The value of learning skillsets within a trio of disciplines and the role each plays in DevOps.

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What Do Agile, Lean, and ITIL Mean to DevOps?

THE METAPHOR OF development teams throwing applications over a wall to the operations group for deployment is often used to vividly illustrate that development and operations operate as silos. The DevOps movement was started in 2008[17] to try and break down these barriers between the development and operations groups. The DevOps movement relies on a culture that strives to understand the capabilities and constraints of the other group (development or operations): "Delivering value to the business through software requires processes and coordination that often span multiple teams across complex systems and involves developing and delivering software with both quality and resiliency."[11]

Automation is a major enabler of DevOps as it is highly desirable to automate provisioning, release management, and anything else that is possible.

Continuous build, integration, and delivery are also enablers of DevOps.[17] But DevOps is not just about tools that facilitate development and deployment. In *The DevOps Handbook*,[19] the following myths are debunked.

1. DevOps replaces Agile.
2. DevOps is incompatible with ITIL.
3. DevOps means eliminating IT operations.
4. DevOps is just "infrastructure as code" or automation.

DevOps is about good development practices that continually deliver product features (Agile) effectively with minimal wasted efforts (Lean) which are overseen by good governance controls (Information Technology Service Management, or ITSM).[2] To that end, a growing consensus within the information technology community is that DevOps = Agile + Lean + ITSM. We believe the integration of Agile, Lean, and ITSM can provide a strong foundation for DevOps.

Adopting DevOps is not an ad hoc or routine operational change, it is transformative in nature and requires a fundamental shift in the traditional ways of working. DevOps is not just a new technology adoption initiative. Rather DevOps adoption should be people-centric, including defining clear roles and providing appropriate training.[14] But the lack of a common

» **key insights**

■ **The consensus within the DevOps community is DevOps = Agile + Lean + ITIL.**

■ **The DevOps goal is to enable cross-functional relationships between the development and operations groups thereby enabling them to work together to ensure IT services are transitioned to the live environment successfully.**

■ **The integration of ITIL with Agile and Lean as part of ITIL 4 is a positive step in establishing a practical framework to enable the implementation of DevOps.**

■ **Our data analysis provides significant evidence that there is value gained by IT professionals if they possess Agile (salary premium 26%), Lean (salary premium 9%) and ITIL skills and knowledge (salary premium 16%).**

DevOps set of skills and knowledge negatively affects the implementation and training of DevOps roles for organizations and educational institutions.[18] We believe that understanding the value of each discipline (Agile, Lean, and ITSM) will assist organizations and educational institutions to better appreciate the value of the specific skills and knowledge for a DevOps role. Specifically, both IT professionals and organizations can select the best course of action to maximize their investment and time when pursuing and acquiring DevOps skills and talents based on the relative value of each discipline.

In a prior study focusing on the value of Agile skills, Agile skills produced a 22.6% increase in average salary.[9] In another study focusing on ITIL (the leading ITSM framework[6]), ITIL skills produced an overall salary premium of 10.0% with ITIL certification producing an even greater 14.5% salary premium.[13]

This article begins with an overview of Agile, Lean, and ITSM, emphasizing the areas of overlap, and then addresses the following research questions: (RQ1) Are there compensation benefits for IT professionals that possess Agile, Lean, and ITSM skills? With the logical follow-up question, if there are benefits: (RQ2) What are the estimated benefits?

Agile

After many years of using the waterfall software development methodology (and other less than successful approaches),[17] software developers met to discuss alternative software development methods in 2001. The "Manifesto for Agile Software Development" was the result of this meeting. The Manifesto[23] is a set of four values that are supported by 12 principles. In a 2010 study of Agile practices,[8] the most widely valued Agile principle was related to business people and developers working together. The 2010 study[8] found 84% of respondents rated this of high importance. The (tied for) second most valued Agile principle related to achieving customer satisfaction through early and continuous delivery of valuable software. Some 60% of respondents rated this of high importance.

Essentially, the Agile approach is designed to drive shorter feedback

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loops that ultimately improve customer value by developing software in a collaborative, iterative, and incremental manner. The main elements of The Manifesto[10] are:

▸ Work is done by self-organizing teams, networks, and ecosystems that mobilize the full talents of those doing the work.

▸ Work is focused directly on meeting customers' needs and interaction with the customer is paramount.

▸ A "lens" focuses attention on the customers' needs (when the lens is a person, as in Scrum, the person is known as a "product owner").

▸ Work proceeds in an iterative fashion and progress toward fulfilling the needs of customers is assessed at every stage.

There are a wide range of Agile software development methods including eXtreme Programming, Adaptive Software Development, Scrum, Agile Project Management, Crystal Methods, Feature-Driven Development, Lean Development, and Rational Unified Process.[1] As a result, agility could be considered more of a mindset rather than a specific set of techniques.

Lean

Manufacturing took many concepts from leadership practices and learned how to remove constraints along the flow of work using a variety of short feedback loops.[25] "The core idea behind lean is maximizing customer value while minimizing waste," states The Lean Enterprise Institute.[20] The Institute goes on to state that "Simply put, lean means creating more value for customers with fewer resources."

There has been a long-time connection between Agile and Lean in the IT field. In 2003, Poppendieck and Poppendieck[23] published their book, *Lean Software Development: An Agile Toolkit*. This book was part of Addison-Wesley's *The Agile Software Development Series*. In their book, Poppendieck and Poppendieck illustrate how 22 different Lean tools, such as seeing waste and value stream mapping, could be applied to the (Agile) software development process.

In 2010, Bell and Orzen[6] published their book *Lean IT: Enabling and Sustaining Your Lean Transformation*. They applied Lean to the entire IT

organization. In their Lean IT pyramid, the top of their pyramid is culture. The starting building blocks are: consistency of purpose, respect for people, and pursuit of perfection. Intermediate layers include: Voice of the Customer (originally a marketing term widely adopted in business to describe the in-depth process of capturing customer's expectations, preferences, and aversions); quality at the source (a Lean manufacturing principle defines that quality output is not only measured at the end of the production line but at every step of the production process; at each step, the responsibility for quality are the individuals working on the step rather than quality inspectors); systems thinking (a holistic approach to analysis that focuses on the entire system and the relationships between each of the system's constituent parts over time); and flow/pull/Just-in-Time (an approach in which materials, goods, and labor are scheduled to arrive or be replenished only when needed in the process—that is, just in time).

The DevOps Handbook was highly influenced by prior work on Lean and Agile applied to IT. A major theme of this book is the *three ways* described as: "the values and philosophies that frame the processes, procedures, practices of DevOps, as well as the prescriptive steps:"[19]

> The First Way emphasizes the performance of the entire system, as opposed to the performance of a specific silo of work or department—this can be as large as a division (for example, Development or IT Operations) or as small as an individual contributor (for example, a developer, system administrator).[19]

> The Second Way is about creating responsive feedback loops. The goal of almost any process improvement initiative is to shorten and amplify feedback loops so necessary corrections can be continually made.[19]

> The Third Way is about creating a culture that fosters two things: continual experimentation—

taking risks and learning from failure; and understanding that repetition and practice is the prerequisite to mastery.[19]

Information Technology Infrastructure Library (ITIL)

Information Technology Service Management (ITSM) is a quality management approach for managing IT services that meet the needs of the business[7] by focusing on the effective and efficient operation of the IT service provider's internal processes.[12] ITSM is defined as the implementation and management of quality IT services that meet the needs of the business and is performed by IT service providers through an appropriate mix of people, processes, and information technology.[12] There are several ITSM frameworks, but the most widely known framework is the Information Technology Infrastructure Library (ITIL). In our data analysis, we use ITIL knowledge to represent ITSM knowledge.

There are five life cycle stages in ITIL v3: Service Strategy; Service Design; Service Transition; Service Operation; and, Continual Service Improvement (CSI). CSI has many similarities to the Lean concept of kaizen. CSI uses methods from quality management such as the Deming PDCA (Plan-Do-Check-Act) Cycle.[16]

Like The Agile Manifesto, ITIL explicitly states some essential principles and values. In ITIL v3, each of the five life cycle books begin with a chapter on services and value. In ITIL's definition of a service, it provides an essential core principle—a service is a means of delivering *value* to customers by facilitating *outcomes* customers want to achieve without the ownership of specific costs and risks. ITIL further expounds on this principle as IT service value is composed of two parts: utility and warranty. Utility is a service's fitness for purpose while warranty is a service's fitness for use. Utility is simply a service's functional requirements. Warranty includes availability, capacity, continuity, and security.

In terms of DevOps, Service Design (Development) and Service Operation (Operations) have considerable relevance because of the overlapping activ-

ities in DevOps performed in the processes that make up these two ITIL life cycle stages. Service Design includes processes for Service-Level Management, Availability Management, Capacity Management, IT Service Continuity Management, and Information Security Management. Service Operation consists of five processes: Event Management, Incident Management, Request Fulfillment, Problem Management, and Access Management. ITIL also suggests four generic functions (employee groups): Service Desk, Technical Management, Application Management, and IT Operations Management.[15]

The updated ITIL framework, ITIL 4, was released in 2019:[3]

> This name reflects the role ITIL will play in supporting individuals and organizations to navigate the Fourth Industrial Revolution. IT is at the core of every modern business in the global economy. The update will allow ITIL to reflect the fast-paced and complex environment we live in, and new ways of working and emerging practices, all of which are essential not only for ITSM professionals, but also for a wider range of professionals working in the digital transformation world. The purpose of ITIL 4 is to provide organizations with comprehensive guidance for the management of information technology in the modern service economy. ITIL 4 will evolve to provide an end-to-end IT/Digital Operating Model, covering the full delivery (and sustaining) of tech-enabled products and services, guiding how IT interfaces with, and even leads, the wider business strategy.[24]

ITIL 4 expands on the previous versions by providing a practical and flexible basis to support organizations on their journey to the new world of digital transformation.[5] It provides an operating model for the delivery and operation of the IT components that fosters team integration. "ITIL 4 also provides a holistic end-to-end picture that integrates frameworks such as Lean, Agile, and DevOps."[22]

Table 1. Median salary for respondents.

Salary: skills and knowledge	n (%)	Median
All respondents	5,081 (100%)	$85,000
Agile	1933 (38%)	$100,000
Lean	445 (9%)	$103,000
ITIL	778 (15%)	$100,600
Agile and ITIL	375 (7%)	$111,200
Agile and Lean	290 (6%)	$112,600
Lean and ITIL	129 (3%)	$120,000
Agile and Lean and ITIL	99 (2%)	$124,800
None of the three	2,620 (52%)	$72,000

Table 2. Human capital model with Agile, Lean, and ITIL (* denotes significant at the .001 level).

	Coefficient
Intercept	11.001*
X	0.026*
X^2	−0.0006*
Agile	0.257*
Lean	0.087*
ITIL	0.158*
F-statistic	192.5*

Data Collection and Results

A voluntary Web-based survey on salary and skills of IT professionals conducted by Dice (http://www.dice.com) was used for this article. The Dice 2018 Tech Salary Report states the survey was administered online by Dice.com, with 10,705 employed technology professionals from the U.S. responding between Oct. 18, 2017 and Dec. 13, 2017. Respondents were invited to participate in the survey in several ways: via an email invitation to Dice's registered database members, through a notification on the Dice.com home page and/or via site intercept invitations within the site to visitors, and via banner ads on external sites. Additionally, technology professionals who were registered users of eFinancialCareers.com were invited to participate in the survey via an email invitation. A cookie methodology was used to ensure that there was no duplication of responses between or within the various sample groups, and duplicate responses from a single email address were removed. Technology professionals earning salaries of $350,000 and above were not automatically eliminated from the survey if they met other criteria (www.DICE.com).

The original dataset contains a certain number of outliers and omissions related to salary. We cleansed the data by setting the minimum wage of $10.00 per hour or $20,000 per year (40 hours per week and 50 weeks per year). The records with less than a $20,000 annual salary were eliminated (most of these eliminated records did not provide a salary figure). We further limited the respondents to only full-time employees in order to obtain a sample of 5,081.

Based on the DICE data, the salaries for IT professionals that possess Agile, Lean, and ITIL skills and knowledge are shown in Table 1. The table provides the salary for all respondents, comparing the salary medians of IT professionals that possess Agile, Lean, or ITIL skills and knowledge to the salary for all respondents.

The results clearly indicate a significant salary premium for possessing Agile, Lean, or ITIL skills and knowledge because the median salaries for individual skills are substantially higher than the overall (all respondents) median. Furthermore, the combination of two skills is even greater and individuals possessing all three skills being the highest. Over half of the respondents did not possess any of the three skills and had substantially lower salaries than their more skilled peers.

Human capital. The dominant economic theory of wage determination is the Human Capital Theory,[3] which predicts that differences in wages arise because of differences in human capital which can be accumulated in two main ways—education and experience.[19] Specifically, investments made in one's occupation are directly correlated to the compensation earned over time that is received for the execution of job tasks. Therefore, educational spending can be considered to be an investment in human capital.[27] The more education workers have, the more productive they will be when compared to their less educated counterparts. As a result, the educated worker is more likely to command higher wages. In addition to formal education (indicated by the acquiring of a high school diploma, college degree, and so on), on-the-job training is a very important factor for many IT jobs. Rather than formal education, we factor in whether an IT professional has (self-reported) Agile, Lean, or ITIL skills/knowledge.

As stated earlier, two research questions will be addressed: (RQ1) Are there compensation benefits for IT professionals that possess Agile, Lean, and ITSM skills? With the logical follow-up question, if there are benefits: (RQ2) What are the estimated benefits? Rather than using salary (given in U.S. dollars in the survey) as the dependent variable in a regression model, we employ the natural logarithm of salary because Roy[26] showed the natural logarithm of

Regression model.

$$Log\ Y_i = \beta_0 + \beta_1 X_i + \beta_2 X_i^2 + \beta_3 Agile_i + \beta_4 Lean_i + \beta_5 ITIL_i + \epsilon_i$$

where Y_i is the yearly income for each worker,
β_0 is the intercept term in the regression model that determines the base rate,
β_1 and β_2 are coefficients that assess the rate of return on experience,
$Agile_i$ is an indicator variable defined to be 1 if the individual possesses Agile skills and 0 if the individual does not possess Agile skills,
$Lean_i$ is an indicator variable defined to be 1 if the individual possesses Lean skills and 0 if the individual does not possess Lean skills,
$ITIL_i$ is an indicator variable defined to be 1 if the individual possesses ITIL skills and 0 if the individual does not possess ITIL skills,
β_3, β_4, and β_5 are coefficients that assess the rate of return on Agile, Lean, and ITIL knowledge, respectively, and ϵ_i is the random disturbance associated with the i-th worker.

salary rather than salary produced a much better model fit. As stated earlier, experience is often incorporated in human capital models so it will also be one of our independent variables. Mincer[21] showed that experience should be modeled as concave because as experience reaches a certain point, salary cannot increase indefinitely. Therefore, experience squared will be another independent variable. In addition, three dummy or indicator independent variables will be used to model whether each respondent indicated whether they possess Agile, Lean, or ITIL skills. This set of variables produce the the regression model depicted in the accompanying figure. We fitted the regression equation using the 5,081 respondents from the cleansed DICE sample with the results given in Table 2.

All coefficients and the overall model are highly significant. Therefore, the answers to the research questions are clearly affirmative based on the Human Capital Model. The fact that the coefficients of Agile, Lean, and ITSM skills in the estimated regression equation are positive provides the answer to RQ1 about compensation benefits for IT professionals that possess these skills. The salary premium is computed by taking each coefficient's inverse of the natural logarithm function—that is, each coefficient is plugged into the exponential function. Agile skills, by far, produce the greatest salary premium (26%) with ITIL (16%) and Lean (9%) skills and knowledge producing significant overall salary premiums. Given the logarithmic nature of the regression model, one can multiply these numbers to get the premiums for pairs of skills and all three skills. The largest salary premium would be produced by the combination of all three skills. This answers RQ2 about the estimated benefits of these skills.

Conclusion

The goal of DevOps is to enable cross-functional relationships between the development and operations groups thereby enabling the two groups to work together to ensure IT services are transitioned to the live environment without problems. The specific skills and knowledge needed for a DevOps implementation will vary based on the infrastructure and business focus. This adds to the challenge of implementing DevOps because there is a clear lack of universally accepted skills and knowledge requirements. The growing consensus within the DevOps community is that DevOps = Agile + Lean + ITIL helps to establish a common set of base skills and knowledge that transcend business environments and toolchains. As reflected by the salary premiums, our data analysis provides significant evidence that there is value gained by IT professionals if they possess Agile (salary premium 26%), Lean (salary premium 9%), and ITIL skills and knowledge (salary premium 16%). Organizations and educational institutions that focus on cultivating these skills and knowledge will enhance the IT professional's ability to build cross-functional processes and also use appropriate technology to enhance an overall collaborative automated DevOps environment.[14]

ITIL's Service Design and Service Operation processes can clearly be adapted for DevOps as these processes and the generic functions will still be necessary. Similarly, Agile can adapt ITIL Service Transition processes that help monitor and control service delivery, such as Change Management, Service Asset and Configuration Management, and Release and Deployment Management. In addition, Lean workflow concepts can better improve most (if not all) ITIL processes.

The integration of ITIL with Agile and Lean as part of ITIL 4 is a positive step in the direction of establishing a practical framework to enable the implementation of DevOps. Kim better summarizes our opinion as follows: "For many years, I've felt I've been the official ITIL® apologist in the DevOps community, because I've always believed that DevOps and ITIL should be able to peacefully coexist. But these days, I feel that a more activist role in the DevOps community is necessary—we must reach out and form effective bridges with the ITIL community, because ITIL is the most powerful and entrenched orthodoxy in large, complex IT organizations."[19] Ⓒ

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