highest across all the large programming language communities of more than 7M users. The rise of data science and machine learning (ML) is a clear factor in Python's popularity. More than 70% of ML developers and data scientists report using Python. For perspective, only 17% use R, the other language often associated with data science.

Upwards of 2.5M developers joined the JavaScript community in the past six months alone

Java is the cornerstone of the Android app ecosystem as well as one of the most important general-purpose languages. Although it has been around for more than two decades now, its traction among developers keeps steadily growing. Since mid-2018, nearly 2.5M developers have joined the Java community, which now counts 9.6M developers.

The group of major, well-established languages is completed with C/C++ (7.5M), PHP (7.3M), and C# (7.1M). Of these, PHP has grown the fastest in the past six months, with an influx of 1M net new developers between Q1 and Q3 2021. As a result, it regained its lead over C#, which added a smaller number of new users during the same period (0.6M).

C and C++ are core languages in embedded and IoT projects for both on-device and application-level coding, whereas PHP is still the second most commonly used language in web applications after JavaScript. On the other hand, C# is traditionally popular within the desktop developer community, but it's also the most broadly used language among AR/VR and game developers, largely due to the widespread adoption of the Unity game engine in these areas.

Rust is rising fast

Rust has formed a very strong community of developers who care about performance, memory safety, and security. As a result, it grew faster than any other language in the last 24 months, nearly tripling in size from just 0.4M developers in Q3 2019 to 1.1M in Q3 2021. According to our data, Rust is mostly used in embedded software projects but also in AR/VR development, most commonly for implementing the low-level core logic of AR/VR applications.

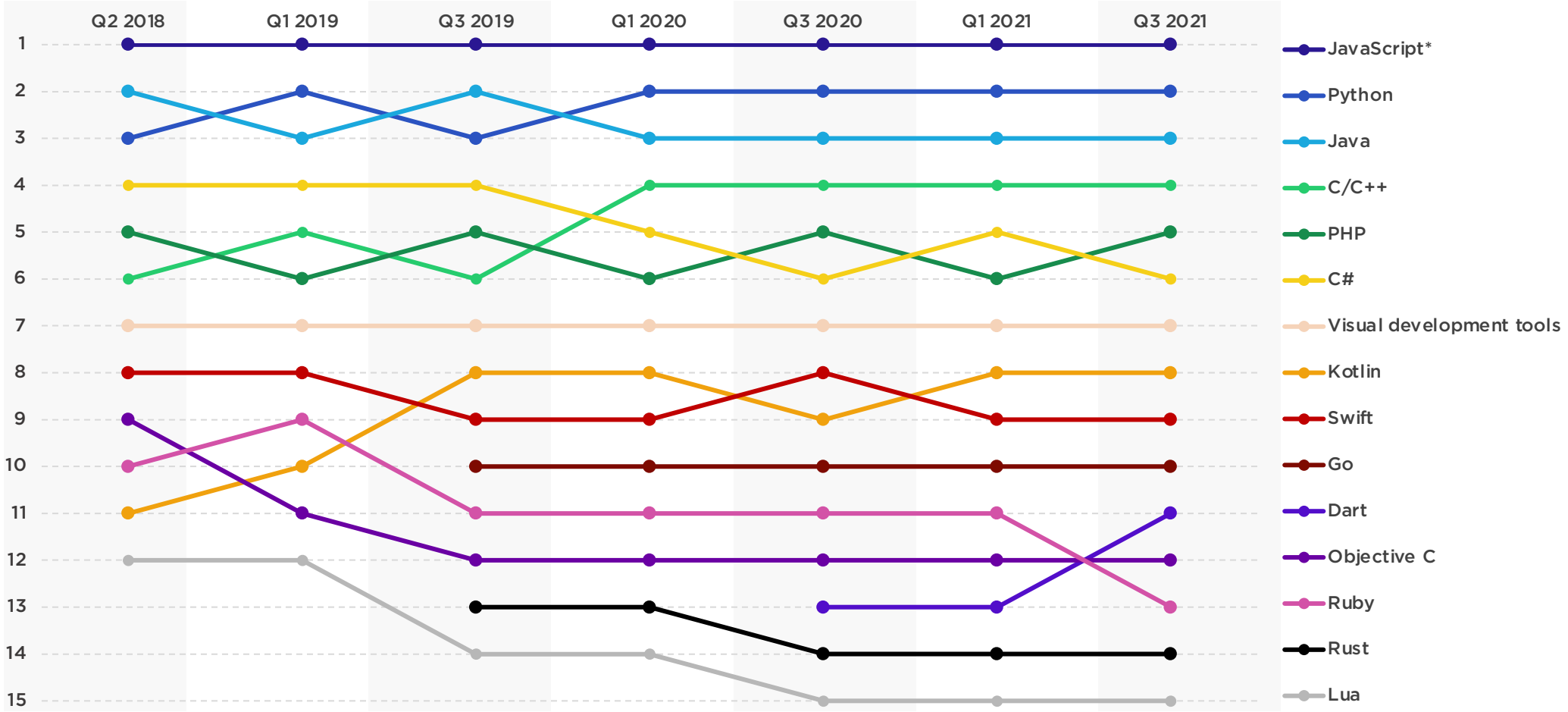
Rust has grown faster than any other language in the last 24 months

In previous editions of this report, Kotlin has consistently been identified as a rising star among programming languages, with an audience that has doubled in size over the last three years - from 1.5M developers in Q2 2018 to nearly 3M in Q3 2021. This trend is largely attributed to Google's decision to make Kotlin its preferred language for Android development. Kotlin is currently the third most popular language in mobile development, behind JavaScript and Java.

Swift was outranked by Kotlin at the beginning of 2021 and has since added only 100K net new developers. In comparison, Kotlin added six times as many developers during the same period. Even so, Swift is currently the default language for development across all Apple platforms, which has led to a stagnation in the adoption of Objective C. This gradual phase-out of Objective C from the Apple app ecosystem is also matched by a significant drop in its rank, from ninth to 12th place.

The more niche languages - Go, Ruby, Dart, and Lua - are still much smaller, with up to 2M active software developers each. Go and Ruby are important languages in backend development, but Go has grown slightly faster in the past year, both in absolute and percentage terms. Dart has also seen a significant uptick in its adoption in the last year, fuelled predominantly by the increasing adoption of the Flutter framework in mobile development.
Finally, Lua was the second fastest growing language community in the past two years, behind Rust, mainly attracting AR/VR and IoT developers looking for a scripting alternative to low-level languages such as C and C++.

Ranking of programming language communities, 2018-2021



(*) JavaScript includes CoffeeScript and TypeScript

THE DEVELOPERS AT THE HEART OF THE 5G AND IoT REVOLUTION

The fifth generation of mobile technology (5G) is upon us - ushering in a new era of hyper-connectivity. Here, we report on developers' involvement in 5G worldwide and across different technology sectors, and investigate how developers are taking advantage of 5G for the rapidly expanding internet of things (IoT).

02

A world in which any device, anywhere, can be connected, communicating at ultra-high speed, and with super-low latency is no longer just a futuristic vision but an emerging reality that is enabled by 5G networks. Such a dramatic transformation in infrastructure opens up new opportunities for developers. We asked more than 10,000 developers about their interest and involvement in 5G. They told us whether they were: actively working in this area; preparing themselves by learning more; interested but not actively engaged; or uninterested/uninvolved in 5G.

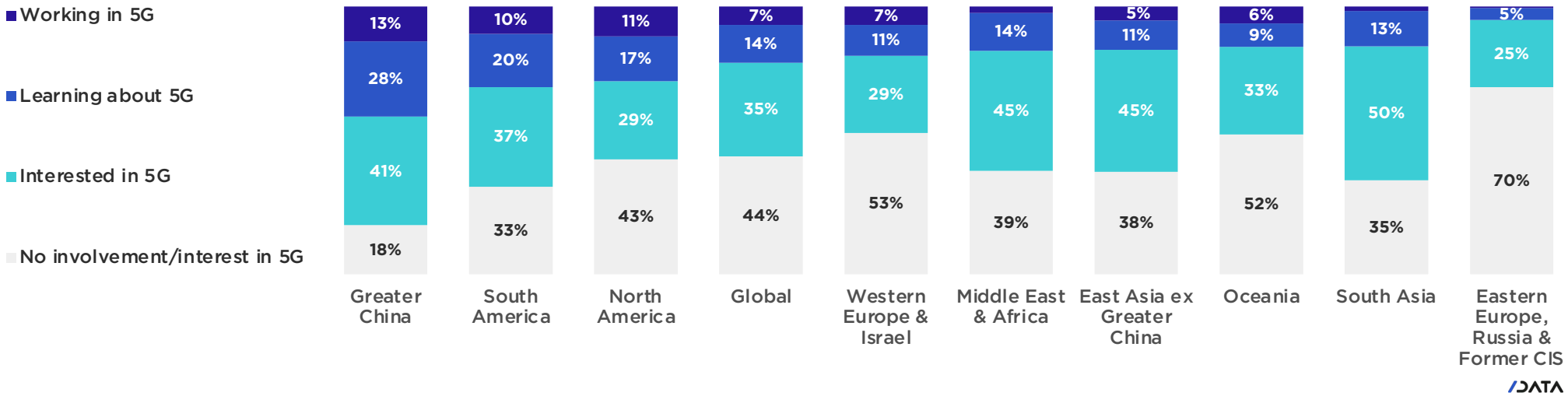
Our data reveals Greater China as the epicentre of 5G for software developers. Here, we find more than four in every five software developers are either interested in, learning about, or working on 5G technologies. Moreover, recent estimates suggest that China's enormous 5G market growth now sees an infrastructure of more than 1 million 5G base stations, serving over 320 million 5G subscribers. China's exploding demand clearly captures its software developers' attention, motivating them to learn more about how 5G can impact their development and provide opportunities for innovation.

In Greater China, 82% of developers are interested in, learning about, or working with 5G technologies

13% of the developer population in China report actively working on 5G technologies, almost double the global average. North and South America follow close behind, with 11% and 10%, respectively. Reports suggest that 5G uptake in the Americas is snowballing; however, this rapid expansion does not appear to be translating into high levels of interest and engagement from developers more broadly, particularly in North America. Here, 43% of the developer population reports having no interest or involvement in 5G, above the global average of 35%. Just 17% of the population are readying themselves to join the future generation of 5G developers by actively learning about 5G. Clearer messaging about the potential of 5G may help to bring new developers on board. However, this is not without challenges in an age where confusion and misinformation about 5G are prevalent.

China is the epicentre of the 5G revolution

% of developers in each region (n=10,434)



Conversely, we see high levels of interest and education for 5G in regions such as South Asia, East Asia, and the Middle East and Africa. Still, relatively few developers here nurture this interest into active development - all of these regions are below the 7% global average of software developers working on 5G.

A slower rollout of 5G networks undoubtedly limits developers' potential for immediate engagement; nevertheless, the legions of developers interested in learning more indicate that the future of 5G still looks promising in these regions. However, the 5G landscape looks less assured in Eastern Europe, where active involvement and interest lag far behind all other regions.

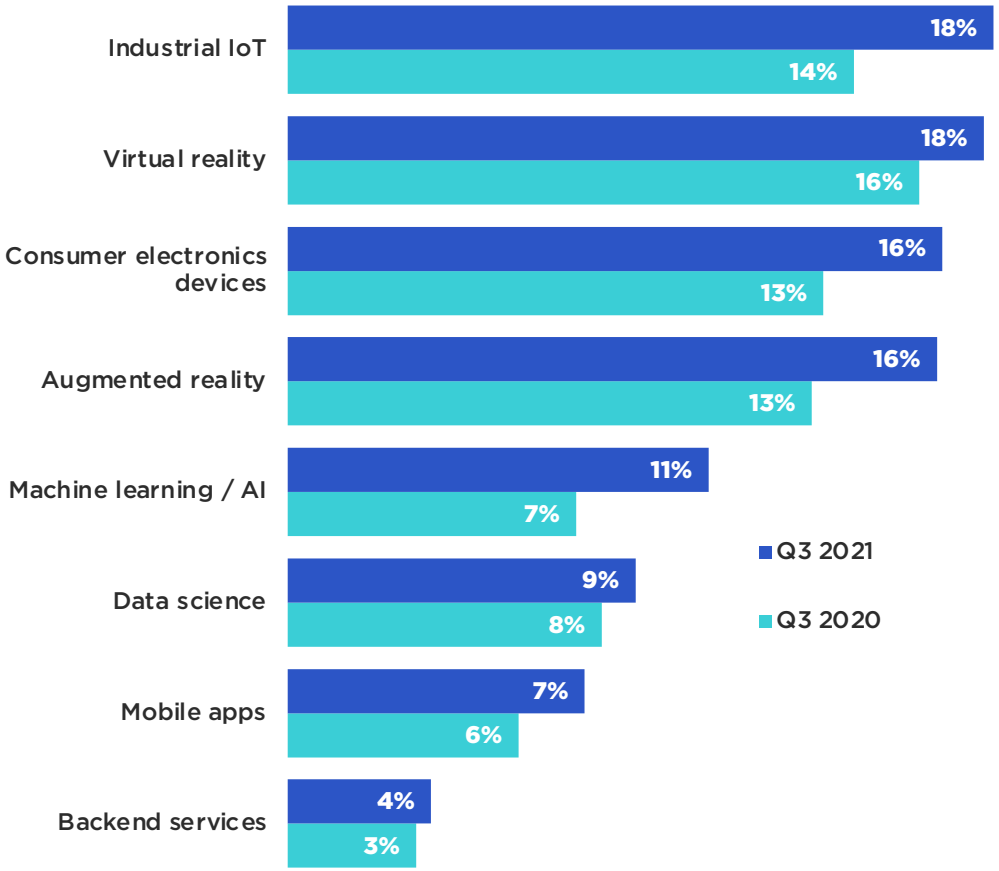
The industrial IoT is now the largest and fastest-growing technology sector for 5G developers

Virtual reality (VR) and augmented reality (AR) are among the technology sectors in which we observe the highest proportion of developers working on 5G technologies. This is partly because the COVID-19 pandemic has dramatically extended our need for new ways for people to remain connected - augmented and virtual environments can play a significant role in this. In addition, the high bandwidth and low latency of 5G are helping to shape the future of AR/VR as a tool for real-time interaction at scale and providing new opportunities for improved direct-to-device streaming.

Industrial IoT (IIoT) and consumer electronics (CE) are also within the break-away group of technology sectors that 5G developers are rapidly entering. Involvement in IIoT exhibits the fastest growth among those working in 5G - tied with machine learning/AI - since our survey in Q3 2020. In fact, IIoT has overtaken all other technology sectors as the area where we find most 5G developers.

IIoT has overtaken all other technology sectors as the area with the highest percentage of 5G developer

% of developers in each software development sector who are working in 5G
(Q3 2020 n=12,781 | Q3 2021 n=10,434)



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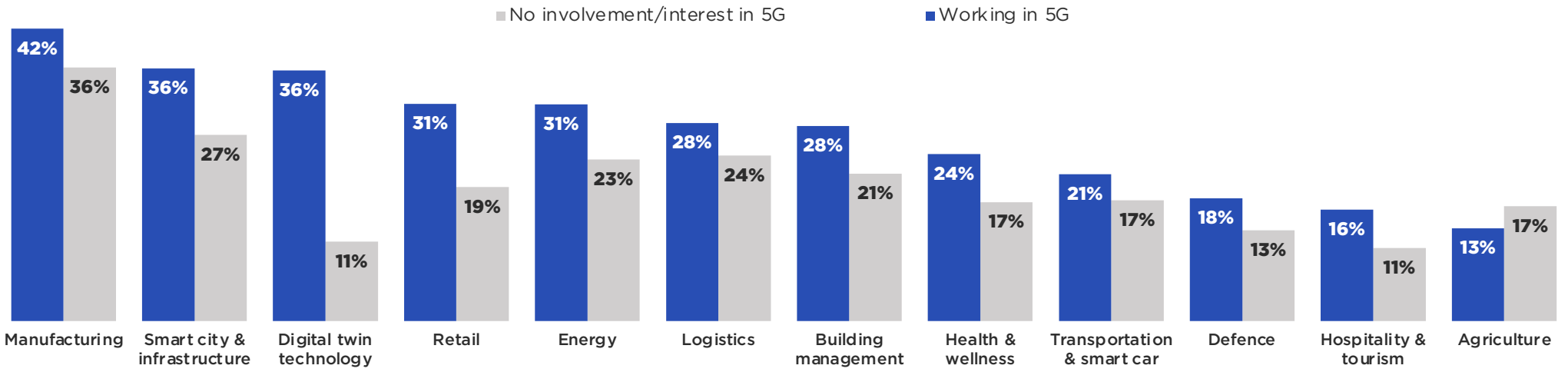
Over one-third of professional IIoT developers working in 5G are currently targeting manufacturing, smart city, or digital twin markets

% of professional IIoT developers working in 5G that target each IoT market (n=334)



5G is transformative for IIoT and a critical enabler for Industry 4.0 - the new phase in the industrial revolution. Its potential to allow seamless delivery of real-time services and insights is essential for the connectivity demands of the industrial sector.

When we take a deeper dive into our data, manufacturing, smart cities, and digital twin technologies emerge as the markets that professional IIoT 5G developers are targeting most - they attract over one-third of professional developers in IIoT that work with 5G. Following behind, just under one-third of IIoT 5G developers are targeting retail, energy, and logistics markets.

Manufacturing, smart cities, and digital twin technologies are the IIoT markets in which we find most IIoT professionals working with 5G

In particular, we find that digital twin technology - virtual models that duplicate physical entities, such as infrastructure and complex physical systems - attracts a more substantial portion of IIoT 5G developers (36%) than IIoT professionals with no 5G involvement, at just 11%. This gap suggests that 5G innovation is vital within this market. Hence, this is where we can expect to see significant evidence of 5G's transformative potential as it becomes more pervasive in the near future.

WHAT WOULD MAKE YOU LEAVE YOUR EMPLOYER?

In our most recent survey, we asked professional developers what - if anything - would make them leave their current employer for another. Here, we take a look at this data in the context of a developers' geographic region and experience level. Spoiler alert: Money talks.

03

Developers consider short- and long-term success when deciding to change employers

As highly trained, specialist employees in a competitive market, it seems that many developers know their worth - just one in ten developers say that nothing would make them leave their current employer. Half of developers would switch employers for higher compensation and a third would switch for an improved benefits package. Nearly two-thirds selected either option. The majority of developers are financially motivated, either in the form of higher compensation and/or an improved benefits package.

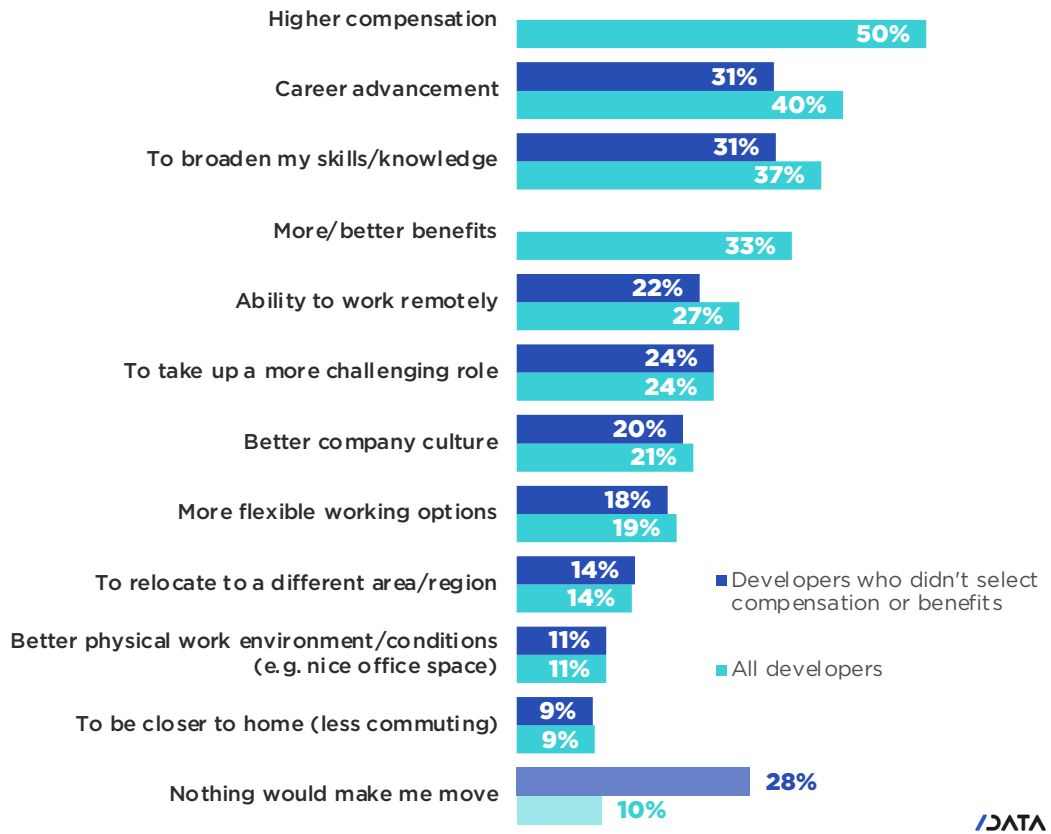
This means that just over a third of developers have motivations that extend beyond immediate financial reward. When we remove the two-thirds of developers who said that increased compensation or better benefits would incentivise them to move, career advancement and broadening skills take the top two spots. This shows that developers are hungry to learn and to progress - these are also important factors for developers who could be tempted by financial rewards. Here, the focus on financials is not explicit nor immediate, but both of these factors can contribute to higher salaries in the future.

Interestingly, three in ten developers who don't have a direct financial motivation to leave say that nothing would make them leave their current employer, three times as many as average. For managers struggling with retention, increasing pay or benefits is likely to reduce the temptation to leave.

Many 'softer' perks are also important to a significant number of developers. Around a quarter could be tempted to move by a remote position, and just over one in eight would move in order to relocate. Software development has historically been a pioneering industry for remote working, and the pandemic has likely made this especially salient.

Half of developers would change company for better pay, but a third aren't financially motivated

% of developers selecting each reason as a motivation for changing employer
(All developers n=8,477 | Developers who didn't select compensation or benefits n=3,085)

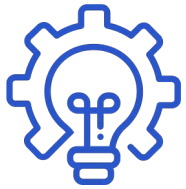


Around one in five developers state that a better company culture would be a tempting reason to switch employers. There are well documented issues with culture in software development - there have been several high profile cases of discriminatory working environments in the last few years, and many software developers are no strangers to long hours, especially as a project nears completion. Employers should therefore ensure that the working environment is safe and inclusive as a bare minimum, but also consider how the company culture contributes to the health and wellbeing of employers in other ways.

Eastern European developers are the most concerned with compensation

Developers in Eastern Europe are the most concerned with increasing their salary - nearly seven in ten say that this would make them switch employers. The close geographical proximity to richer Western European countries likely makes depressed salaries in this region feel particularly unfair. For these underpaid developers in Eastern Europe, an upgraded benefits package won't cut the mustard; instead, broadening skills (50%), taking a more challenging role (32%), or relocation (22%) are more important than average to these developers. It seems that Eastern European developers are taking a longer-term look at their finances and possibly considering uprooting their lives for an increased chance of success.

Developers in North America seem the happiest at their current jobs - 14% said that nothing would make them switch. As with most regions, higher compensation is the most tempting option; half of developers here selected this. These developers are much less likely than average to select career advancement, broadening skills, or taking on a more challenging role as reasons for moving. By and large, North American developers appear to be satisfied with their professional lives, but for those who would be tempted to move, higher compensation is mentioned as a reason by three in five.



14%

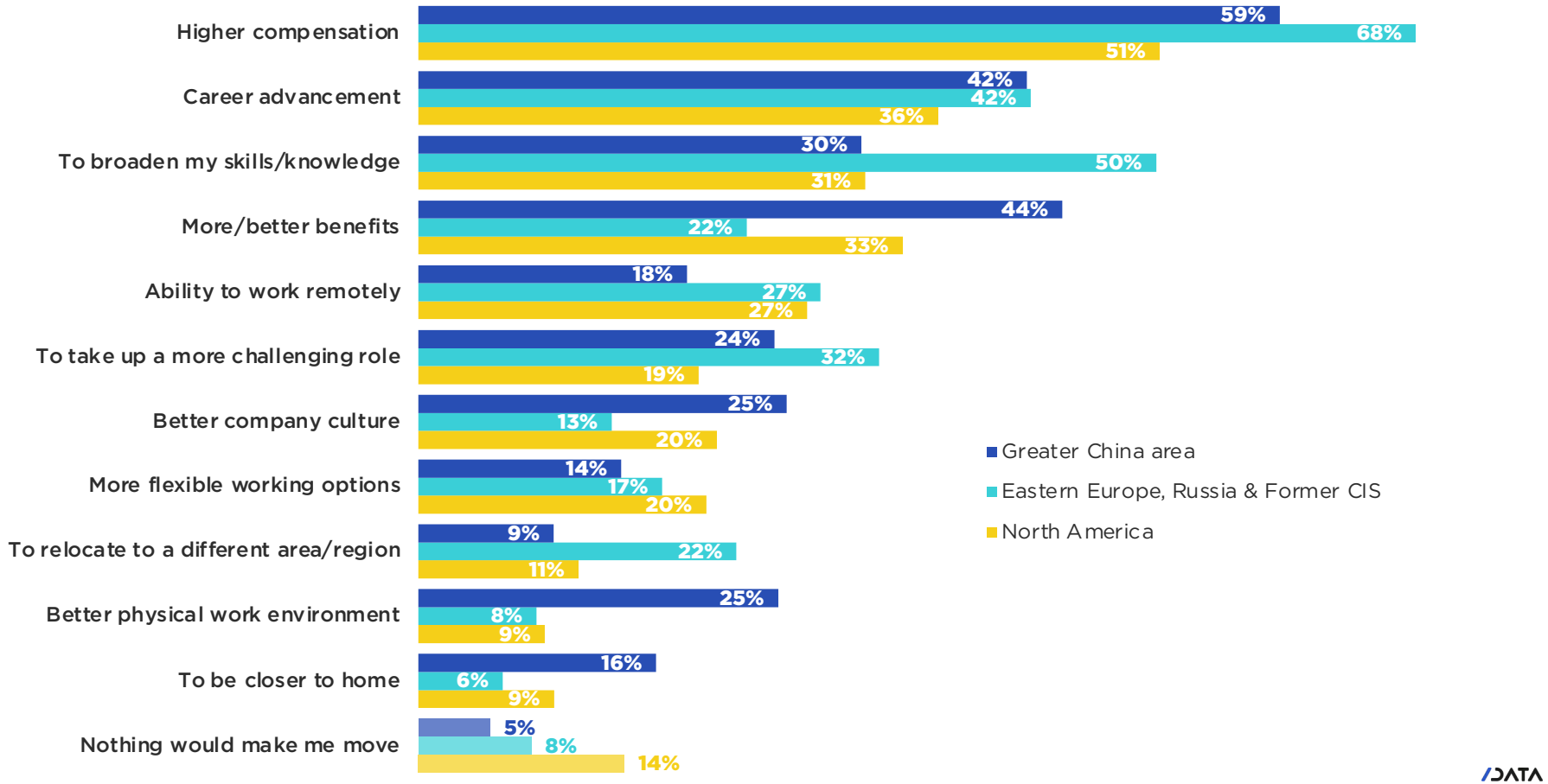
OF NORTH AMERICAN DEVELOPERS SAY THAT NOTHING WOULD MAKE THEM CHANGE JOBS

For Chinese developers, compensation is also important - three in five developers here selected this option, the second-highest of any region. In comparison with their Eastern European counterparts, however, Chinese developers were almost twice as likely to say that a better benefits package would tempt them to move. This said, although financial motivations are important for developers in Greater China, they are some of the most likely to select 'softer' benefits such as better company culture, working environments, or shorter commutes. Reports of the Chinese government taking steps to reduce the '996' working culture prevalent in many tech organisations in the country may well make these factors less of an issue in the future.

Developers in Greater China are less likely to say that remote or flexible working would tempt them to switch employers - such flexibility is more highly valued by developers in Eastern Europe or North America. It's likely that the pandemic's effect on working culture has affected different regions in different ways - developers in North America may well be used to working from home after more than a year of doing so, and with Eastern Europe already an established outsourcing destination, remote work is more likely to be salient for developers here. On the other hand, developers in regions that may have limited opportunities to offer are more likely to see remote working as a door opener to the global labour market. More than one in three developers in the Middle East and Africa and 30% of developers in South America, for example, would switch employers to get a remote job.

Eastern European developers feel underpaid and better benefits won't help

% of developers in each region who selected each reason as a motivation for changing employer
(North America n=1,982 | Eastern Europe, Russia & Former CIS n=901 | Greater China area n=480)



Experienced developers are the most content in their jobs

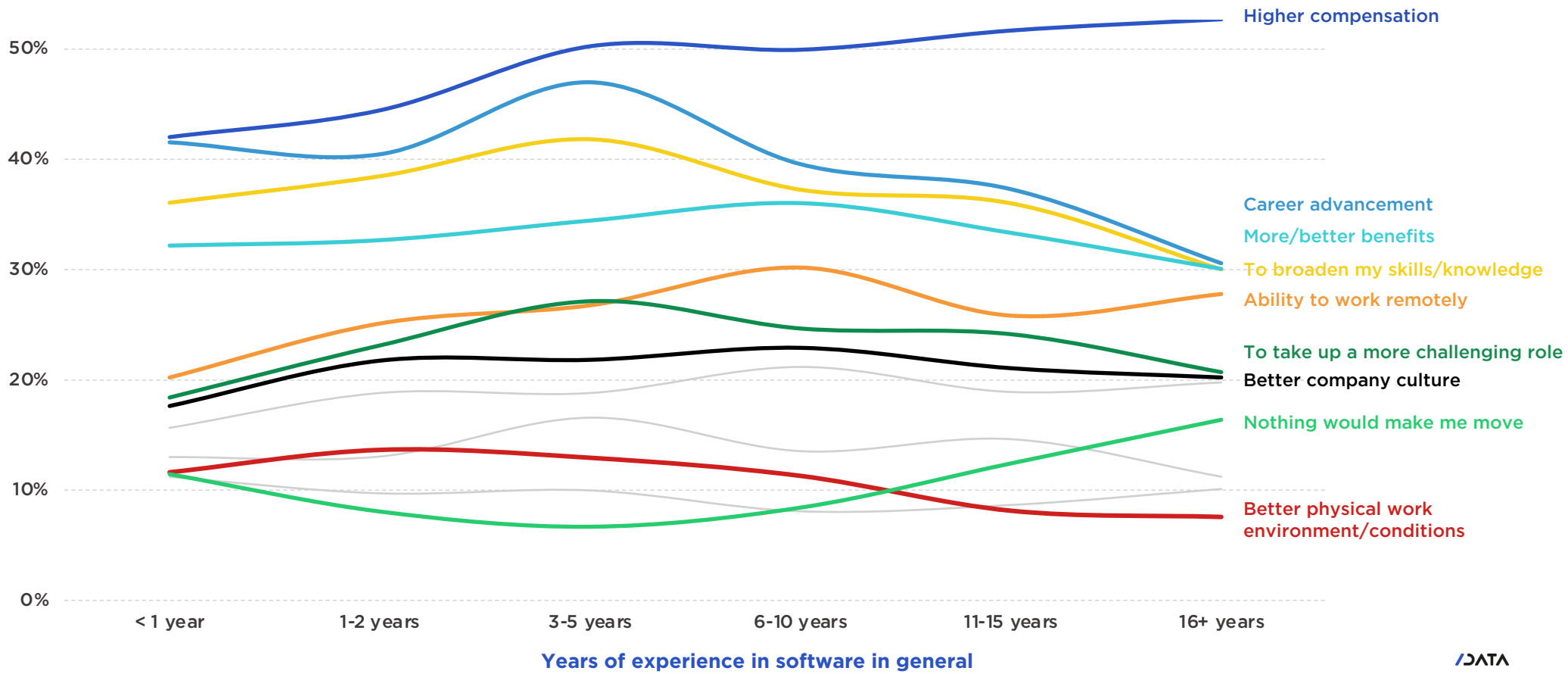
Experienced developers are the most content in their jobs - around one in six of those with 16 or more years of experience say that nothing would make them move. This group is also the most financially-motivated, with over half saying that higher compensation may tempt them to move. As one would expect, career advancement becomes less important with experience. As developers gain experience, they know better which roles they want to take, and with managerial positions often forming an artificial ceiling, some experienced developers will want to stay closer to the code. Career advancement and taking on a more challenging role both peak for developers with three to five years under their belts. A well-timed change at this point in a developer's career can have a large impact on their future earnings and professional success. At three to five years of experience, many developers are beginning to feel established and comfortable in their skills, so a challenging opportunity can often provide a catalyst for future success.

We see much smaller changes with experience for benefits, company culture, and physical working environments as drivers for a change in employer - developers at all experience levels have similar views on their importance. Interestingly, remote working isn't so important to early-career developers - many developers at this stage of their careers value the close contact with colleagues that allows them to learn.

There are many reasons why a developer may choose to switch employers, and whilst it's impossible to ignore the impact of compensation, other factors play an important role, especially as the role of work in our lives continues to evolve. For those concerned with hiring and retaining developers, money talks, but it's not the only topic of conversation.

Compensation becomes more important as developers gain experience

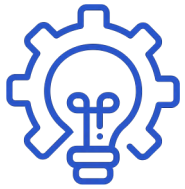
% of developers at each experience level who selected each reason as a motivation for changing employer (n=8,862)



STAGES OF THE MACHINE LEARNING AND DATA SCIENCE WORKFLOW

As machine learning models become more complex, so too do the infrastructure and working practices that underpin them. From data ingestion through to model deployment and lifecycle management, there are many different stages of the data science and machine learning workflow. Here, we discuss where developers are involved and how their involvement is changing over time.

04



JUST 1 IN 10

DS/ML DEVELOPERS ARE INVOLVED END-TO-END IN THE DS/ML WORKFLOW

Data scientists and machine learning developers are characterised by specialisation - just one in ten of them are involved end-to-end in the data science/machine learning (DS/ML) workflow. Excluding these generalists, around two-thirds of the remaining DS/ML developers are involved in three or fewer distinct stages of the DS/ML workflow. As we will see later in this chapter, this is part of a longer-term trend towards specialisation in data science and machine learning. As working practices mature and technical complexity increases, developers have to specialise in order to stay competitive.

For those involved in different stages of the DS/ML workflow, data exploration and analysis is the most often selected - nearly half of DS/ML developers said that they are involved here. Furthermore, with around two in five selecting model development or visualisation/presentation, it's clear that these three activities form the bedrock of DS/ML projects. In fact, nearly three-quarters of DS/ML developers are involved in at least one of these three stages, and 14% do all of them. Whilst DS/ML developers are rarely involved end-to-end, most maintain a varied skill set, incorporating coding, statistics, and communication into their repertoire.

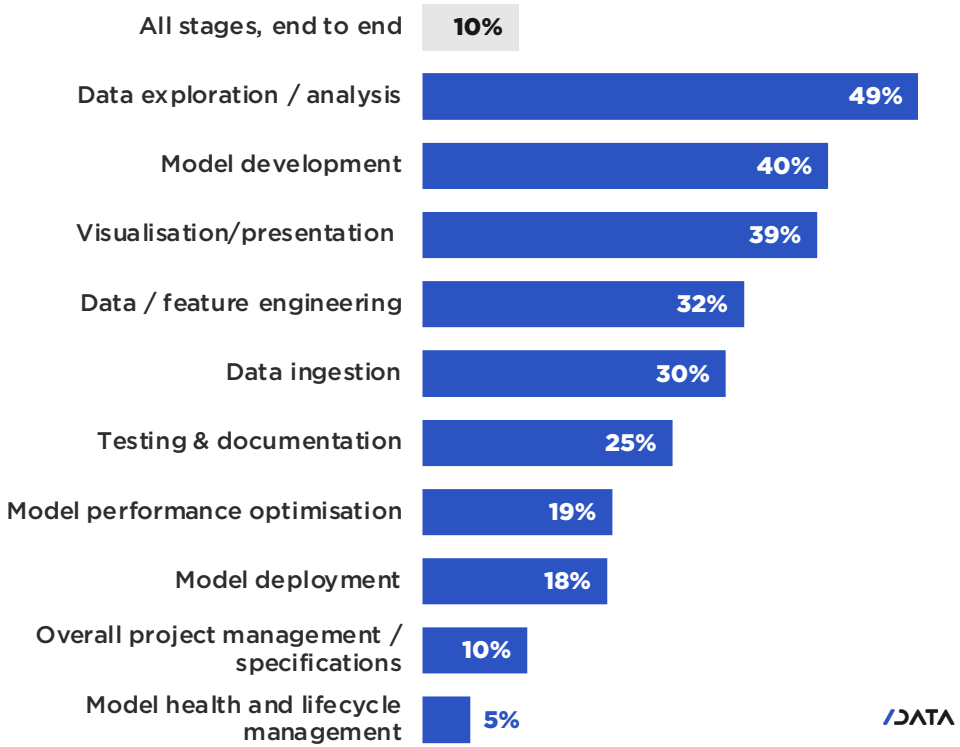
Further down the list, just under a third of DS/ML developers reported being involved in data/feature engineering or data ingestion. These somewhat less glamorous activities nevertheless underpin much of the DS/ML lifecycle. DS/ML developers doing data engineering or ingestion tend to only stay involved early on in the DS/ML workflow. Those concerned with data ingestion are only more likely than average to also do data engineering or exploration/analysis - there are clearly some transferable skills here, but these don't often translate to model deployment or optimisation. DS/ML developers involved in feature engineering often take part in the model development process - the iterative synergy between feature engineering and model development is clear here.

Many DS/ML developers maintain a varied skill set

Finally, with just 5% being involved in model health and lifecycle management, this is by far the least popular stage of the DS/ML workflow. This may be to do with the complexity or specialist knowledge needed here. However, with more and more models being actively deployed to production environments, we expect that this stage will become ever more important - the costs of tweaking an existing model for consistent performance are likely much lower than developing a new one from scratch. Furthermore, as users expect 100% uptime and good model performance, specialists involved in this stage will be responsible for both.

Just one in ten data scientists are involved end-to-end

% of data scientists / machine learning developers involved in each stage of the DS/ML workflow (n=2,412)



The proportion of developers involved end-to-end has dropped by 50%

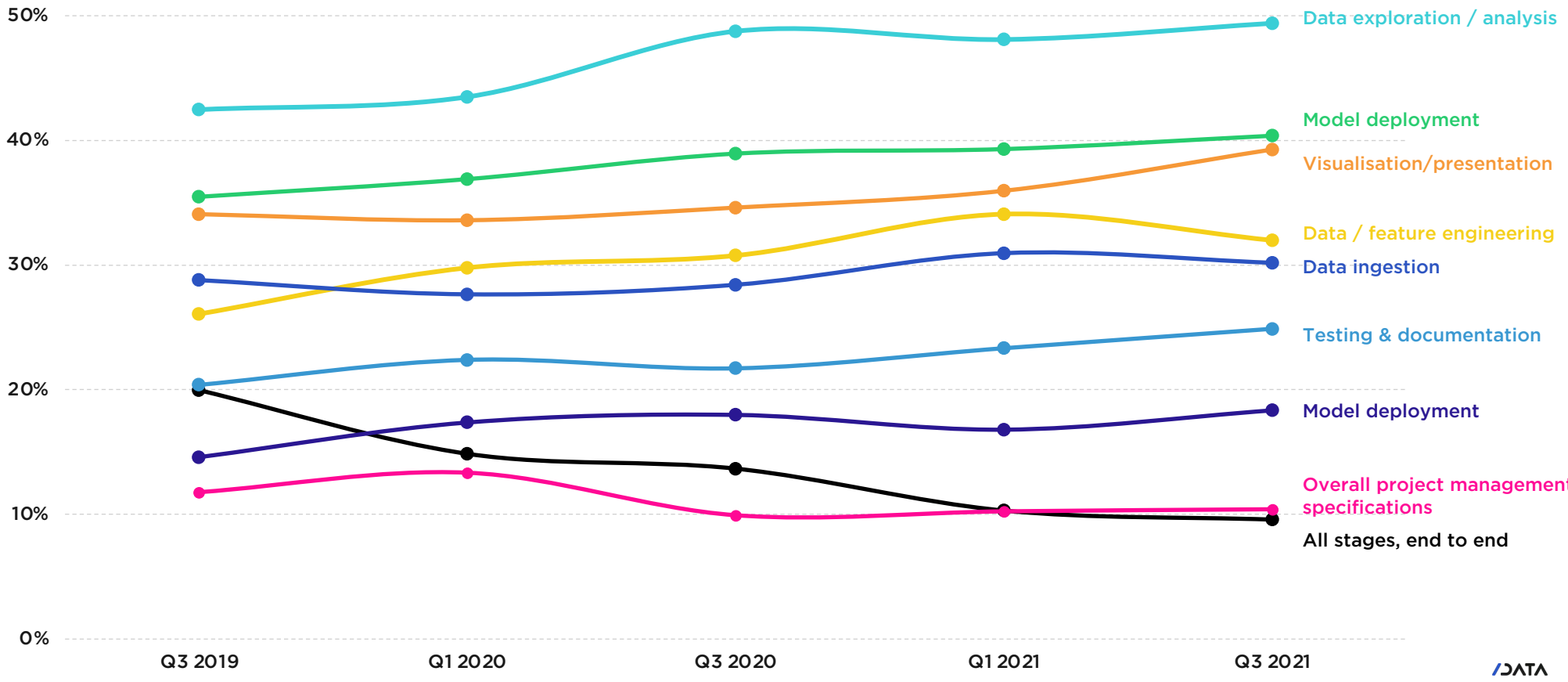
Whilst fewer developers are involved end-to-end in the entire data science workflow - the proportion has dropped by 50% since Q3 2019 - more developers are getting involved in each individual stage of the workflow. In fact, we have seen the proportion of developers involved in five or more individual stages increase from 12% to 18%, a 50% increase.

At first glance, these two facts seem to be somewhat in opposition to each other. How are developers simultaneously becoming less generalist, but developing more general skills? What we're seeing here is the evolution of working practices within the data science and machine learning sectors. Each stage of the DS/ML workflow is becoming more complex - it's difficult for developers to stay up-to-date with the newest backend technologies and cutting edge machine learning algorithms, and so we're seeing fewer people involved end-to-end. Here, developers are increasing the number of individual stages that they're involved in, while still remaining somewhat specialised within a section of the overall process.

What this means is that the DS/ML workflow is becoming siloed - developers involved in a particular stage, such as data ingestion, are also often involved in adjacent stages, such as data and feature engineering, for example. On the other hand, developers involved in model deployment tend to stay further upstream, being more likely to also be involved in testing, optimisation, and ongoing management. Interestingly, DS/ML developers who actually build the models are less likely than average to be involved in nearly every other stage of the DS/ML lifecycle - staying ahead of the curve here is a full-time job!

Each individual stage is increasing in importance, at the expense of true generalism

% of data scientists / machine learning developers involved in each stage of the DS/ML workflow
(Q3 2019 n=1,860 | Q1 2020 n=2,301 | Q3 2020 n=2,489 | Q1 2021 n=2,744 | Q3 2021 n=2,412)



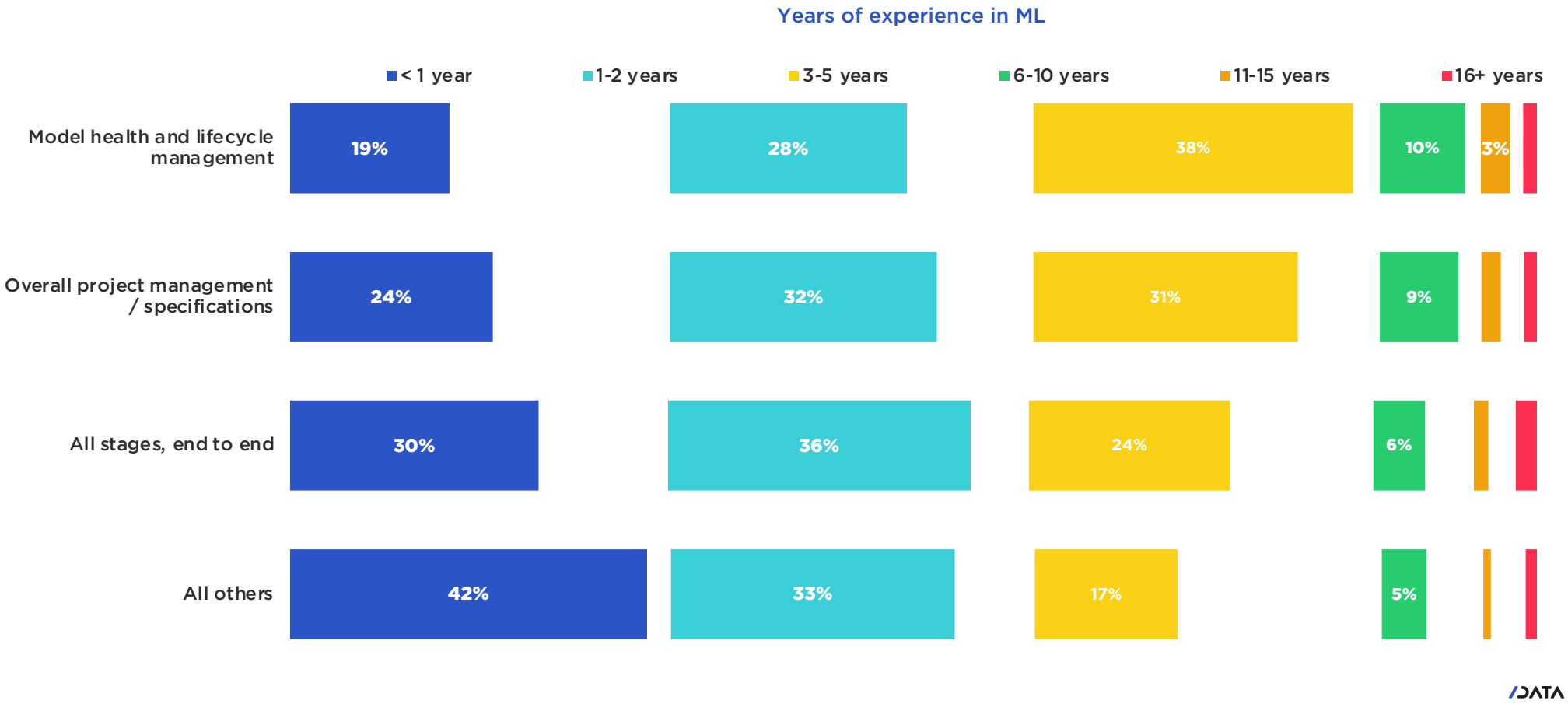
For the majority of stages in the DS/ML workflow, developers have a fairly similar experience profile. However, developers involved in model health and lifecycle management and overall project management/specifications tend to be more experienced: 48% of DS/ML developers involved in overall project management/specifications have three to ten years of experience, compared to just 31% of developers involved in any other stage. This rises to 61% for those involved in the model health and lifecycle management stage. These two stages require distinct sets of skills, built over a long career. For the overall project management and specifications, a generalist skill set and a high-level view are advantageous, allowing these developers to marry business needs with technical requirements for the bigger picture. On the other hand, model health and lifecycle management instead requires specialist knowledge.

Interestingly, though, those involved in all stages end-to-end have a similar experience profile, with experience peaking at one to two years. DS/ML developers at this stage of their careers may well be trying out many different activities in order to shape their future careers. We also see that these less experienced DS/ML developers are more likely than average to work as a freelancer - nearly a quarter do so - and end-to-end involvement is most prevalent amongst freelancers.

Involvement in the different stages of DS and ML projects is therefore dependent on many different factors - experience really counts for some activities, but at the same time, necessity is the mother of invention for inexperienced freelancers.

Overall project management/specifications, and model health and lifecycle management require distinct sets of skills, built over a long career

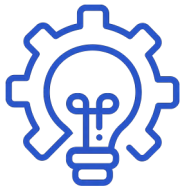
% of DS/ML developers doing each stage of the ML workflow (n=1,651)



ON DEVELOPERS WHO BUILD APPS AND EXTENSIONS FOR THIRD-PARTY PLATFORMS

Our digital world can be described as a collection of ecosystems filled with applications and services working alongside each other. Some services have evolved into their own platform, serving as a hub of opportunity for developers to build applications and extensions to enhance the platform's functionality. This chapter takes a closer look at the developers who build applications for third-party ecosystems, the types of platforms and audiences they're targeting, and the goals of their development.

05



44%

OF DEVELOPERS WHO BUILD APPS FOR THIRD-PARTY PLATFORMS HAVE SIX OR MORE YEARS OF EXPERIENCE IN BACKEND SERVICES

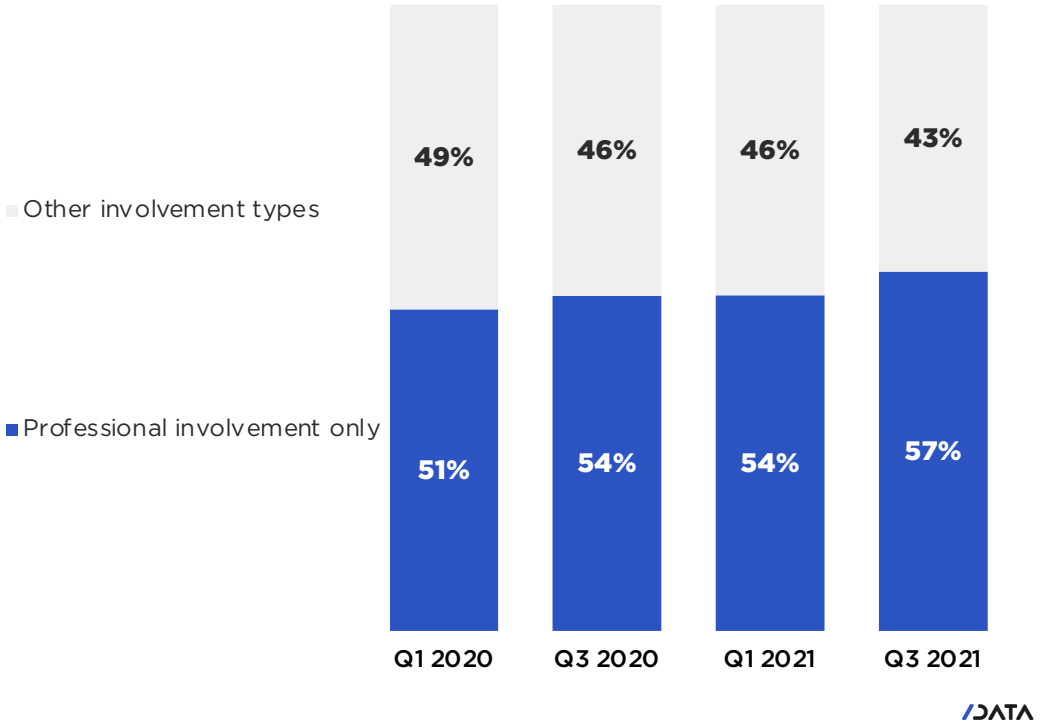
Back in the early 2000s, a few companies - Salesforce, eBay, and Amazon - recognised the need to share data across different business applications. The popularity of these platforms spawned a growing number of developers looking to support the users of these platforms with their own services. Powerful application programming interfaces (APIs) were introduced by platform vendors to enable application developers to interact with the inner workings of these platforms, thus forming an ecosystem with an extended variety of applications.

The market for applications and extensions for third-party ecosystems has been around for a number of years now, yielding a moderate level of experienced developers. Almost a quarter (24%) of developers building such applications have six or more years of experience in this specific development area. This ranks third-party app platform developers at an average level in terms of experience when compared to their peers in other development sectors. However, given the nature of this area, it's common for developers who build apps for third-party platforms to be involved in other development sectors, such as backend services, where 44% of developers have six or more years of experience. In general, these developers tend to be more experienced in other development sectors, indicating that development of applications for third-party ecosystems is more of an extended skill than a primary development focus.

Overall, our data shows that the population of developers who build apps for third-party platforms has been maturing, with a shrinking percentage of hobbyists and a growing percentage of professionals. As of this last survey (Q3 2021), we can see that 57% of third-party developers now identify strictly as professionals, which is the result of a decent increase since Q1 2020. This trend indicates that the market for applications and extensions for third-party ecosystems is healthy, with development opportunities that are attractive for professional developers.

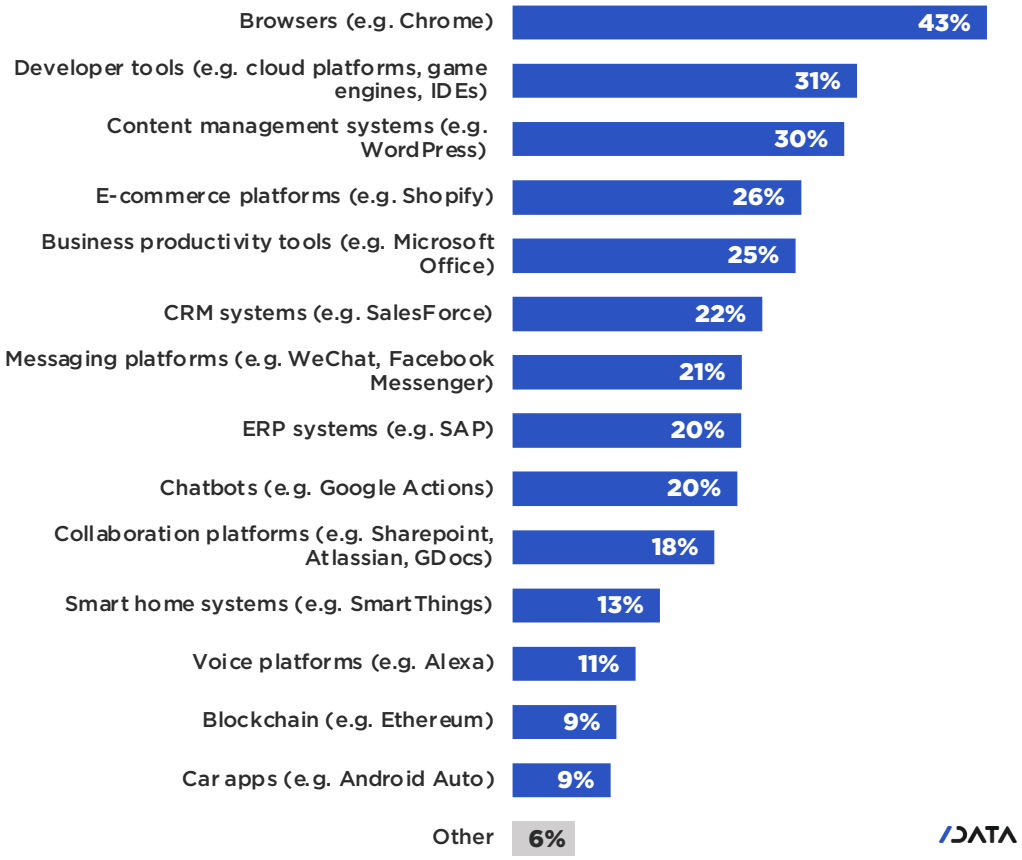
The proportion developers building apps for 3rd-party platforms is growing

% of developers who build apps for 3rd-party platforms and ecosystems
(Q1 2020 n=1,911 | Q3 2020 n=1,777 | Q1 2021 n=1,888 | Q3 2021 n=1,787)



Browsers are the most targeted platform type among third-party ecosystem app developers

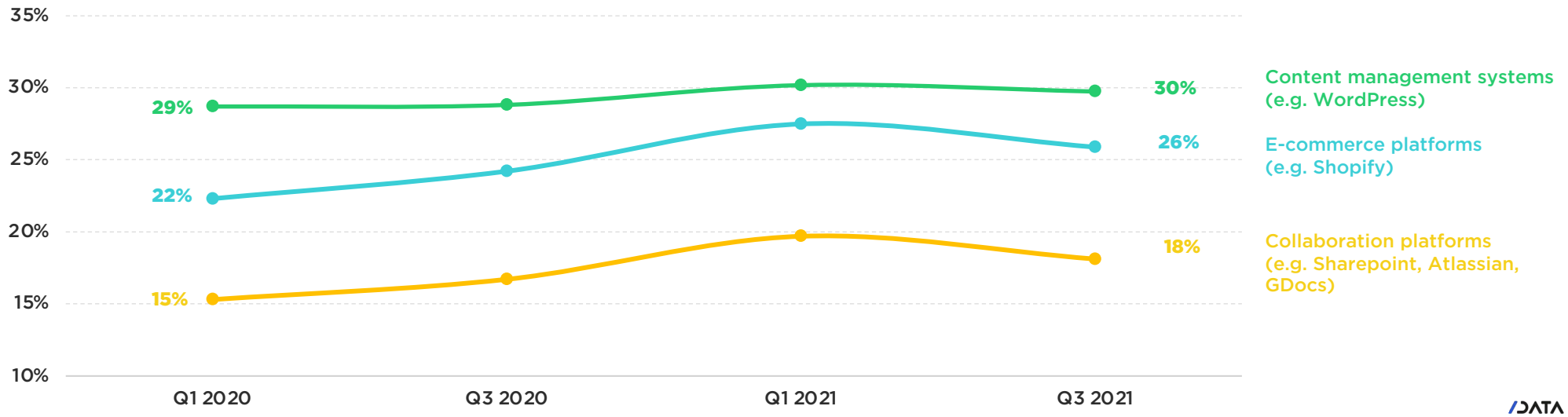
% of developers who build apps for third-party ecosystems targeting each platform type (n=1,765)



After the introduction of APIs in the early 2000s, other companies across multiple industries started to do the same. Our data suggests that 43% of third-party ecosystem developers are creating applications and extensions for web browsers, making them the most targeted platform category. If we only look at the world's most popular web browser, Google's Chrome, it has more than 2.6B global users and over 137K extensions. The total addressable market alone is good cause to target web browsers, regardless of their functional versatility. Looking at the past two years of data, browser interest has seen a slight decrease among third-party developers, but larger shifts in interest are taking place in other types of platforms.

Third-party app developers have increased their focus on e-commerce platforms

% of third-party app developers targeting each platform type (Q3 2020 n=1680 | Q1 2021 n=1750 | Q3 2021 n=1822)



Despite their affinity for web browsers, developers building apps for third-party ecosystems are finding new opportunities in e-commerce platforms. In the last two years, we've seen a 16% increase in third-party ecosystem app developers targeting e-commerce platforms. E-commerce transactions saw a massive 77% increase from 2019-2020 with a total of $82.5B.

This is largely due to the COVID-19 pandemic, which pushed more consumers to online stores. With a surge of potential new customers and a high concentration of monetary transactions, merchants looking to expand their product reach should look to integrate their services and products on e-commerce platforms to capitalise on this rising trend.

App developers for third-party ecosystems are increasing their focus on other professionals

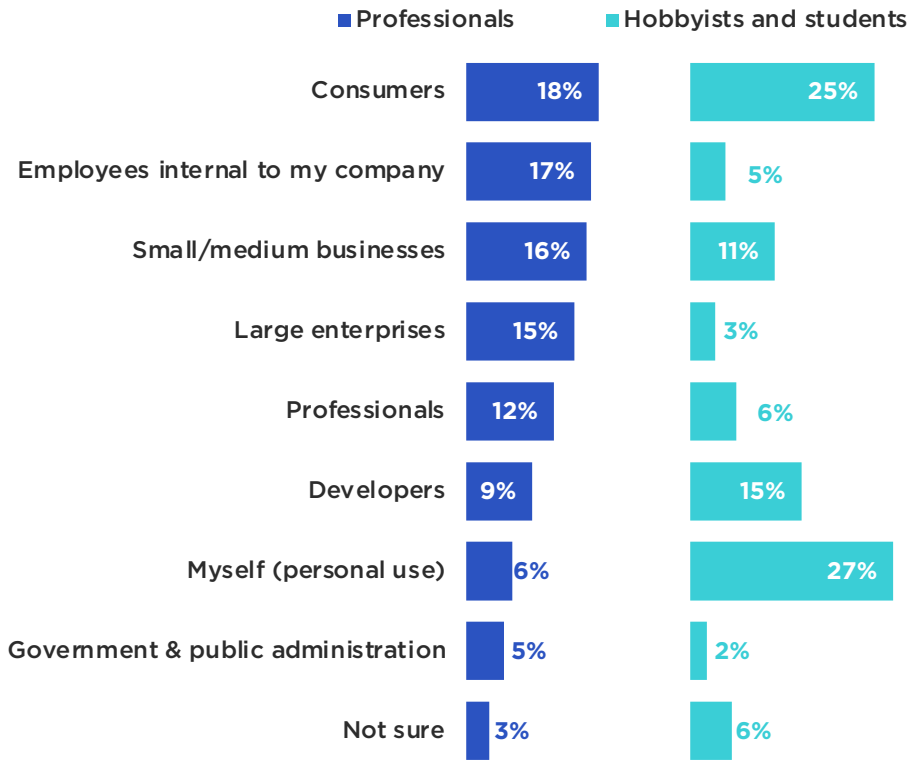
Now that we know a bit more about who third-party ecosystem app developers are and what platform types they're targeting, it's time to discuss who they're building applications for. We can see that one in five developers building applications and extensions for third-party ecosystems are targeting consumers. When analysing the goals of third-party developers focussed on consumers, 28% are developing products to gain experience or to maximise future opportunities, while only 25% are looking to generate revenue. While consumers may be the most popular target audience, motivations for this targeting are more about exposure than revenue.

When analysing the data by involvement type, there's a significant difference in target audiences when we compare professional developers to hobbyists and students. When filtering for professionals only, we can see that the percentage of developers targeting internal employees is almost the same as those targeting consumers. Further analysis shows that over half of these developers (58%) are building products to increase organisational efficiency and reduce costs. This illustrates the popularity of businesses customising and extending the functionality of established applications to better fit their goals. However, our trend data shows a slight decline in developers building apps for third-party platforms that target internal employees, signaling that business-adopted tools are becoming more robust, requiring less customised functionality.

Professional developers building apps for third-party platforms are also showing a waning focus on consumers with a growing interest in individual professionals. 12% of professional developers are now targeting other professionals when building applications and extensions for third-party ecosystems, a 26% increase in the last two years. The freelance population in the U.S. saw a 22% increase from 2019 - 2020. Now, over a third of the American workforce freelances in some capacity with signs of continued growth. This growing audience of individual professionals will need tools and resources to manage portfolios of clients and third-party platform app developers are looking to fulfill those needs.

Among developers who build apps for third-party platforms, professionals have a more diversified audience than hobbyists and students

% of developers building apps for third-party ecosystems that target each audience (Professionals n=754 | Non-professionals n=279)



TECHNOLOGY IN GAME DEVELOPMENT

Video games can be found everywhere: sold as physical copies, digitally downloaded versions, or subscription-based access over the cloud. The availability and variety of game-ready devices has impacted the technologies that game developers are using today. This chapter focusses on where game developers are deploying the code for their games and the technologies they're leveraging in developing them.

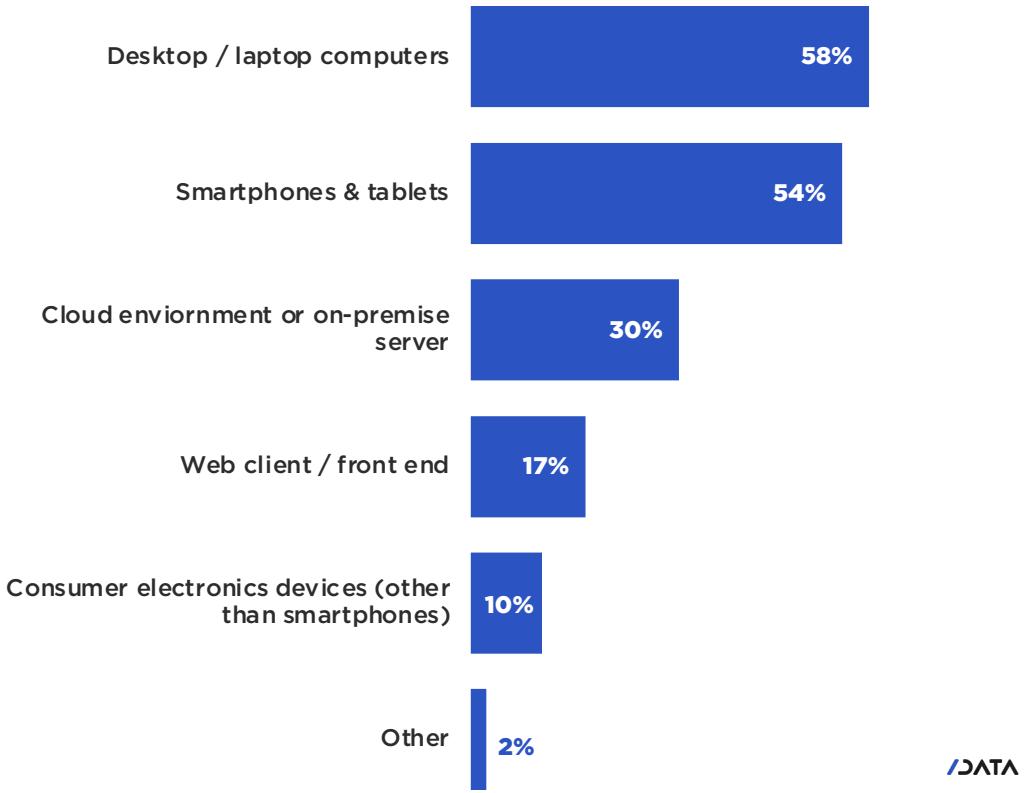
06

The game development sector has long targeted on-device game deployment. More than half of all game developers are writing code and deploying games for the usual suspects: personal computers and mobile devices. The percentage of developers deploying code for PCs saw a slight increase to 58% in the last six months, indicating that gaming on PC hardware is still a thriving market. However, the proportion of developers creating games that run in the cloud saw a slightly larger percentage increase in the last six months, rising to 30%.

Cloud gaming is arguably one of the most foundationally innovative trends in the game development sector. The increased usage and availability of smartphones with high-speed internet connections has paved the way for game developers to deploy their code to a game-configured server instead of a downloadable, platform-specific version. With less game-specific content to download and similar performance to on-device versions, both gamers and companies stand to benefit greatly from cloud gaming.

Where does the code of game developers run?

% of developers and the location where their game code runs (n=1,195)

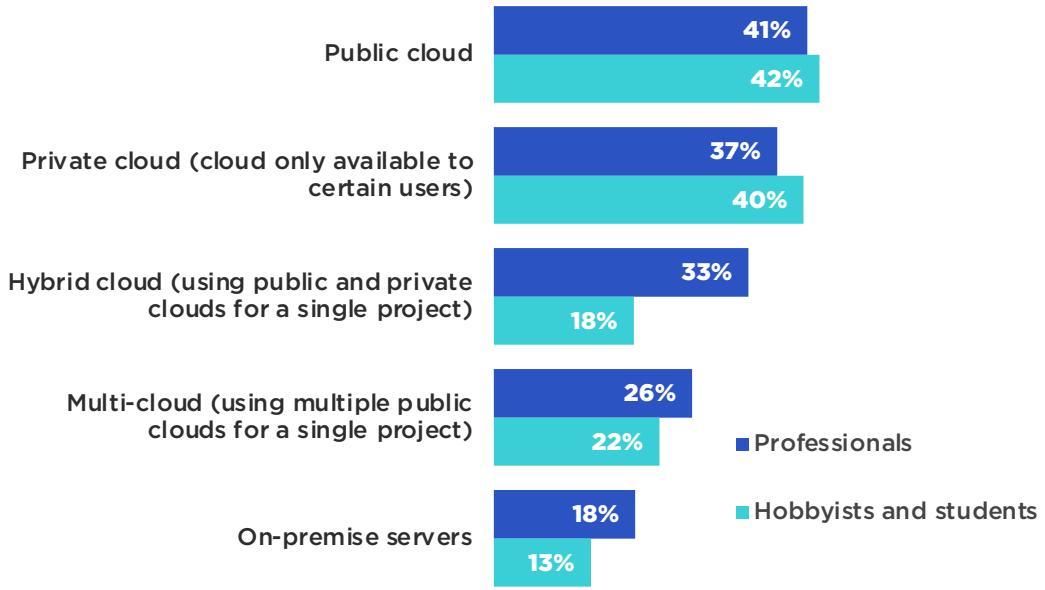


59%

OF PROFESSIONAL GAME DEVELOPERS DEPLOYING GAMES TO THE CLOUD USE A MULTI/HYBRID CLOUD STRATEGY

Server strategy usage among game developers

% of developers deploying games using each server strategy (n=310)



Cloud developers can either work with a single public, private, or on-premises server, or they can devise a strategy that uses a combination of these server types. Our data shows that about 46% of game developers deploying their code to the cloud are now using a multi/hybrid cloud strategy. Further, we see a significant increase in multi/hybrid cloud deployment to 59% when we filter for professional game developers only. Though a multi/hybrid cloud strategy can be more complex, it's a popular approach for game developers when tackling one of cloud gaming's biggest issues: latency. To reduce the amount of delay for users, game developers can leverage a multi/hybrid cloud approach that regionalises players and directs their interactions to the closest server.

Multi/hybrid cloud solutions are becoming more popular as companies look to reduce dependency on a single vendor and avoid vendor lock-in. There's also a cost optimisation that's associated with hybrid solutions, whereby companies can keep a steady amount of compute resources available on a private server, while engaging a public server for variable increases in resource requirements. With this growing trend, coupled with latency-reducing benefits, game developers can expect more projects to involve a multi/hybrid cloud approach.

Over the last 12 months, backend technologies have seen a massive increase in usage by game developers, making this the third most popular technology in game development, behind only 3D and 2D game engines. Backend technology use by game developers has almost doubled in this timeframe, from 11% to 21%. The growing trend of games being deployed in the cloud has partially fuelled the growth of backend technologies, especially among professional developers. Later in this chapter, we'll take a closer look at the other technologies that are driving this trend.

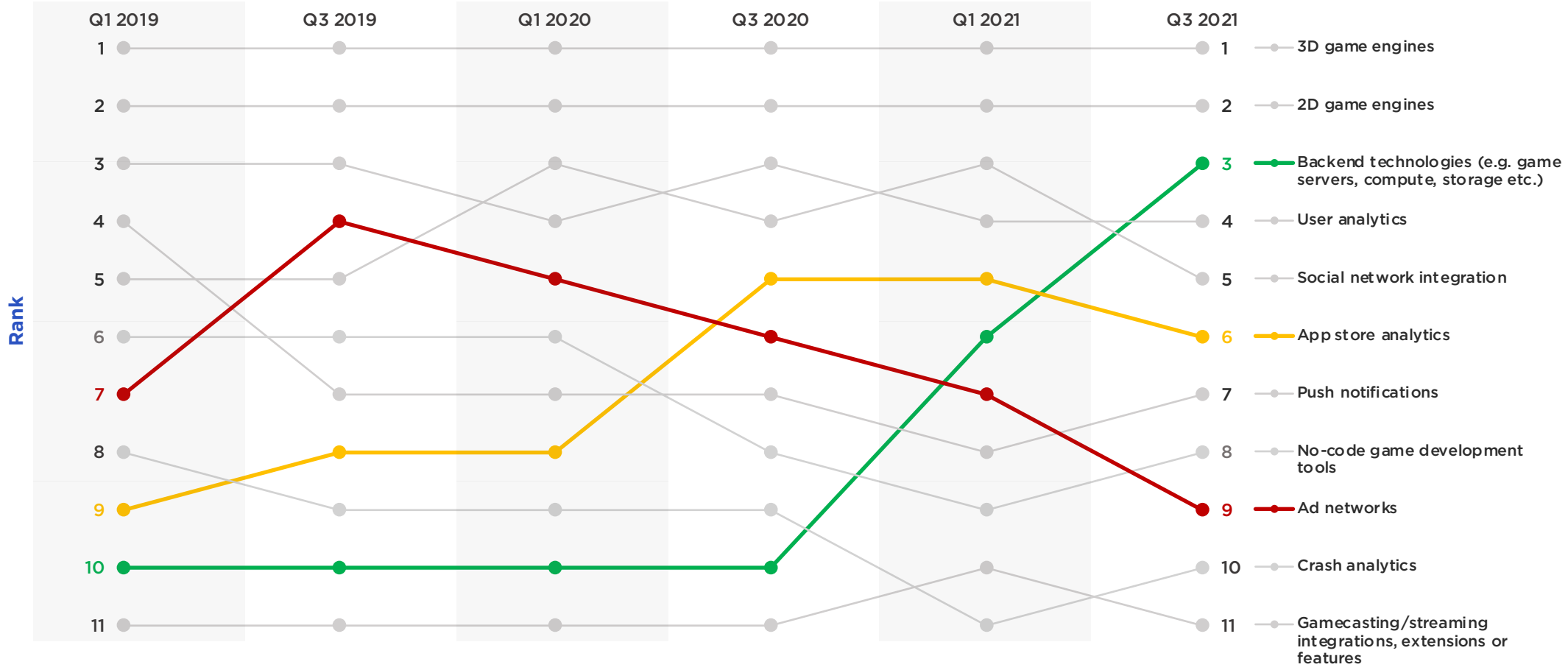
Looking further back to Q1 2019, app store analytics usage has seen a slight usage increase to 16% and is now the sixth most used technology in game development. Digging deeper, we can see that 70% of developers using app store analytics are deploying games via smartphones or tablets. Even though app store analytics exist for games on platforms other than mobile - Steam, for example - the growth in app store analytics usage can largely be attributed to the massive popularity of mobile gaming.

Ad network usage has dropped from the fourth most used technology to the ninth most used

In the two years leading up to this this most recent survey, ad networks had an average usage of about 27% among professional game developers. Usage has now dropped to 21%, a change that is in line with Apple's recent update requiring iOS developers to ask users for permission to be tracked by third-party websites and other applications. A survey was conducted before the iOS 14.5 update that showed about 57% of users were either unlikely or extremely unlikely to allow tracking by an application. Restricting access to users' Identifier for Advertisers (IDFA) reduces the possibility of conversion tracking, meaning less revenue potential for the advertiser and publisher, making the revenue strategy less attractive.

Leveraging backend technologies is a new trend for game developers

Ranking of technologies used by game developers (n=1,781)



Half of professional game developers are using game server technology

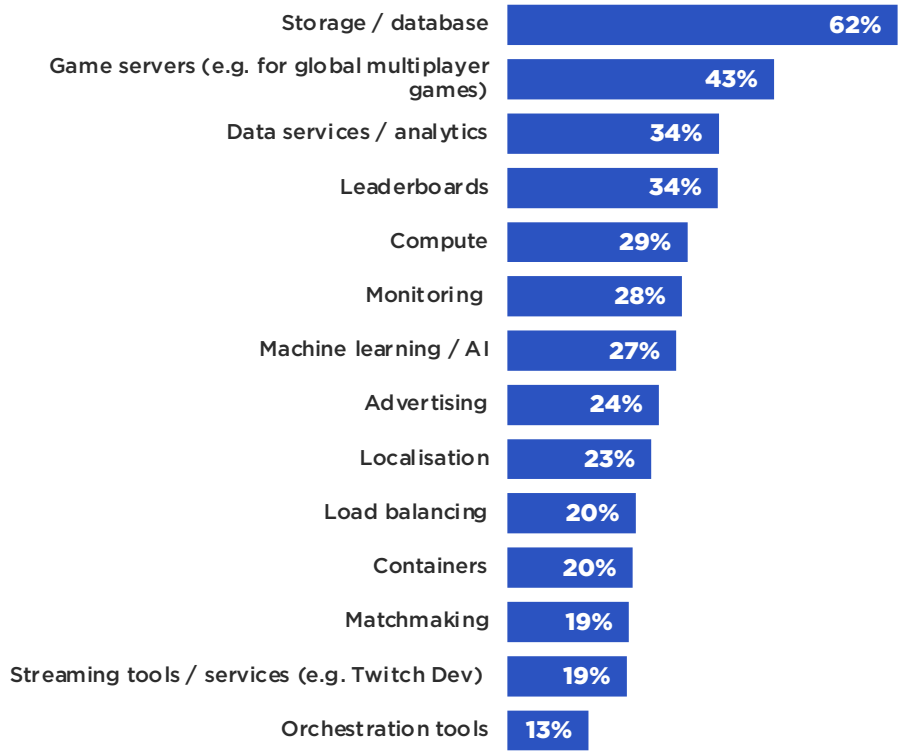
Taking a closer look at what is fuelling the backend technologies trend, our data shows 62% of game developers are using storage/database technologies. Databases are used to store and retrieve game and player data and can range from simple, flat file types to complex database structures. Game developers need to consider the right storage/database structure for each project to ensure a good gaming experience for the user, making storage strategy a near-essential part of game development.

Game development is a popular sector, attracting a wide group of developers with different levels of involvement. So much so that only 24% of game developers identify as professionals. When filtering for professional game developers only, we can see that they're using backend technologies 47% more than students and hobbyists. We subsequently see the usage for almost all backend technology types increase, conveying a greater sense of complexity in professional game development.

Usage of game servers and orchestration tools rise to 50% and 18% respectively among professional developers. Game servers function as the single point of truth for multiplayer games by processing user inputs and displaying the current game state back to the players. Multiplayer functionality has seen a growing demand for a few years now, to the point where single-player focussed games, like Red Dead Redemption 2, are now offering a multiplayer experience. Game server technology is also evolving, with the emergence of dedicated multiplayer products like Agones that are built on the back of Kubernetes. The growth of both backend technologies and cloud gaming are interdependent and are impacting the methods by which professional developers are building games. The future of game development will leverage the advantages of cloud technology more often, requiring game developers with skills and experience in managing data across multiple servers.

Databases are the most important backend technology in game development

% of game developers using backend technologies that work with each technology



METHODOLOGY

The Developer Nation Survey

The 21st edition of the Developer Nation survey reached 19,000+ respondents from 168 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 nine weeks between June and August 2021.

Respondents to the online survey came from 168 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 nearly 60 leading community and media partners within the software development industry.

Our respondents came from a broad age spectrum, from young coders who are under 18 to the seasoned ones over 55.

Respondents were asked which types of projects they are involved in out of the 13 under study, namely web apps / SaaS, mobile apps, desktop apps, backend services, augmented reality, virtual reality, games, data science, machine learning / artificial intelligence, industrial IoT, consumer electronics devices, embedded software, and apps/extensions for third-party app ecosystems. They also told us if they are into their areas of involvement as professionals, hobbyists, or students - or as any combination of these - and how many years of experience they have in each.

To eliminate the effect of regional sampling biases, we 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 https://www.slashdata.co/methodology.

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- **Reach new developer audiences**
  Get your offering in front of our Developer Nation community with 90,000+ developers in 165 countries. Promote your products, tools, events, and developer programs via newsletter inclusions, goody bag sponsorship, content amplification on our blog, or brand placement in our free reports.

- **Get insights into global developer trends**
  Understand how your audience stacks against the global average by inviting your developer community to participate in our research. Get 25+ graphs with the key trends based on the data from our surveys, which will help you shape your developer outreach strategies.

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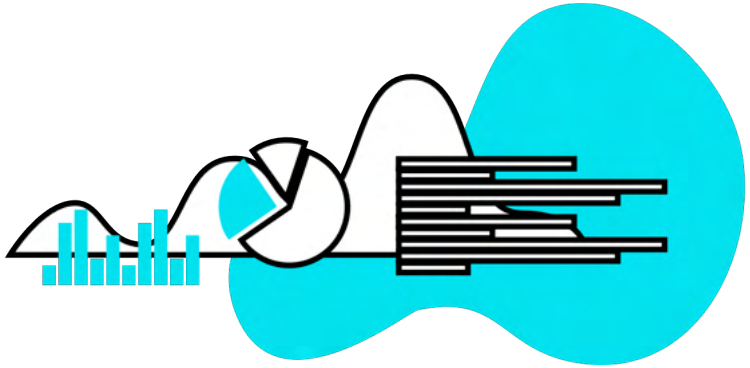

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