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Table of Contents

Introduction

Unleashing the full creativity of the workforce.

Human-machine symbiosis is important. But it could be costly. And the skills needed to do the work aren't sufficient yet. According to some estimates, the U.S. alone will lose $162 billion due to the shortage of software talent, with the shortfall in the analytics space twice as dire as in product or service design.[1] Further, by only employing incumbent software coders to do the hard work, firms are giving away the opportunity to harness the creative capability of the entire workforce.

More software is essential for the 21st-century operating model. In our Agile Radar research, we found that firms with a strong software pipeline and a customer-centric approach have better business outcomes.[2] Further AI research of close to 700 companies at various stages found that making software easier to use has the indirect effect of bringing business and IT closer together. In this study, the visionary AI firms could share data science knowledge more rigorously than others and proved in-house competency to deliver AI technologies at scale[3] (see Figure 1).

This theme looks at a firm's hypothetical journey from democratizing its software knowledge (termed no code/ low code, or **NC/LC**) to augmenting workers using **AI-driven coding and writing** (as long as there's a **human in the loop**) to an organization that automates its core processes from the inside out **(native automation)**.

At each stage, humans become even more productive and focused. While full automation of business processes

Figure 1. Nine-tenths of AI visionaries have developed in-house competency, whereas seven-tenths of the rest depend on external support
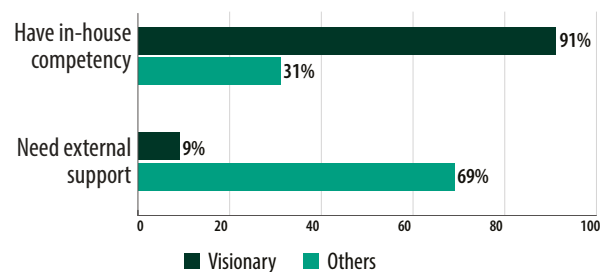
Source: Infosys

often inspires fears of job loss, many studies are on the reverse side. Automation can create more jobs than it takes away and enable knowledge workers to be more self-sufficient in their professional and personal lives.[4] For instance, instead of garbage collectors filling trucks, they can get involved with managing a fleet of robots — enabling them to use critical thinking skills that might have lain dormant otherwise. Detractors of this one-to-one mapping will say that blue collar worker can't easily take on knowledge-work, nor do they want to. This is a theme that is becoming highly charged in newspapers across the world, and only time will tell which side is right.

data. For smaller companies, tools like FreshDesk empower accounting departments, and Canva (now worth over $3 billion) enables individuals to design and publish visual content, leveling the playing field for high-quality design.

Gartner predicts that NC/LC **will account for** 65% of all app development by 2024

With everyone involved in the coding process, LC alone can cut 90% of development time for web apps.[6] It is often as simple as point-and-click or pull-down menus. Business professionals can build departmental systems in a few hours. And with a bit of robotic process automation (RPA) in the mix, users can design automated workflows that touch on multiple systems. By using special connectors and application programming interfaces (APIs), databases connect to AI tools for further innovation.

Other NC/LC use cases include function-specific tools for marketing, virtual assistants, modernization of legacy systems to achieve agility, and LC case management systems. With analytics growing in importance, something we touched on in the Digital Radar report, NC/LC versions of predictive analytics are now possible that take the data scientist through an automated ML process.[7] Microsoft's Power Platform is a suite of NC/LC software for the enterprise. Programs run as web apps and democratize coding across data visualization, workflow automation, and analytics. Some LC platforms such as Sketch2Code and Yeoman also create evocative omnichannel experiences.

Benefits of the NC/LC paradigm

There is less need to onboard coding superstars, and complex software can be built quickly, within three to 12 weeks. Data scientists can work on higher-value projects, which need acute data knowledge, and the rest of the organization has a chance of working with new tools, developing careers in the process. Other benefits include:

- Simplified security and compliance adherence
- Migration and elimination of existing shadow IT applications
- Easy minimum viable product and prototype development

Sub-theme 1: NC/LC

Contains:
- **NC/LC utilizes the whole workforce**
- **Benefits of the NC/LC paradigm**
- **The need for effective governance**
- **Use case: Democratizing design with NC**

NC/LC utilizes the whole workforce

NC/LC technologies require little to no coding knowledge to build applications and processes. This enables firms to overcome the shortage of talent in this area while empowering "citizen coders" to utilize their collective imagination on a working product.

Through NC/LC, executives build a strong software pipeline and democratize the firm's IP. This way, they can make their business more innovative, resilient, and data driven. According to Gartner, NC/LC applications will account for 65% of all app development by 2024. And Forrester perceives the LC market alone to be worth $21 billion by the end of 2022.[5]
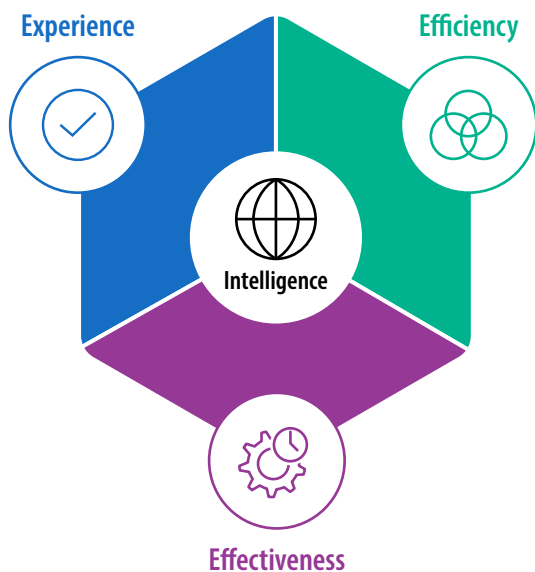
Shopify (worth $180 billion in 2021) has empowered layman developers to build and scale an e-commerce company at will. Tableau (a Salesforce acquisition) enables product owners to understand and visualize

Figure 2. A framework for NC/LC implementation

INTELLIGENCE

Unleash the power of AI-simplified data science and ML for predictive decisions and reusable congnitive services of NL vision, etc.

Amazon sagemaker, Azure MLstudio, Google autoML, H2O Driveless AI

EXPERIENCE

Design platform powering the best in class user experiences leverage power of the cloud to build, host, deploy rapidly mobile and web applications.

Invison, Adobe XD, Skecth, Figma Outsystems, Axure, Powerplatform

EFFICIENCY

Model, automate, and optimize complex end-to-end processes with robotics, business process management, case management, process mining with cloud-first mindset.

Pega, Appian, Bizagi, Celonis, IJP path, Automation, Anywhere

EFFECTIVENESS

Effectiveness of employees and teams by connecting enterprise data and people for dramatically increasing productivity.

Microsoft power platforms G-Suite, AppSheet, Amazon Honeycode

Source: Infosys

- Ability to build niche use cases built on the top of the existing enterprise resource planning (ERP) systems to avoid customization of the underlying system

For firms to get a handle on horizontal and industry use cases of NC/LC, a good start is to think about the problem space in terms of "experience," "efficiency," "effectiveness," and "intelligence" (see Figure 2).

The need for effective governance

Of course, there are risks involved. Some of these NC/LC tools have limited flexibility and use proprietary technology with partial portability. They also touch mission-critical systems. This is why building systems with human principles are even more important. And domain product owners are needed to scale, integrate, maintain, and govern these new systems — which comes at some expense. Additional security and privacy controls will also have to be configured and implemented to ensure data loss prevention, regulatory compliance, and controlled access and visibility to data and associated environments.

With an effective NC/LC playbook, business leaders can ensure their teams are using the technology appropriately. This means having the right policies in place, along with guidelines around which applications are allowed to be built on a platform and by whom. It also means designating a central authority to own the

approval process. Also, the whole enterprise should know which business processes can be automated using these tools and where manual, or human in the loop, exceptions are necessary.

As NC/LC proliferates (and to some extent AI-generated code does also), large enterprise vendors must keep an eye on disruptive upstarts taking them unawares. The NC/LC software platform upBoard is currently building a marketplace of instantly customizable business process apps.[8] SAP and Oracle in the enterprise space will need to continue simplifying their solutions for greater customization too. SAP Fiori, Salesforce Lightning, and Microsoft Dynamics are good examples of business platform add-ons. Such add-ons help customize enterprise applications, extend application functionality, and provide mobility extension on business platforms.

> *Effective governance, operations, and monitoring can ensure NC/LC scales, and that adoption and consolidation are done in a structured way to democratize application development by citizen developers.*
>
> **Viral Thakkar**
> *AVP and Senior Principal Technology Architect, Infosys*

Use case

Democratizing design with NC

Even as Adobe grows ever more confident and lucrative under the watchful eye of swashbuckling CEO Shantanu Narayen [REF 9], nimble design tools from the likes of Canva are making strides. Canva is a multimedia design platform that allows users to create visual content via a mobile app or web browser. These NC tools emphasize ease of use and address a market where price point and user functionality are becoming ever more important. Teams are increasingly adopting these tools to produce graphics much faster (see Figure 3)

NC tools remove development bottlenecks, which gives designers more control over the look and feel of the experiences they create. In Agile teams, developers focus on logic (often using LC tools themselves), and designers concentrate on style. The real magic is that tools like Canva and Adobe XD integrate all the underlying layers of software into end products, "providing functionality through modular components that can be harnessed through intuitive visual interfaces," according to design author Jeremy Q. Ho.[10]

The near future of NC experience design will include:

- Omnichannel design for voice, mobile, and web, all in an integrated manner.
- AI services built on experience design platforms to automate design for UI artifacts, including icons, backgrounds, logos, and branding aspects.
- Rules-based and AI services to automatically translate designs into production code that can be directly used by development teams.
- ML-based code generators to create design and code from drawings and designs. Tools like Sketch2Code and Screenshot-to-Code and code generators like Jhipster and Yeoman are at the forefront.

Figure 3. NC design software is growing in importance
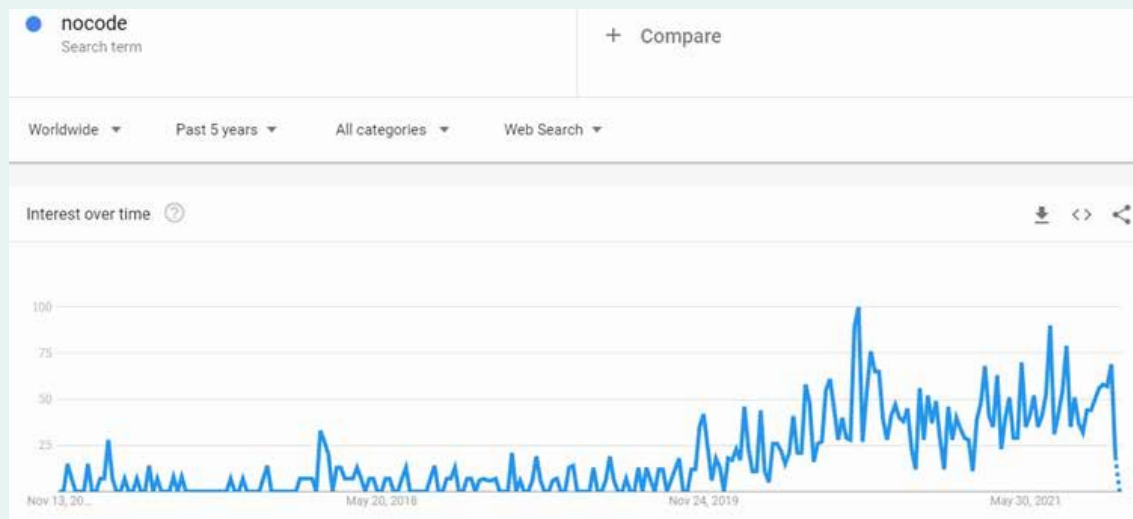
Source: Google Trends

Sub-theme 2:

AI-driven coding and writing

Contains:

- **AI augmentation delivers significant business value**
- **Using natural language to code**
- **Making coders, designers, and ML scientists more productive**

AI augmentation delivers significant business value

Netflix now deploys new code 4,000 times every day.[11] To keep up with this unprecedented pace, other firms are turning to AI-driven coding technologies. Innovators like Google, OpenAI, and Microsoft are letting their machines do the hard labor. This means that AI systems auto complete segments of code, fine-tune algorithms, search source code, and find troublesome bugs.[12] Analysts say that this sort of AI augmentation created $2.9 trillion of business value in 2021 alone, surpassing other AI initiatives.[13]

AI augmentation created $2.9 trillion

of business value in 2021, surpassing all other AI initiatives

Using natural language to code

These systems can even use natural language prompts and write code from scratch. This is what OpenAI's Codex software does. Trained on OpenAI's GPT-3 natural language model (and billions of lines of source code retrieved from public sources, including GitHub), the system can translate natural language into 12 different computer languages. And it can even translate among them. After breaking down a problem into manageable smaller problems, a developer can call Codex to map these problems to existing code (libraries, APIs, or functions) automatically. Joel Hellermark of Sana Labs, a Swedish startup, is creating dynamic coding courses

using Codex. The courses start by applying natural language to coding but then train students to craft more of their own, more efficient code over time.[14]

SourceAI, a Paris startup, is also doing work in this area. In their model, a short test description of what the program should do is all that's needed. Given simple commands such as "add apples and oranges in my Excel spreadsheet," students will now be able to "do their homework quickly," says CEO Furkan Bektes.[15]

Making coders, designers, and ML scientists more productive

According to Brendan Dolan-Gavitt, a professor of computer science at New York University, other products will be built that "make software programmers even more productive by identifying likely bugs in the code as they're being written, and by looking for 'surprising' code in completed scripts."[16] Facebook published details of Aroma in 2019. This AutoML tool identifies functionally similar lines of code, enabling programmers to write scripts more quickly and identify subtle bugs in a language such as Python or C++. Microsoft, for their part, has their GPT-3 PowerApps natural language software — which is, as of the time of writing, mainly used for complex data queries to underlying databases.[17]

There are also programs that generate images based on a wide array of natural language prompts. DALL-E, from OpenAI, treats text-image pairs as a generative task and learns to generate believable images (see Figure 4) from a wide array of prompts. DALL-E is a 12 billion-parameter version of GPT-3 and receives encoded images and texts in the form of a sequence of 1,280 tokens, which it models autoregressively. The best image samples are ranked using a technology called Contrastive Language-Image Pre-training (CLIP) — a neural net with zero shot capabilities — to consistently yield impressive visualizations. A natural question that arises here is, "What is the right prompt to use?"[18] Indeed, the exact framing of the text prompt has a large effect on the quality of the results.

As a popular Wired article by Tom Simonite explored, ML can even be used to generate better ML. The paper famously quipped, "About three years ago, some Google researchers paid handsomely to invent new AI software invented AI software to do some of their work. Their metalevel AI was soon better at some parts of their job than they were."[19]

It's not untoward to imagine that Microsoft might integrate an AI natural language code feature into Excel, reaching hundreds of millions of users, and vividly expanding access to enterprise users.

Figure 4. Images generated by DALL-E, which uses GPT-3 and autoregression modeling

Source: OpenAI

Sub-theme 3:

Humans in the loop

Contains:

- **The problem with bias, malware, and Tay Risk**
- **The AI Act in Europe: A sign where things are headed**

The problem with bias, malware, and Tay Risk

"Codex can generate code with structure that reflects stereotypes about gender, race, emotion, and class," OpenAI researchers warned in a paper released in July 2021.[20]

Measuring bias is, therefore, an important first step toward more inclusive research outcomes. In health data, the problem is fierce. ML solutions trained on data with missing information and biases in demographic information are widespread, and solutions need to adapt for these biases to avoid perpetuating health and social inequities. Also, by replicating buggy software, these new tools might inject security vulnerabilities into systems, and the software itself might be used to empower phishing attacks or introduce malware that remains undetected. AI is also vulnerable to Tay Risk — meaning that it can often offend people. These dangers all require supervision.

"Human oversight and vigilance are required for safe use of code generation systems," the OpenAI paper concludes. Shashank Srikant, a Ph.D. student at MIT, concurs. Some AI models shouldn't be relied on too much at present. "Once these models go into production, things can get nasty pretty quickly."[21] For instance, he says that AI language models are notoriously capricious. Words and phrases are often mixed up, with some sentences contradicting themselves. The irony is that it often requires deep coding experience to check the output of AI coding programs.

Further, AI tends to replicate unconscious human biases. It's then not just a case of examining the assumptions the AI and ML are working on, but also including diverse humans in this effort. Bias-free AI is impossible, however good the intentions, especially when much of it is strategized, built, and overseen by largely college-educated Westerners. With oversight by more typically marginalized workers, firms will have more reason to be transparent in their creation of code, overcoming the tension many have in disclosing what for many is reputationally-sensitive IP. Organizations that are prepared to be transparent will be the ones that will do better in the future, as they are the ones that will be trusted to do what's right for the world at large.

The AI Act in Europe: A sign where things are headed

Regulation can also help in this regard. The AI Act in Europe[22], introduced in April 2021, ensures that "high-risk" AI systems, including code generation algorithms that touch on industries like health, finance, and

defense, are subject to more scrutiny and accountability. Outputs of systems need to have human oversight, and be built so that intervention, judgement, and review is possible. According to a draft of the report shared at the Nordic Conference in late 2021, AI itself can be used to narrow down a set of contentious content for human vetting, "who then may need to assess the illegal nature of such content" and weigh in on areas where "error rates are high or where contextualization is necessary."[23]

Get this part right, and we're headed to what some experts call Software 2.0. In this brave new world, the focus will be less on teaching humans how to understand computers, and, in the words of Microsoft CTO Kevin Scott, more on teaching "computers how to accomplish a task in terms that are convenient for a human."

> "
>
> *Outputs of AI systems need to be interpretable, secure, and must contain all necessary technical documentation for effective use, while registering logs of their behavior. Even more, they must have effective human oversight.*
>
> **Rajeshwari Ganesan**
> *AVP, Infosys*
>
> "

Sub-theme 4:

Native automation

Contains:

- **Embedding AI into operations**
- **Implementing native automation with the focus on customer experience**
- **Human in the loop for exception handling**

Embedding AI into operations

In a hyperproductive business environment, automation is the key player. AI is actually embedded into the enterprise systems, moving away from rules-based methods of value creation. This sort of continuously learning and evolving organization, with sentient principles woven into the whole technology stack, is the subject of Rafee Tarafdar and Jeff Kavanaugh's book "The Live Enterprise: Create a Continuously Evolving and Learning Organization."

"In our research, we've found that organizations leading in AI operations, including the ability to scale native automation, outperform laggards by as much as 6 percentage points of operating margin," says John Gikopoulos, a partner at Infosys Consulting (see Figure 5).

Figure 5. Effective AI operations can increase operating margins by up to 6 percentage points across industries
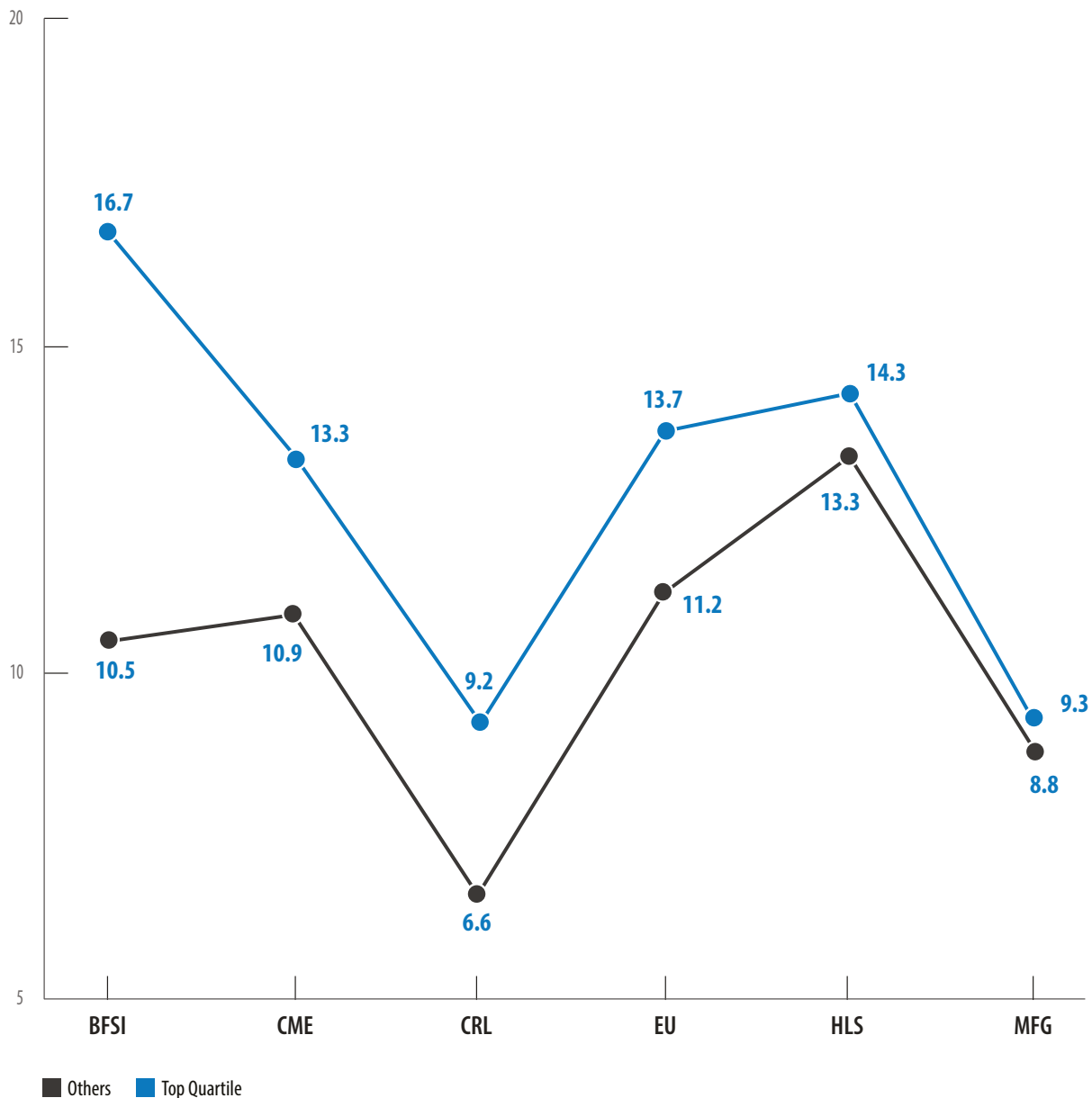
Source: IKI

More organizations are creating such fully automated operations. According to Gartner, by 2025, more than one-fifth of retail products will be "manufactured, packed, shipped, and delivered without being touched."[24] Our work with BP demonstrates this vision. In BP's fully autonomous store, a customer refuels their electric vehicle (EV) before walking into the store to buy something. From that moment on, everything is automated, with the customer ordering and receiving

goods with almost no human interaction. Picking robots collect the chosen items (via mobile app) from storage, with the process bringing together order fulfillment, inventory management, and robot fleet management. Autonomous mobile robots use computer vision to place the chosen items on conveyor belts, which the customer then picks up from an attendant before walking out to a fully charged vehicle.

Figure 6. How to introduce Native AI in your organization

For a narrow business domain	For a broad business domain
You solve a niche problem through AI, leave route inefficiencies untouched, and don't consider interrelated processes in a business domain	Work will take over two years to complete, with return on investment not seen until then
Leaders aren't involved across the value chain, and the business owner realizes that solving the problem won't have enterprise significance	There's no clear business owner with accountability, and many business owners conflict on how to get the work done
The solution doesn't integrate with both upstream and downstream processes	The business needs to resolve underlying tech and data architecture issues to derive any meaningful value from native automation

Source: Adapted from HBR "Getting AI to Scale"[25]

Implementing native automation with the focus on customer experience

Firms with a software-defined operating model (think platform-based giants, such as Amazon or Ocado in the U.K.) find it easier to automate whole value chains, such as the recruitment process or insurance claims approval. They already have a strong product-centric strategy — with a focus on how solutions and services are consumed rather than the features they exhibit — and are customer-focused. For less innovative firms, native automation can be introduced by first selecting a medium-sized business domain (see Figure 6), where automation can deliver significant business outcomes (efficiency, reliability, scalability, and agility).

The framework (Figure 4) used in our first theme — "Humans at the center of technology design and development" — can be used to work backward from

a key automation goal or business process challenge. For example, when using AI to repurpose the customer experience, firms might envision what a five-star customer experience would look like and then explore in granular detail how to achieve it. This sort of innovation is progressive. For example, in the case of credit scoring customers, a firm might decide to automate the whole process. Neener Analytics, an AI credit scoring company, can be onboarded to ensure a one-click customer experience.[26] The AI used in the Neener algorithm sifts through a customer's credit history and, in 15 seconds, decides whether to offer risk products to customers. Instead of a lengthy documentation process, the AI looks at social media history and uses deep learning to work out the likelihood of default based on customer behavior. This opens the market to customers without a credit profile (56% of Americans have either limited credit history or no history at all). For the lender, the

Figure 7. Neener's AI system: Automating the credit approval process
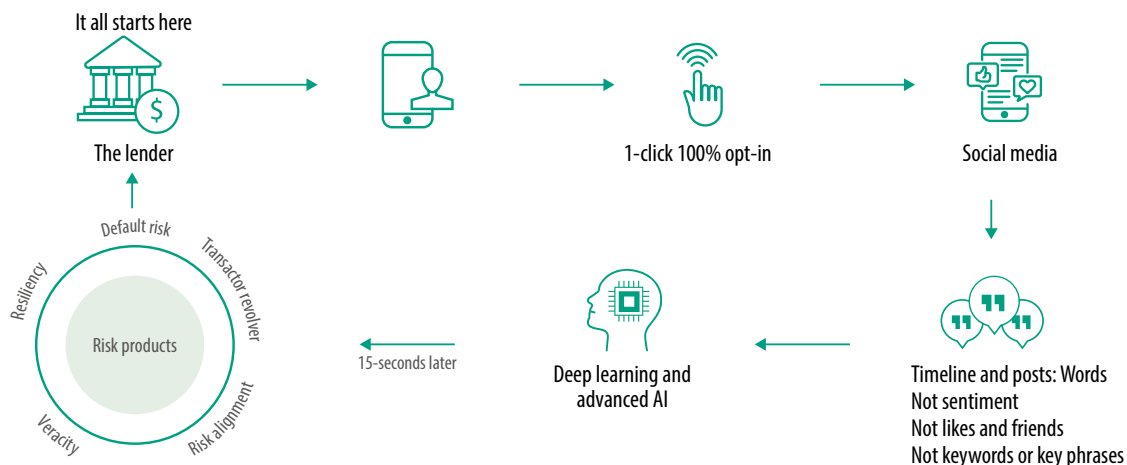
Source: IKI

efficiency is astronomical. This end-to-end process (see Figure 7) is an example of breaking down a manual process into constituent elements and then using AI to reimagine it from the ground up.

The focus then should be less about using RPA or automation in an ad hoc manner to make processes more efficient. Instead, whole customer journeys should be reconsidered with AI at the core. In our Agile Radar research, we found that focusing on customer journeys in this way has a remarkable effect on both business and IT success, as measured by market share, revenue, and swift software delivery.[27]

Human in the loop for exception handling

Again, a human in the loop should always be available for edge cases or when real-time decision-making can be detrimental to safety. Known as exception handling, human attention is built into the autonomous system, especially where black-box AI systems and RPA are used. To get ahead, visionary firms will need to upskill their workforce and ensure partners are well versed in the

systems. A proactive automation plan is also needed to ensure that automation doesn't get out of control in the enterprise.

"Executives [and chief product officers] must ask the question: How much automation is tolerable, required, and most importantly, ethical?", says Prasad Joshi, head of iCETS at Infosys. "Answers to these are a key part of system design, with the relevant objectives and key results mapped to process key performance indicators (KPIs)."

Of course, fear of job loss will be widespread when a whole process is reimagined. But AI can generate far more work than it takes away, which is the subject of the stellar book "Exponential: How Accelerating Technology Is Leaving Us Behind and What to Do About It" by Azeem Azhar. MIT, for its part, predicts that AI will enable new ways of working, and new industries will emerge.[28] This sort of reassurance will go a long way to get the whole enterprise behind the AI vision, whether that's just using NC/LC to democratize coding or automate the entire business process.
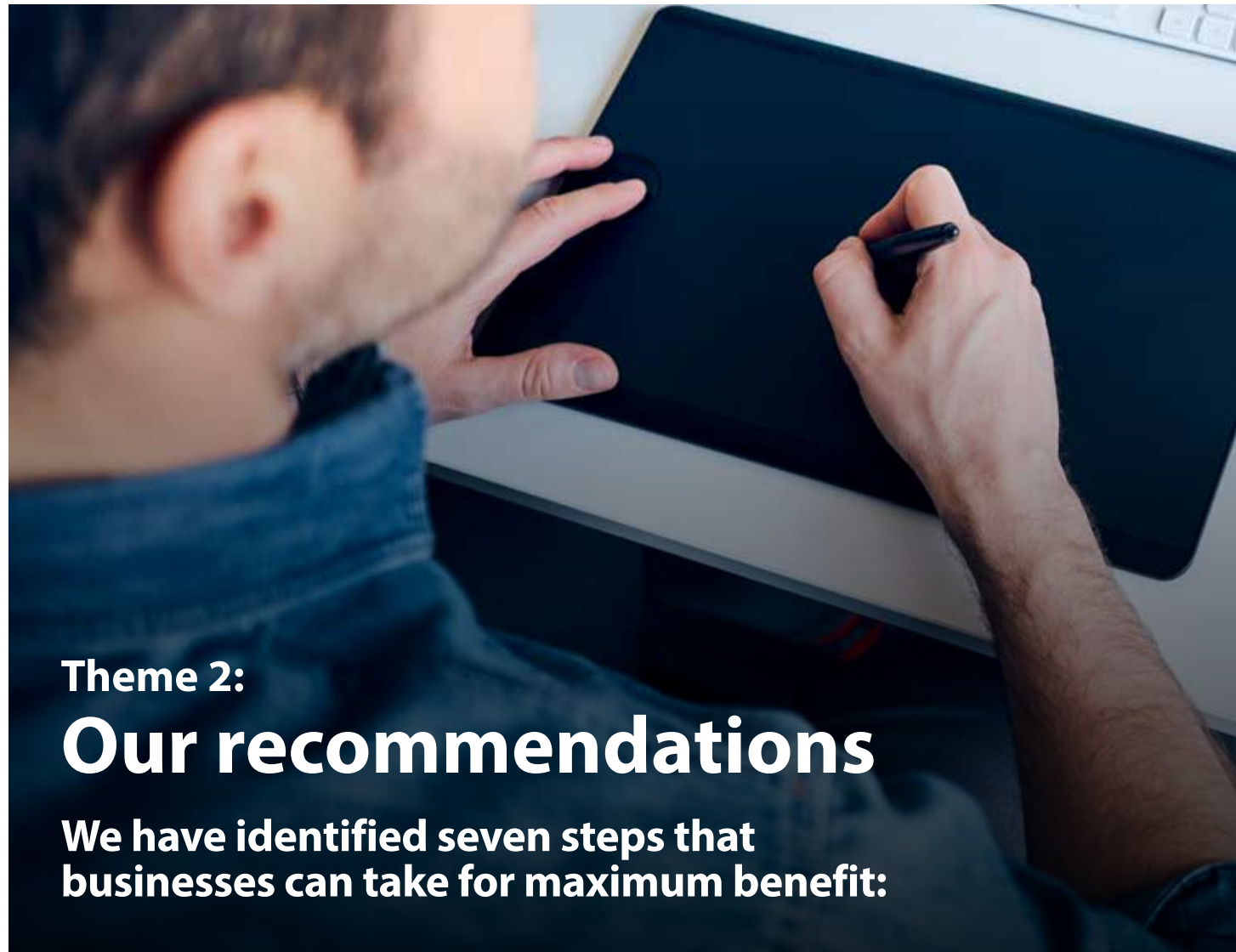
Theme 2:

Our recommendations

We have identified seven steps that businesses can take for maximum benefit:

Strategic recommendations

- **Lay out an enterprise vision for NC/LC across five key dimensions:**

  a. **Experience design,** such as omnichannel design for voice, mobile, and web

  b. **Digital experience,** such as AI-assisted development with sentience

  c. **Digital process automation [and operations],** such as advanced process intelligence with support for cognitive capabilities like NLU and image processing

  d. **Enterprise productivity,** such as AI-enabled productivity apps with pre-built models for data analytics and display

  e. **Artificial intelligence,** such as enterprise-level AI, with a shift from fragmented to integrated, managed, and monitored pipeline building and modeling

- **Use modular software to unbundle and rebundle key competencies:** Use the opportunities afforded by NC/LC to consider how to rebuild processes so that the organization is focused on customers rather than on internal processes.

- **Keep leaders in the loop on AI code generation systems:** Leaders should ensure there is someone responsible in the organization for the safe, transparent, and responsible use of AI, even as it applies to code generation.

- **Set up a cross-functional leadership team for native automation and track results:** This drive

needs to be overseen by a cross-functional leadership team. This will help drive technology investment. A good plan for measuring success is also important, using objectives and key results.

Tactical recommendations

- **Keep experienced developers and leaders to monitor NC/LC implementation:** Even though NC/LC platforms are easy to build, they require more experienced oversight to ensure that programs are stitched together effectively and properly connected to databases and transactional systems.

- **Security by design:** Data security and privacy professionals need to be involved at all stages to make sure the self-service approach doesn't compromise privacy or security.

- **Upskill the workforce to work in the democratized AI paradigm:** As firms mature in their AI journey, the whole organization will require upskilling and community development to work in an open, Agile, low-code landscape. To help here, executives should use a light-touch mode of leadership, investing power in self-contained, autonomous Agile teams that collaborate effectively across functional boundaries.
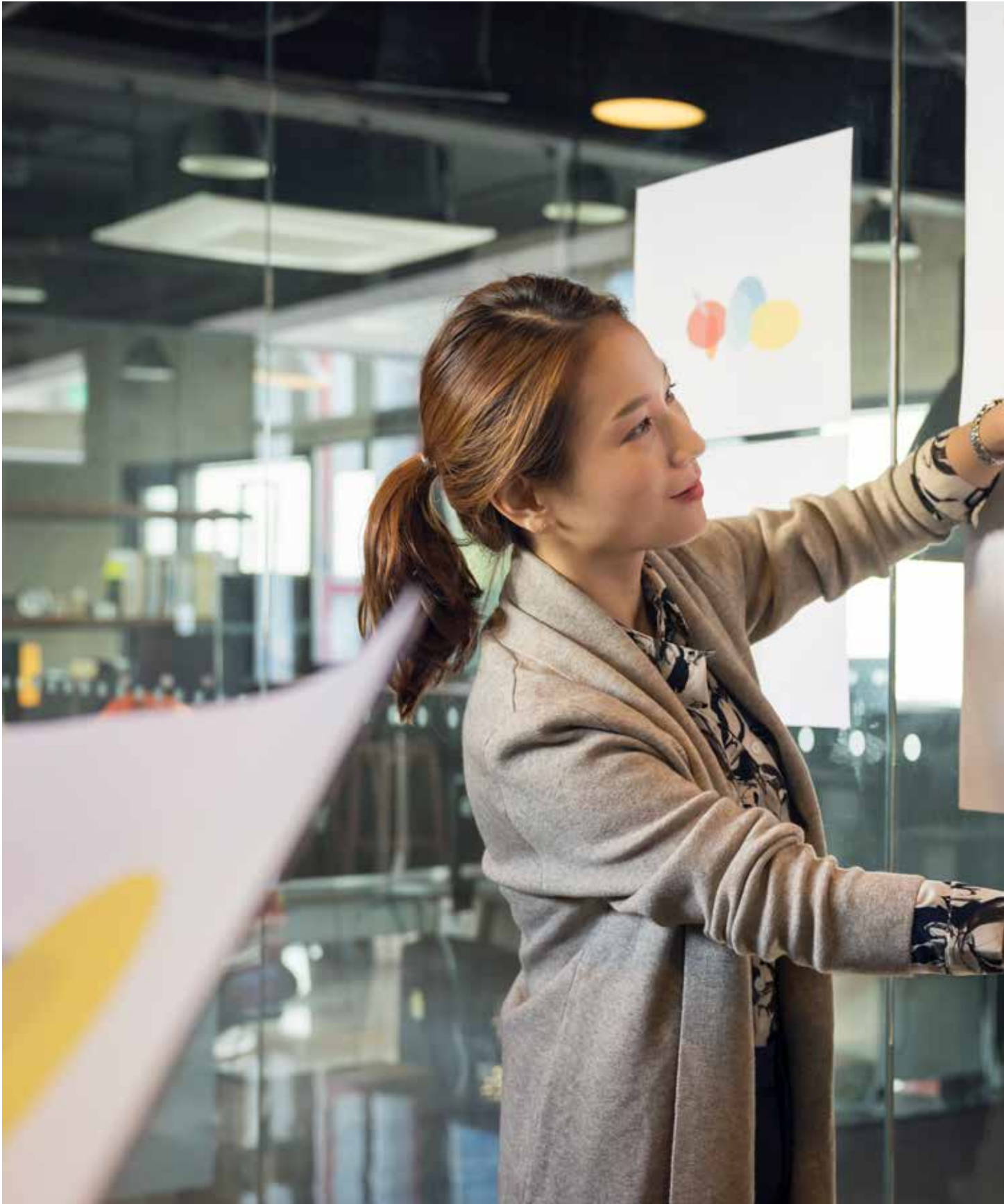
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