



IE UNIVERSIDAD

TESIS DOCTORAL/ DOCTORAL DISSERTATION

“APLICACIÓN DE LEAN SIX SIGMA EN UNA
INDUSTRIA DEL CONOCIMIENTO: UN CASO DE
ESTUDIO DEL NEGOCIO DE LA AUDITORÍA”

“APPLICATION OF LEAN SIX SIGMA IN A KNOWLEDGE
INDUSTRY: A CASE STUDY OF THE AUDIT BUSINESS”

NIGEL PAUL BRASHAW

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ABSTRACT

This dissertation explores the application and associated challenges of applying Lean Six Sigma in a knowledge work context, using the US asset management audit practice of a large professional services firm as a large-scale case study. This environment is significantly different from the manufacturing and services repetitive operations use-cases hitherto explored by the academic literature and process improvement practitioners.

We explore the specific implementation challenges, or 'restricting factors' associated with the audit industry: high turnover/long-cycle times, significant seasonality and team composition, and then present the results of a two-part experimentation involving 97 engagement teams. Our results demonstrate that LSS can meaningfully improve efficiency while maintaining quality. In addition to the efficiency improvements observed, we identify ancillary benefits through the adoption of improvement initiatives.

This study also discusses the implications of technology change – in particular Robotic Process Automation and the impact of this developing technology on the relevancy of Lean Six Sigma.

ABSTRACT

Esta tesis explora la aplicación de *Lean Six Sigma* en un contexto de trabajo del conocimiento y los retos asociados de aplicarlo en él usando la práctica de auditoría de gestión de activos de EE. UU. de una compañía de servicios profesionales de gran tamaño como caso de estudio a gran escala. Este entorno es sustancialmente distinto al de los casos de uso de manufactura y operaciones repetitivas de servicios explorados hasta la fecha por la literatura académica y los profesionales de mejora de procesos.

Exploramos los diversos desafíos de implantación o ‘factores restrictivos’ asociados a la industria auditora: alta rotación/ciclo largo, elevada estacionalidad y composición de equipos, y a continuación presentamos los resultados como un experimento de dos partes que implica a 97 equipos de encargo. Nuestros resultados demuestran que LSS puede mejorar significativamente la eficiencia sin sacrificar la calidad. Además de las mejoras de eficiencia observadas, identificamos beneficios complementarios a través de la adopción de iniciativas de mejora.

El presente estudio también analiza las implicaciones del cambio tecnológico, concretamente la automatización robótica de procesos y el impacto que tiene esta tecnología en desarrollo sobre la importancia de *Lean Six Sigma*.

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1 INTRODUCTION

Lean Six Sigma (“LSS”) is a consolidated approach with the aim of improving efficiency and maintaining quality in work-knowledge contexts. Essentially, LSS is *“a business improvement methodology that aims to maximize shareholders’ value by improving quality, speed, customer satisfaction, and costs: it achieves this by merging tools and principles from both Lean and Six Sigma”* (Laureani & Anthony (2012, p.110). Lean is described as an “on-floor improvement technique” (Sunder 2013, p.21) and has been defined by Womack and Jones (1996, p.15) as *“a way to specify value, line up value-creating actions in the best sequence, conduct those activities without interruption whenever someone requests them, and perform them more and more effectively. In short, lean thinking is lean because it provides a way to do more and more with less – less human effort, less human equipment, less time, and less space – while coming closer and closer to providing customers with exactly what they want”*. Six Sigma, the second component of LSS, has been defined by Snee (1999, p.100) as: *“a business strategy that seeks to identify and eliminate causes of mistakes or defects in business processes by focusing on outputs that are critical to consumers.....The Six Sigma approach combines statistical methods with quality processes....”*.The amalgam of lean and Six Sigma in the form of LSS is the focus of this paper.

Until recently, while LSS has been applied and studied in different operational settings in addition to manufacturing such as healthcare, banking, financial services, utility services and others (Antony et al., 2007), limited attention has been devoted by researchers and practitioners alike to the implementation of LSS to knowledge work in professional service environments (Staats et al., 2011). In particular, with this study we focus on the application

of LSS to the auditing Industry, a setting that offers theoretical and practical reasons for investigating the applicability and outcomes of LSS, and for which empirical research is absent.

From a practical standpoint, the dual goals of reducing waste and variability of LSS are particularly salient in the auditing industry. The global audit market is a significant industry, important in its own right estimated to be in excess of \$210bn in 2017 (The Business Research Company, 2018). In addition to its absolute size, the industry has received considerable attention from the media, regulators and government agencies, given the mandate for auditors to ensure transparency of the capital markets, the mandated nature of demand in many jurisdictions and the high level of supply concentration in the commercial audit sector¹. There are already significant cost pressures in this industry – a UK Competition Commission report found a 16.7% decrease in average fees per hour for the Big 4 firms auditing FTSE 350 companies between 2006 and 2011 (UK Competition Commission 2012, p.19). Historically there has not been much process innovation in the auditing sector and a limited focus on operational improvements. The principle reaction of the Big 4 firms to these margin pressures thus far has been to offshore simpler audit tasks to lower-cost centers such as India, Latin America and Eastern Europe. Simultaneously the audit industry continues to face high levels of scrutiny in respect to the quality of work performed. Audit quality is a focus of regulators, media, shareholders groups and other stakeholders.

¹ The 'Big 4' firms consist of EY, KPMG, PwC and Deloitte which in the UK collectively audited 99% of FTSE 100 firms and 96.8% of FTSE 250 firms in 2017 (UK Parliament, 2018). In the US the 'Big 4' (or predecessor firms) audit 98% of the 1,500 largest public corporations (United States Government Accountability Office, 2008)

From a theoretical standpoint, the unique characteristics of the audit industry pose a potential challenge to the applicability of LSS, thereby offering an opportunity to investigate the boundaries of the validity of LSS improvement logic beyond the settings where it is proven. Specifically, three characteristics of the audit industry challenge the applicability and potential benefits of LSS: *high turnover of staff*, *long cycle times*; and *high seasonality*. First, high turnover implies a loss of LSS training-acquired knowledge when staff leave. Expected turnover is 10%-12% annually for the organization and can spike to approximately 25% due to external market conditions and factors such as high demand for certified public accountants because of regulatory mandated change or strong economic growth. Second, audit operations have long cycle times, as audits are typically performed for each entity on an annual basis. Long cycle times reduce the speed and opportunities to accumulate data for diagnosis of problems and the testing of possible solutions by leveraging the DMAIC cycle (as further described in section 2.2.2). Finally, the audit industry is characterized by *high seasonality*. Since a significant proportion of audited entities have a financial year-end of 31 December, 36.3% of annual work is performed in the period between mid-January and the end of March (representing approximately 19% of the year). Due to this seasonal peak team members can reach individual utilization rates exceeding 250%, a situation that not only hampers root problem solving activities (execution of new DMAIC cycles), but also challenges the ability of team members to comply with operational standards defined by previous improvements (the “control” stage of previously executed DMAIC cycles). Besides these three challenges, the audit industry is characterized by flat organizations where audit teams include the highest-ranking official and owners of the audit firm, while in manufacturing teams this

usually consists of lower ranking personnel. This organizational feature of audit firms presents both potential difficulties and advantages for LSS implementation, which are worthy of investigation. On the positive side, the involvement of senior personnel provides visibility and support for improvement initiatives as well as allowing for success to be more quickly replicated throughout the organization. On the negative side, these senior staff must be trained in LSS and approval gained for proposed changes, which may retard progress.

Based on these considerations, studying LSS implementation in the audit industry offers a rich opportunity to advance knowledge about the potential for application of LSS logic beyond the repetitive and stable operational settings where it initially developed. To this end, I report in this dissertation the result of a two-stage research project that investigated the effect of LSS training at the US practice of a Big-4 auditing firm ("Firm A"). The first stage consists of a pilot study meant to hone the LSS implementation approach for the firm, based on a small sample of 10 engagement teams. The second stage consists of a larger-scale field experiment, meant to quantify efficiency gains accruing from LSS implementation on a larger data set of 97 engagement teams.

The remainder of this thesis is organized as follows. We first review the literature providing an overview of Lean Production, Six Sigma and LSS and the role of these methodologies in the knowledge work context. Subsequently we illustrate the methodology followed to empirically investigate the phenomenon under study and generate hypotheses. We then report research findings from the pilot stage and then the field experiment. Finally, we discuss the implications of the findings, limitations of the study, and sketch out directions for future research.

1 INTRODUCCIÓN (Español)

Lean Six Sigma (“LSS”) es un enfoque consolidado que tiene el objetivo de mejorar la eficiencia y mantener la calidad en contextos de trabajo del conocimiento. Fundamentalmente, LSS es “una metodología de mejora de negocio que busca maximizar el valor de los accionistas mejorando calidad, velocidad, satisfacción del cliente y costes. Logra tal cosa uniendo herramientas y principios tanto de *Lean* como de *Six Sigma*” (Laureani y Anthony (2012, p.110). *Lean* se concibe como una “herramienta de mejora sobre el terreno” (Sunder 2013, p.21) que Womack y Jones (1996, p.15) han definido como “una forma de especificar valor, alinear acciones de creación de valor en su secuencia óptima, llevar a cabo esas actividades sin interrupción cuando alguien las solicita y ejecutarlas de manera cada vez más eficaz. En resumen, el pensamiento *lean* (ajustado) lo es porque proporciona una manera de hacer más con menos: menos esfuerzo humano, menos equipamiento humano, menos tiempo y menos espacio, mientras que a la vez se acerca cada vez más a proporcionar a los clientes exactamente lo que quieren”. Snee (1999, p. 100) define *Six Sigma*, el segundo componente de LSS, como “una estrategia de negocio que busca identificar y eliminar las causas de los errores o deficiencias en los procesos centrándose en los resultados cruciales para los consumidores [...]”. El foco de este artículo está puesto en la confluencia de *lean* y *Six Sigma* en LSS.

Hasta hace poco, si bien LSS se aplicaba y estudiaba en diversos contextos operativos además de la manufactura, tales como la salud, la banca, los servicios financieros, los servicios públicos y otros (Antony et al., 2007), tanto los investigadores como los profesionales han prestado escasa atención a la implantación de LSS en el trabajo del

conocimiento en entornos de servicios profesionales (Staats et al., 2011). Concretamente, en este estudio nos centramos en la aplicación de LSS en la industria auditora, un contexto que ofrece razones teóricas y prácticas para investigar la potencial aplicación y los resultados de LSS y de los que no existe investigación empírica.

Desde un punto de vista práctico, el doble objetivo de reducir el desperdicio y la variabilidad de LSS es especialmente prominente en la industria auditora. El mercado global de la auditoría es una industria de peso por méritos propios, con un valor estimado superior a los 210 000 millones de dólares en 2017 (*The Business Research Company*, 2018). Además de su tamaño absoluto, la industria ha recibido una atención considerable por parte de los medios, los organismos reguladores y las agencias gubernamentales debido al mandato que tienen los auditores de garantizar la transparencia de los mercados de capital, la naturaleza obligatoria de la demanda en muchas jurisdicciones y el alto nivel de concentración de la oferta en el sector de la auditoría comercial². Ya existen presiones de costes significativas sobre esta industria: un informe de la Comisión de Competencia del Reino Unido constató un aumento del 16.7 % del coste medio de las tarifas por hora de las Big 4 que auditaron a las empresas del FTSE 350 entre 2006 y 2011 (*UK Competition Commission* 2012, p.19). En términos históricos no ha habido una gran innovación en los procesos del sector de la auditoría, mientras que las mejoras operativas no han recibido demasiada atención. Hasta ahora, la principal reacción de las Big 4 ante estas presiones sobre los márgenes ha sido externalizar las tareas de auditoría

² Las empresas 'Big 4' son EY, KPMG, PwC y Deloitte, que en el Reino Unido auditaron al 99 % de las compañías del FTSE 100 y al 99,8 % de las compañías del FTSE 250 en 2017 (Parlamento del Reino Unido, 2018). En EE. UU., las 'Big 4' (o compañías predecesoras) auditan al 98% de las 1500 mayores empresas cotizadas (*United States Government Accountability Office*, 2008).

más sencillas a centros con menores costes como India, Latinoamérica y Europa del Este. De manera simultánea, la industria de la auditoría sigue enfrentándose a elevados niveles de escrutinio con respecto a la calidad del trabajo llevado a cabo. Los reguladores, los medios y los accionistas, así como otros *stakeholders*, tienen el foco puesto en la calidad de las auditorías.

Desde un punto de vista teórico, las singulares características de la industria auditora plantean un potencial desafío a la posibilidad de aplicar LSS, lo que ofrece la oportunidad de investigar los límites de la validez de la lógica de mejora LSS más allá del terreno donde se ha demostrado su eficacia. Concretamente, hay tres características de la industria auditora que desafían la posibilidad de aplicar LSS, así como los beneficios potenciales de hacerlo: *alta rotación del personal*, los *ciclos largos* y la *elevada estacionalidad*. En primer lugar, la elevada rotación implica una pérdida de conocimiento de LSS aprendido por medio de formación cuando el personal se marcha. La rotación esperable es del 10 %-12 % anual para la organización, y puede dispararse hasta aproximadamente el 25% debido a las condiciones de mercado externas y factores como la elevada demanda de contables con certificación oficial, debido a la imposición de cambios regulatorios o un fuerte crecimiento económico. En segundo lugar, las operaciones de auditoría son de ciclo largo, puesto que se llevan a cabo de forma anual para cada entidad. Los ciclos largos reducen la velocidad y las oportunidades para acumular datos para el diagnóstico de problemas y la comprobación de posibles soluciones aprovechando el ciclo DMAIC (tal como se describe más adelante en el apartado 2.2.2.). Por último, la industria auditora se caracteriza por una *elevada estacionalidad*. Dado que existe una proporción significativa de entidades auditadas con

un año financiero que termina el 31 de diciembre, el 36,3 % del trabajo anual se lleva a cabo entre mediados de enero y finales de marzo (lo que representa el 19 % del año). Debido a estos picos estacionales, los miembros del equipo pueden alcanzar tasas de utilización individual por encima del 250 %, una situación que no solo obstaculiza la resolución de problemas de base (ejecución de nuevos ciclos DMAIC), sino que también es un reto para la capacidad de los miembros del equipo de cumplir con los estándares operativos definidos por mejoras previas (la fase de “control” de ciclos DMAIC ejecutados anteriormente). Aparte de estos tres desafíos, la industria auditora se caracteriza por organizaciones planas donde los equipos auditores incluyen a los más altos cargos y a los propietarios de la auditora, mientras que los equipos de manufactura suelen incluir a personal de rango más bajo. Esta característica organizativa de las auditoras entraña, a la vez, dificultades y ventajas potenciales para la implantación de LSS que merecen ser investigadas. En el lado positivo, la implicación de personal sénior proporciona visibilidad y apoyo a las iniciativas de mejora, además de permitir que el éxito se replique más rápidamente por toda la organización. En el lado negativo, es preciso formar en LSS a este personal sénior y ganarse su aprobación para los cambios propuestos, lo que puede ralentizar el progreso.

Si tenemos en cuenta estas consideraciones, el estudio de la implantación de LSS en la industria auditora ofrece una interesante oportunidad para mejorar el conocimiento acerca del potencial que tiene la aplicación de la lógica LSS más allá de los contextos operativos estables y repetitivos donde se desarrolló originalmente. A tal fin, en esta tesis informo de los resultados de un proyecto de investigación en dos fases que analizó el efecto de la formación LSS en las prácticas estadounidenses de una compañía auditora

de las Big-4 (“Compañía A”). La primera fase consiste en un estudio piloto destinado a afinar el enfoque de la implantación de LSS en la compañía, basándose en una pequeña muestra de 10 equipos de encargo. La segunda fase consiste en un experimento de campo a mayor escala con el propósito de cuantificar las ganancias en eficiencia obtenidas a través de la implantación de LSS en un conjunto de datos más amplio de 97 equipos de encargo.

El resto de la presente tesis se divide de la siguiente forma. Primero analizamos la literatura que ofrece una visión general de la producción *Lean*, *Six Sigma* y LSS, y el papel que desempeñan estas metodologías en el contexto del trabajo del conocimiento. Posteriormente, ejemplificamos la metodología seguida para investigar empíricamente el fenómeno objeto de estudio y generar hipótesis. Luego informamos de los hallazgos de la investigación en la fase piloto y el experimento de campo. Por último, analizamos las implicaciones y las limitaciones del estudio, y esbozamos líneas de investigación futura.

2 REVIEW OF RELATED LITERATURE

Although there are a number of competing continuous improvement methodologies available to organizations, two stand out as the most utilized – Lean Philosophy and Six Sigma (George, 2002). Recently business improvement practitioners and academics have combined these hitherto separate approaches to create an aggregated methodology termed ‘Lean Six Sigma’, or “LSS” (Psychogios & Tsironis, 2012; Salah et al., 2010; Wang & Chen, 2012). LSS takes advantage of both donor methodologies incorporating waste reduction productivity concepts from Lean Philosophy and improvement processes from Six Sigma (Salah et al., 2010; Wang & Chen, 2012). In order to fully understand LSS it is therefore necessary to examine both contributing methodologies – Lean Philosophy and Six Sigma.

2.1 Lean Philosophy

2.1.1 Origins of Lean Philosophy

Lean Philosophy represents a step on the continued evolution of manufacturing. Early manufacturing was an artisanal pursuit where skilled craftspeople made a complete product themselves. The advent of mass production resulted in significant productivity gains through the harvesting of economies of scale. In comparison to mass production, Lean Philosophy seeks to be responsive to end-customer demand. With lean production, the execution of operational activities is “pulled” by customer demand, instead of being “pushed” by forecasts or production heuristics, as with traditional mass production. A second important difference between mass and lean production is that while the former sees improvement as a discontinuous and disruptive activity, the latter frames

improvement as a continuous and incremental activity aiming at elimination of waste throughout the process.

The first use of the term Lean in a management context was by Krafcik (1988), describing the efficiency of the Toyota Production System (TPS) in comparison to western automobile manufacturers (Holweg, 2006). The TPS was initially developed by Taiichi Ohno at Toyota after the second world war, though not formally first codified until 1965 (Holweg, 2007). Lean Philosophy is based upon the TPS and was popularized by Womack & Jones in two books – *The Machine that Changed the World* (1990), detailing the effects of an MIT study of the automobile manufacturing industry, and *Lean Thinking: Banish Waste and Create Wealth in Your Corporation* (1996). These books sounded an alarm for organizations using mass production and associated economies of scale as their primary competitive strategy. They suggested that this model would imminently be superseded by 'lean production' as exemplified by Japanese automobile manufacturers. The authors detail at length the productivity disadvantages of western auto manufacturing firms in contrast to Japanese producers. Lean production was described as having essentially been implemented by Toyota in the 1950s and as a methodology focused on increasing the responsiveness of manufacturing enterprises to consumer demand and reducing waste in the production process via a program of continuous improvement. This focus on responsiveness to consumer demand stands in stark contrast to mass production's approach, which emphasized planning over reactivity and assumed that capacity-constrained manufacturers had to serve mass markets demanding high volumes of standardized goods.

While Womack & Jones are generally perceived as having fired the starting gun for Lean Philosophy in North America and Western Europe, Schonberger (2007) has noted that in fact lean manufacturing had already been well-established under various guises in the early 1980s.

2.1.2 Principles of Lean Philosophy

Lean was defined by Radnor et al. (2012) as: *“a management practice based on the philosophy of continuously improving processes by either increasing customer value or reducing non-value adding activities (‘muda’), process variation (‘mura’), and poor work conditions (‘mur’i).”* (p. 365). Womack & Jones (1996) described a Lean Philosophy as one that allowed companies to *“specify value, line up value creating actions in the best sequence, conduct these activities without interruption whenever someone requests them, and perform them more and more effectively”* (p.15). This work led to the identification of five principles associated with lean philosophy (1) Specify value (p.16); (2) Identify the value stream (p.19); (3) Flow (p.21); (4) Pull (p.24); and (5) Perfection (p.25).

“Value” was defined as *“capability provided to customer at the right time at an appropriate price, as defined in each case by the customer”* (p. 311). The point is made here that value is the starting point of lean philosophy and that only the end customer can define the meaning of value.

“Value stream” refers to the aggregation of activities *“required to design, order, and provide a specific product, from concept to launch, order to delivery, and raw materials in the hands of the customer”* (p. 311). There were said to be three types of activity in a

value stream: (i) Value-added – activities that unambiguously create value; (ii) Type One Muda [muda is a Japanese term for waste] – defined as activities that create no value but are unavoidable, given current technologies or productive assets; and (iii) Type Two Muda – representing activities that create no value and can be immediately eliminated.

“Flow” was described as the *“progressive achievement of tasks along the value stream so that a product proceeds from design to launch, order to delivery and raw materials into the hands of the customer with no stoppages, scrap or backflows”* (p. 306). Streamlining flow requires organizations to dispense with batch production and instead to implement processes that enable quick changes of tooling, deploying machinery with appropriate capacity and locating sequential processes in physical proximity to each other.

“Pull” was defined as a *“system of cascading production and delivery instructions from downstream to upstream in which nothing is produced by the upstream supplier until the downstream supplier signals a need”* (p. 309). As opposed to mass production, where items are produced in large quantities for sale, Lean Philosophy requires that products are made when demanded by the end customer.

Perfection: this final principle requires the elimination of all forms of non-value adding activities *“so that all activities along a value stream create value”* (p. 308). Taken to its logical conclusion, this final principle results in companies continuously seeking to eliminate waste – though the elimination of all waste is a desired end state rather than an achievable goal. Seven wastes were catalogued by Womack & Jones (1996): (i) overproduction; (ii) defects; (iii) unnecessary inventory; (iv) inappropriate processing; (v) excessive transportation; (vi) waiting; and (vii) unnecessary motion.

In a services environment, the nature of waste varies from that observed in a manufacturing context: as set out in table 2.1 below and detailed in Holweg (2018) referencing Ohno (1988) and Bicheno & Holweg (2016).

Wastes in Manufacturing Operations	Wastes in Service Operations
Transportation	Unclear communication
Inventory (excess)	Incorrect inventory
Motion	Unnecessary movement
Waiting	Delay
Overproduction	An opportunity lost to retain or win customers
Over processing	Duplication
Defects	Errors in service transaction
Skills	Service quality errors

Table 2.1 Wastes in Manufacturing from Holweg 2018 (sourced from Ohno, 1988 & Bicheno and Holweg. 2016)

According to Shah et al. (2008) the view of Lean Philosophy as a set of principles is just one lens. There is also a broader *Philosophical* level, where Lean Philosophy can be understood as a continuous process aimed at reducing waste by adopting value-adding processes. At the implementation level, Lean Philosophy is reflected in the application of multiple tools, which can or cannot be individually deployed, depending on the specific setting under consideration. Among these tools are value-stream mapping, “*a tool created by the lean production Movement for redesigning the productive systems*” (Lasa et al.

2008, p. 39). Value-stream mapping was defined by Rother & Shook (1998): “A *value stream is all the actions (both value added and non-value added) currently required to bring a product through the main flows essential to every product: (1) the production flow from raw material into the arms of the customer, and (2) the design flow from concept to launch*” (p. 3). In practical terms, “*Value-stream mapping is a pencil and paper tool that helps you to see and understand the flow of material and information as a product makes its way through the value stream. What we mean by value-stream mapping is simple: Follow a product’s production path from customer to supplier, and carefully draw a visual representation of every process in the material and information flow. Then ask a set of key questions and draw a “future state” map of how value should flow*” (Rother & Shook 1998, p. 4). The point of value-stream mapping is that this technique allows organizations to identify visually the steps in a process and then allow improvement ideas to be suggested.

2.1.3 Lean Philosophy Applicability to Professional Services

Bicheno & Holweg, (2016) set out “*Professional services (the ‘custom’ type) feature high customer interaction, and low repeatability. Innovation and creativity matter most, so lean implementations must draw on lean Design concepts*” (p. 315). “*Many have superficially concluded that Lean is not applicable in Design, Innovation and New Product Development. Although it is true that tasks are less predictable, less repetitive, and inventory cannot be seen, many lean concepts are applicable but need adaption*” (Bicheno & Holweg, 2016 p. 249).

Compared to other service operations, professional services require workers to engage in knowledge-intensive work. Knowledge work is described by Drucker (1959) as being

work that *“primarily involves the use of information”* (p. 93). While Lean Philosophy is well established in manufacturing industries, only more recently have organizations sought to apply these concepts to knowledge work (for instance, Poppendick & Poppendick, 2003; Piercy & Rich, 2009; and McDermott & Venditti, 2015). Staats et al., (2011) set out that the role and benefits of applying Lean Philosophy in a knowledge work context has not been established. In particular, they observe that *“knowledge work not only has a context separate from manufacturing, but also differs fundamentally in structure, calling into question lean principles’ universal applicability”* (p. 2). Through the study of lean implementation at an Indian IT services firm, the authors identify three differences between knowledge work and manufacturing. These differences are relevant to the empirical setting of this dissertation as well—the asset management auditing industry.

First, *“knowledge work typically takes on a character more dynamic than that generally associated with manufacturing”* (p. 2). In the professional services asset management audit context, the product may be different from that originally ordered – a client may change year-end dates, require additional assurance, change the accounting basis, merge or close funds, etc. This can be contrasted with a manufacturing environment where products are generally not changed when they are on the production line in the process of being manufactured.

Secondly, *“Knowledge work processes and their connections are often invisible”* (p. 2). In a manufacturing environment, a process and associated connections between activities can be observed and assessed. Conversely, in completing an audit, no ‘physical’ product or process can be observed directly. Information is contained in an audit software tool, in digital or physical repositories, or is left uncodified until assembled in an audit file.

Finally, “*Knowledge work is often a design task that spans high-level architecture to low level details (Boone et al. 2008 and Clark 1985)*” (p. 3). Mass production manufacturing leverages the same knowledge and processes repeatedly, demanding only micro-adjustments by the operator. In contrast, knowledge work may require substantial problem-solving, design-oriented tasks, which may occur during ‘production’ and entail major modifications to operational processes.

In aggregate, these factors paint a picture of a knowledge work environment as one where the flow of activities necessary to ‘produce’ the service is more uncertain and less easy to visualize than in manufacturing. These characteristics in turn make it more difficult to identify and eliminate waste than in a more predictable manufacturing or repetitive service environment.

2.2 Six Sigma

2.2.1 Origins of Six Sigma

Six Sigma was developed in the 1980s at Motorola as an in-house quality improvement initiative. Subsequently, many organizations have adopted this methodology to improve product and service quality. Some commentators have described Six Sigma as the most popular improvement methodology in history (Eckes, 2001) – this may be debatable; however Six Sigma has profoundly influenced a range of organizations, including General Electric, which identified \$2bn in annual savings as a result of Six Sigma implementation (Pande et al., 2000).

Breaking down the term ‘Six Sigma’ into its component pieces – ‘Sigma’ is derived from the Greek letter sigma – which in this case represents a standard deviation (i.e. the

dispersion of data from the average). 'Six' relates to the accepted level of quality maintaining six standard deviations of variation with respect to process tolerance limits – in certain circumstances the goal being no more than 3.4 defects per million. Prior to the commencement of an improvement project, a cost benefit analysis should be applied to determine if a process error rate should be set at a Six Sigma or a lower level. In contrast to Lean Philosophy, Six Sigma places a significantly greater emphasis upon data, statistical rigor and modelling.

Like Lean Philosophy, Six Sigma has been dogged by similar definitional ambiguity. There are numerous definitions, (Henderson & Evans, 2000) however, useful definitions are provided by a number of authors who agree on the main tenants of the methodology (Schroeder et al., 2008; de Koning & de Mast 2006). De Mast (2007) describes Six Sigma as a *“prescriptive framework for the routinisation of incremental product and process innovation, organized as a decentralized project organization”* (p. 353), de Koning & de Mast (2006) set out a comprehensive detailing of Six Sigma tools and steps. Linderman et al., (2003) define Six Sigma as *“an organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in customer service defined defect rates”* (p. 195), Schroeder et al., (2002) offers a similar definition *“Six Sigma is an organized, parallel-meso structure to reduce variation in organizational processes by using improvement specialists, a structured method, and performance metrics with the aim of achieving strategic objectives”* (p. 540). It is the latter definition we shall adopt in this paper.

2.2.2 Principles of Six Sigma

Breaking down the definition of Six Sigma into its essential components as defined by Schroder et al., (2008) above, results in the identification of *“four relevant constructs or elements (parallel-meso structure, improvement specialists, structured method and performance metrics)”* (p. 540).

Parallel-meso structures are defined as *“extra creations that operate outside of, and do not directly alter, an organization’s normal way of operating”* (Lawler, 1996; p. 132, quoted in Schroder et al., 2008, p.540). Needless to say, Six Sigma was not the first and not the last quality improvement methodology to determine that a parallel structure focused on organizational improvement would be accretive. *“Meso theory concerns the integration of both the micro- and macro-levels of analysis”* (Daft 2001; p. 32 quoted in Schroder et al., 2008, p. 540). In relation to project selection, as noted by Linderman et al., (2003) *“From a goal setting perspective, Six Sigma advocates establishing goals based on customer requirements, not internal considerations”* (p. 195). A choice must be made, as resources are limited and priorities must be set in any organization. Schroeder et al., (2008) set out that in the context of Six Sigma, decision rights are *“allocated to senior management”* (p.541) with respect to selecting projects, ongoing involvement and assessing results.

Improvement specialists are trained in Six Sigma with certifications at various levels or so-called belts. These are *“.....Black Belts, Master Black Belts, Green Belts and Project Champions. Full-time Black Belts lead improvement projects and typically receive 4 weeks of training. Master Black Belts receive even more training and generally serve as instructors and internal consultants. Green Belts are part-time improvement specialists that receive less training since they provide supporting roles on the improvement projects.”*

Finally, *Project Champions* who identify strategically important projects for the improvement teams and provide resources, typically receive an orientation to Six Sigma rather than detailed training” (Linderman et al., p. 195).

Six Sigma brings a *structured method* to process improvement. There are a number of tools in use, one of the most common of which is the Define-Measure-Analyze-Improve-Control (“DMAIC”) cycle that encompasses the following phases: (1) *Define* – understand the problem to be solved or the process to be improved; (2) *Measure* – understand how the current state is meeting the organization’s requirements; (3) *Analyze* – examine collected data to determine influential variable; (4) *Improve* – identify solutions and implement; and (5) *Control* – hardwire the changes to maintain the gains achieved. There are also seven basic quality tools popularized by Kauro Ishikawa who believed that 95% of quality problems could be addressed by these tools (McLaughlin & Olsen, 2012). These tools are: (i) *Fishbone diagrams* – a cause-and-effect tool useful in root cause analysis. (ii) *Check Sheet* – a custom data collection form to track quantitative and qualitative data on problems and defects in real time. (iii) *Histogram* – graph illustrating probability or frequency distributions. (iv) *Pareto chart* – a sorted histogram that focuses on the most influential factors. Predicated on the ‘Pareto principle’ that 80% of costs, issues or defects can be attributed to 20% of the items being measured. (v) *Flowchart* – a process map. (vi) *Scatter Plot* – a graph of the relationship between two factors identifying either causation or correlation. (vii) *Run Chart* – a chronologic plot of a process metric – used to examine trends.

Finally, Six Sigma focuses on two broad *performance metrics* categories: customer satisfaction and financial result metrics. Linderman et al., (2003) sets out the importance

of the first thus *“A key step in any Six Sigma improvement effort is determining exactly what the customer requires and then defining defects in terms of their “critical to quality” parameters”* (p. 195). A key tenant of Six Sigma is therefore gaining an understanding of client requirements, quantifying these and measuring improvement over an established baseline. As noted at the outset of this section a cost-benefit analysis should be performed prior to approval being given for an improvement effort. In order to determine the ‘benefit’ attributable to the Six Sigma project undertaken, any improvements must be converted into a financial impact that can be assessed against the financial cost. Management may employ cost allocation accountants who in turn use various techniques such as activity-based accounting to determine the current cost and savings attributed to improvement efforts.

The purpose of the four aspects of Six Sigma (parallel-meso structure, improvement specialists, structured method and performance metrics) is to foster a culture of continuous improvement with an organization. The parallel-meso structure contributes to a culture of continuous improvement in that a separate structure focused on improvement required continuous quantifiable organizational improvement to justify its existence. Improvement specialists are drivers of change in an organization, trained in a proven methodology to analysis issues, identify the root cause and implement improvements. By definition, full-time specialists enhance the culture of continuous improvement, as their primary function is to implement process improvements. The structured approach facilitates the training of improvement specialists and drives consistency in implementing improvement efforts. Performance metrics provide a feedback loop to an organization and

an incentive to maintain improvements for as long as quantified benefits outweigh associated costs.

2.2.3 Six Sigma Applicability to Professional Services

In contrast to Lean Philosophy, there is minimal research specifically addressing the applicability of Six Sigma to knowledge-intensive settings such as professional services. In fact, most research into the applicability of Six Sigma to service environments focuses on repetitive service operations, such as retail, back office transaction processing, etc.

Goh (2002, p. 407- 408) has identified ten problems with the application of Six Sigma to knowledge work. Essentially, he suggests that a critical weakness of Six Sigma is the “*overarching philosophy of defect prevention*” (p. 407) and that this weakness is a particular issue in a knowledge work context where knowledge is “*being acquired, created, packaged, applied and disseminated*” (p. 407). Goh (2002) sets out the differences in the nature of knowledge work, the involvement of knowledge-work staff, motivations of knowledge workers and the cultural barriers to implementing Six Sigma in a knowledge work environment. The author uses a university as a case study, stating: “*Expressing the level of performance and its improvement via some definitive metric would fail to make sense in a knowledge-based organization such as a university.*” (p.408). The author is not convinced as to the applicability of LSS in a knowledge-intensive context.

A number of authors have set out common criticisms about the applicability of Six Sigma to service operations in general, thereby including professional services (Revere et al., 2006; Kumar et al., (2008). To begin with, the goal of reaching a true six sigma quality

level—that is, 3.4 defects per million, is not realistic in most service settings, due to the variability of customer requirements. However, as noted by Linderman et al., (2003) “*Not all processes should operate at the Six Sigma level. The appropriate level will depend on the strategic importance of the process and the cost of the improvement relative to the benefit*” (p. 194 – 195). Few processes in a knowledge work environment can or should be brought to a defect rate below 3.4 million however; this does not eliminate the importance of reducing error rates to a level appropriate in the circumstances of work undertaken. A second issue in the application of the Six Sigma methodology to services is the challenge of calculating the defect rate (Behara et al., 1995). This problem is particularly apparent for professional services, where variability in operating routines makes the definition of homogeneous quality metrics more challenging. It remains a fact, however, that each professional service organization tends to have its own key performance indicators, which offer a logical target measure to evaluate operational improvement.

Notwithstanding the abovementioned difficulties, multiple studies document the successful application of Six Sigma in industries such as banking, healthcare, airlines etc. (Natarajan & Morse, 2009). Critically, though most of the successful implementations of Six Sigma are described by the authors as being ‘back room’ (back office) – in essence transactional in nature. These operations bear strong similarities to conventional manufacturing operations where Six Sigma is well established. It remains less clear whether Six Sigma can improve ‘front office’ processes – where product delivery involves interaction with customers. General Electric – one of the original implementers of Six Sigma, had a large non-manufacturing business including finance, healthcare and others

and was a catalyst in spreading the use of the methodology outside of manufacturing (Hoerl, 2001). This dearth of research is even more evident when it comes to professional services, a sizeable component of modern economic systems (Wang and Chen, 2010).

2.3 Towards a definition of LSS and its principles

LSS was first introduced as a term in management literature around 2000 (Timans et al., 2012). As with Lean Philosophy and Six Sigma, LSS suffers for a lack of consensus over its definition, for example Sreedharen & Raju (2016) identified 45 different definitions of LSS in a survey of the literature. This paper will adopt the simple and concise definition offered by Laureani & Antony (2012): *“Lean Six Sigma is a business improvement methodology that aims to maximize shareholders’ value by improving quality, speed, customer satisfaction, and costs: it achieves this by merging tools and principles from both Lean and Six Sigma”* (p. 110). This combination of complementary tools addresses the limitations that each approach faces in isolation as LSS seeks to reduce waste (as in Lean) and variation (as in Six Sigma). This manifests itself in practical terms as Six Sigma providing statistical approaches, as Lean Philosophy is not well suited to resolving complex problems requiring detailed data analysis. Conversely, not every problem requires a Six Sigma approach, with the associated detailed and costly data gathering over a lengthy period (Snee & Hoerl, 2007).

Bendell (2006) has criticized LSS as an ineffective approach – setting out the charge that LSS is ill defined. His view is that the tools are diluted by specifics relating to how each company implements LSS. While there are a number of such vague definitions that encompass a range of approaches - for example LSS has been defined as *“a business strategy and methodology that increases process performance resulting in enhanced*

customer satisfaction and improved bottom line results” (Snee 2010, p.10). There are also more specific attempts at defining the methodology. Pepper & Spedding (2010) describe a framework that can successfully merge Lean Philosophy and Six Sigma into a single coherent approach and provides a useful working definition “Lean philosophy underpins the framework, providing strategic direction and a foundation for improvement, orientating the general dynamics of the system by informing the current state of operations. From this, lean thinking identifies key areas for improvement (“hot spots”). Once these hot spots have been identified, Six Sigma provides a focused, project-based improvement methodology to target these hot spots and ultimately drive the system to the desired future state.” (p. 150). Pepper & Spedding (2010) also characterize the relationship between the two methodologies in a similar way to Anthony et al. (2017), noting: “Six Sigma complements lean philosophy in as much as providing the tools and know-how to tackle specific problems that are identified along the lean journey” (p. 146). They also set out key lean implementation steps alongside Six Sigma tools that can be used to address each step.

Fundamentally, LSS is a quality philosophy that uses Lean Philosophy to speed up the process while applying Six Sigma. This is performed by focused continuous improvement aimed at eliminating the non-value adding elements from the process, using structured and quantitative tools such as the DMAIC cycle. Improvement areas are more easily identified by implementing pull systems, and improvement is focused on reducing non-value added activities (waste). Lean Philosophy and Six Sigma are strongly complementary to each other.

2.4 LSS Applicability to Professional Services

There is almost no specific literature on the application of Lean Six Sigma approaches to professional services. Given the above-mentioned challenges in the application of both Lean and Six Sigma to professional work, pursuing the study of LSS implementation in this context is a valuable effort. Besides this general consideration, as noted, three specific characteristics of the investment management audit industry make the adoption of LSS challenging in this environment (high turnover of staff, long cycle times and high seasonality). By means of this study, we can therefore gain deeper insights about the broader applicability of the principles undergirding LSS to operational environments substantially different from those where it originated. We briefly discuss hereafter these three characteristics.

High turnover of staff is an important factor in many professional services organizations, where between 10% – 12% of the workforce leaves annually. This is planned for and needed to maintain an ‘up or out’ promotion culture based on a pyramid-shaped staffing model, with large numbers of junior members at the bottom, where turnover is highest. Junior members are responsible for completing tasks in the first instance and are on the front line of any LSS implementation (see **Appendix 1** for an overview of roles). High turnover can undermine the successful implementation of LSS due to loss of knowledge, as well as making it difficult to embed LSS culture within the organization. Additionally, high turnover implies that workers have little time to accumulate deep knowledge about a process. This is a problem, because a fundamental assumption of LSS is that workers hold valuable, deep, tacit process knowledge that can be unleashed through their involvement in DMAIC meta-routines (Adler, 1999).

Turnover is also a problem because people are usually trained internally – it is rare for audit professionals to transfer from other audit firms. Inter-firm transfer is infrequent: staff at manager-level and below tend to move to fields outside of public accounting. Because of the need to train staff internally, it is difficult to directly replace people who leave. The principle mechanism is to hire more new entrants, who over time will gain experience. Turnover rates are also unpredictable, and heavily dependent on the trends in the wider economic and employment environment, as most staff are recruited away to commercial firms, oftentimes clients. LSS implementation therefore needs to take into account these unpredictable and generally high levels of turnover and difficulties in replacing staff.

A further factor potentially stifling LSS effectiveness are the **long cycle times** associated with the investment fund audit industry. Audits have long cycle times because audit planning typically occurs nine months or more before the year-end of the entity being audited. The audit itself is generally finalized two to three months after the entities' year-end, meaning that the total cycle time is approximately a year in length. Long cycle times reduce the time and opportunities to accumulate data for diagnosis of problems and to test possible solutions by leveraging the DMAIC cycle. A slower cycle time reduces these opportunities and may hinder the effective implementation of LSS in comparison to a manufacturing industry case study.

High Seasonality is inherent to the audit industry. The cause is that a significant proportion of entities' financial year-ends coincide with the end of the calendar year – such that mid-January – March is colloquially known as 'the busy season'. High levels of activity in this period restricts the ability of staff to analyze data, reflect on potential improvements or process/implement real-time changes i.e. execute the DMAIC cycle.

LSS improvements can, however, be implemented in the next cycle. Cycle length and the passage of time between process issues occurring and LSS-derived fixes are challenges to be overcome and are significantly different from a typical manufacturing environment.

In a nutshell, turnover, long cycle times and high seasonality, all may hinder the successful implementation of LSS in the investment fund audit industry and therefore, establish an important boundary against the generality of LSS precepts. It may be, however, that some of these factors actually favor the successful implementation of LSS. For instance, turnover and personnel mobility may prevent people from developing ossified views of their processes. The goal of this work is therefore to investigate the implementation of LSS in this context, possibly interpreting the performance effects of LSS implementation through the lens of these factors.

3 RESEARCH SETTING

The setting for this study is the audit practice of a global firm offering auditing, tax and consulting services, which we refer to as “Firm A”. Firm A employs more than 250,000 employees in some 150 countries. Like its competitors, it is organized as a network of legally independent firms. Firm A is focused on increasing efficiency while maintaining quality, and as a result decided to pursue a trial applying LSS methodology to its audit business in the asset management sector of its US business.

We provide hereafter a description of the asset management audit industry and of the core processes that underlie an audit, which are a natural target for LSS improvement initiatives.

3.1 The asset management audit industry

Audits are critical for the efficient operation of the capital markets. An audit provides assurances to stakeholders in a business that the financial statements that report the financial performance (profit & loss) and financial position (balance sheet) of the company are correct. As President Reagan once memorably said, repeating a Russian proverb, *“trust, but verify”*. The audit process provides this verification.

An audit entails the examination by an independent registered public accounting firm of an entity’s books and records. The accounting firm then provides an opinion as to whether the financial statements are accurate and prepared in accordance with the organization’s underlying records, and whether these financial statements are in accordance with applicable generally accepted accounting standards (“GAAS”) and generally accepted accounting principles (“GAAP”) in all material respects.

Like the other Big 4 accounting firms, the audit practice of Firm A is subdivided into various industry sectors to facilitate specialization. Asset Management is a component of the financial services industry sector. As depicted in figure 3.1, asset management audits can be further categorized into three broad types of entity, based on the nature of the organization subject to audit. These categories are: (1) Registered 40 Act Mutual Funds (generally termed “40 Act funds”); (2) corporate audits of investment advisors (“advisors”) – an investment advisor manages ‘funds’, while a single advisor may manage one or many funds within a ‘fund complex’ and; (3) alternative products/real estate (“alternatives”) funds.

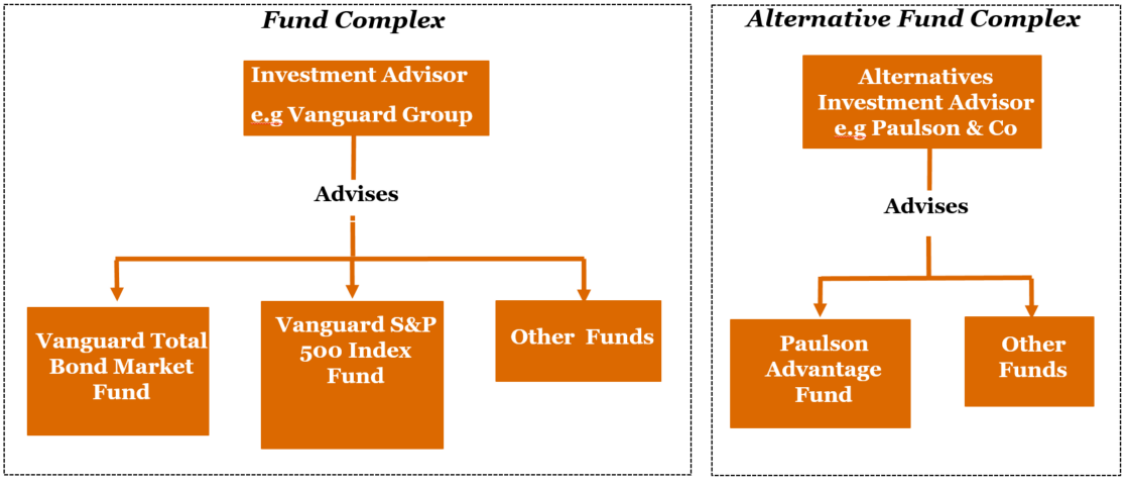


Figure 3.1: Overview of types of Asset Management entity.

Each of the engagement types defined below exhibit differences in terms of the specific nature of activities undertaken, however, all follow the same processes with respect to PBCL (prepared by client listing), FRP (financial statement review) and OPR (overall review process). All entities are required to undertake an annual audit.

40 Act funds – constitute a single fund or number of funds managed by an investment advisor. Each fund is a pooled investment vehicle registered and regulated under the US 1940 Investment Company Act.

Corporate advisor audits. Corporate advisors are the companies responsible for providing investment advice. Advisors manage 40 Act funds on behalf of investors.

Alternative investments funds are entities similar to 40 Act funds that invest in alternative strategies (such as private equity, venture capital, hedge funds or real estate funds).

3.2 Core Processes in the audit of an investment fund

Firm A is an innovative organization seeking to maintain and build upon its strengths in the audit market. Given the competitive nature of the audit industry, the organization is focused on identifying technological/process and methodology efficiencies that do not compromise quality. A number of technological-driven efficiencies have been implemented, and Firm A became increasingly interested in the potential of methodological changes such as LSS. The applicability of LSS in a knowledge-work environment was unproven and as a result a specific sector (asset management) was chosen in a single territory (the United States) in order to trial this approach. The nature of audit work means that a number of processes are self-evidently important, since they significantly affect widespread areas of work undertaken. The role of the three activities (Prepared By Client Listing, Financial Statement Review and Overall Review Process), selected as components of the overall audit is discussed in the following sections.

3.2.1 Prepared By Client Listing (PBCL)

The PBCL is the list of information requested from the client prior to the commencement of substantive audit work. It represents the information necessary to complete the audit (e.g., trial balance, cash flow reconciliation et cetera together with identification of associated item owners and due dates). The PBCL includes details of the specific information required, format of information, date that each item will be provided and the client team member responsible for providing each item. This process also involves establishing escalation protocols in the event that information is missing or late. The process is depicted in figure 3.2 below.

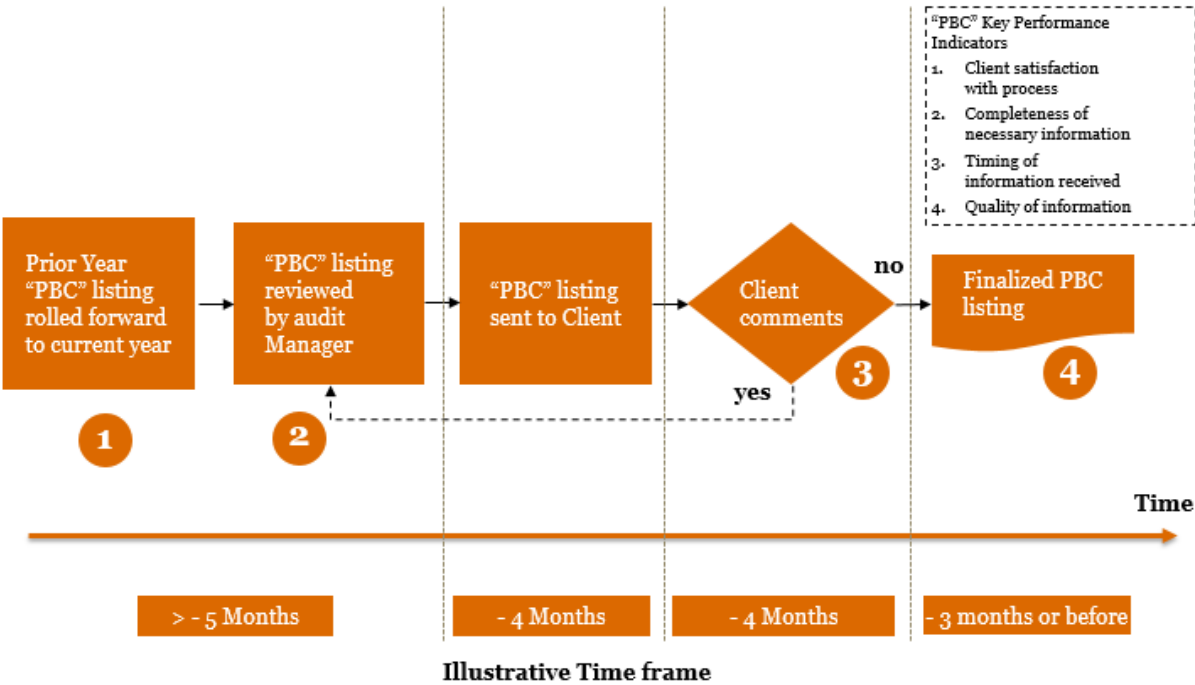


Figure 3.2: Summary of the PBCL process

The PBCL is generally rolled forward from the prior year by an audit associate. The roll-forward process generally involves taking the prior year PBCL and amending for new information/reports or other information identified during the prior year audit process. The

PBCL is then reviewed by the engagement senior associate and audit manager and sent to the responsible individual at the client for comment. The client will respond (usually after discussing changes internally in their organization) and either approve or provide comments on the information requested, the deadlines or manner in which information will be provided. Comments (if any) are discussed and a resolution agreed, at which point the PBCL is finalized and a final copy provided to the client. Responsibility is assigned, usually to a senior associate, for monitoring of client performance in providing information on time, in the agreed format and for the quality of this information. Any omissions, delays or quality issues should immediately be brought to the client's (and engagement management's) attention and the pre-agreed escalation process followed.

The PBCL is reviewed for completeness and accuracy and approved by the client: an agreed upon escalation process for delays/quality issues is the output of this process. The PBCL must be completed prior to substantive audit work beginning; maximum efficiency is achieved when this process is finalized prior to audit planning work and the PBCL covers information needed during the planning phase and allows for allocation of work at year-end. The PBCL planning phase typically starts four to five months pre-year's end and is completed three months prior to the entities' year-end. In addition to finalizing the PBCL on a timely basis, the PBCL must be monitored during the course of the audit to ensure that information is provided by the agreed dates and that there are no errors or omissions. Any failures to provide information or data quality issues should be escalated in accordance with the agreed escalation protocols so that the client management is aware and a remediation plan agreed.

This process was included as a mandatory for LSS review, as the PBCL process is critical for an efficient audit – since this determines the information (in manufacturing terms ‘raw material’) to be provided, format, associated timings and escalation with the client. With incomplete or delayed information during the fieldwork stage, a fully staffed engagement team will not be able to complete work, and inefficiencies and delays will inevitably result.

3.2.2 Financial Reporting Process (FRP)

The production of Financial Statements are the ultimate output of the audit, comprising a set of financial statements and the associated notes. The financial statements are the ‘product’ that is provided to users of the financial statements. This process involves client management and auditor review of the financial statements for completeness and accuracy with the underlying accounting records of the entity, as well as a check to ensure that all relevant accounting standards have been complied with and adequate disclosure made. The auditor is responsible for rendering an opinion on the financial statements.

Inputs to this process include the draft financial statements prepared by client management, who are also responsible for notifying the auditor of any changes in the businesses operations that may require alteration to the financial statements (and likely additional audit work to verify). Changes to auditing or accounting standards are also inputs to the process that may drive changes in the FRP – management should be aware of new requirements, but generally, there is an expectation that the auditors will proactively discuss any additional requirements. The FRP is set out in figure 3.3.

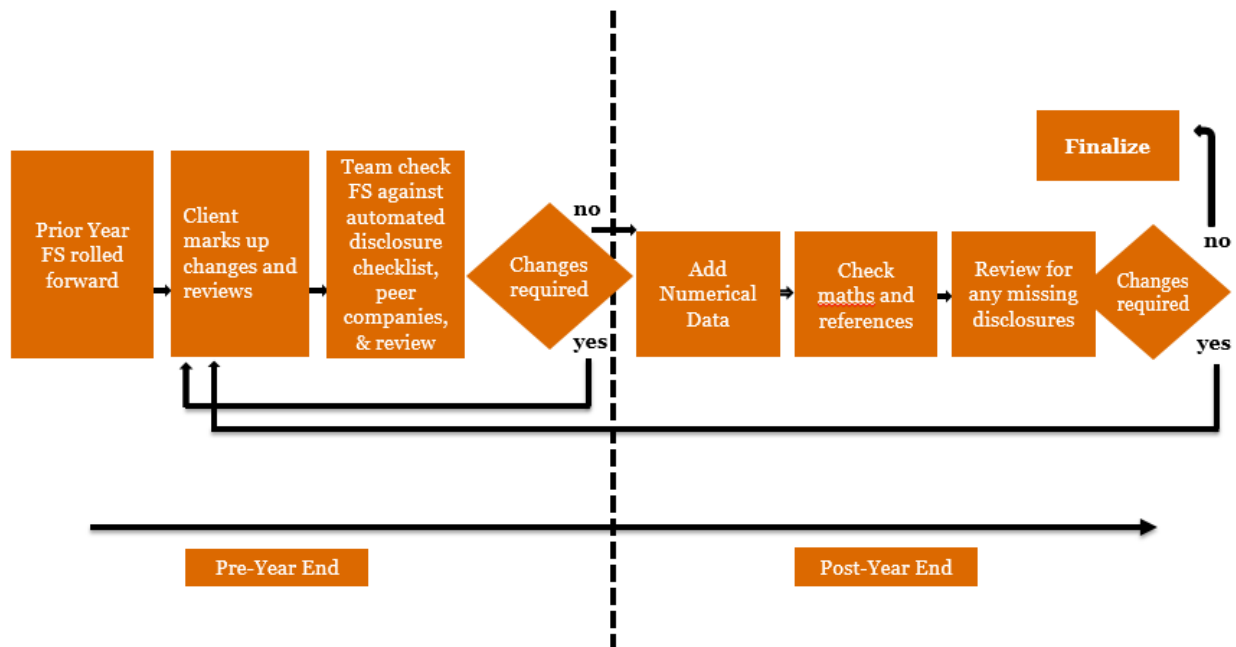


Figure 3.3: Financial reporting process

The process begins with an audit associate or senior associate supervising the roll-forward of the prior year financial statements – this involves removing the comparative numbers (if applicable) and migrating prior year data into current year comparative columns, while dates and references are also updated. This process is administrative in nature and may be performed by the client, however the output is identical – a blank set of current year financial statements. Client management then amend the rolled-forward financial statements – changes may be driven by modifications to the entity’s operations or new/clarified accounting standards. A senior associate will check the draft financial statements using an ‘automated disclosure checklist’ – a propriety system of Firm A that uses a questionnaire format, inputted by the senior associate, to ensure that all required disclosures have been made. A manager, and dependent on complexity, a partner reviews the output of the automated disclosure checklist. Any changes are discussed with

the client and format/wording agreed. This roll-forward occurs before the entities' year-end – in order to agree the format of the financial statements prior to peak season and to ensure that all appropriate audit tests have been identified. Post year-end numerical data is known and is then added to the draft financial statements by the client. The audit senior associate will ensure that the engagement team verifies that data input into the financial statements matches the audited data, that the financial statements are mathematically accurate and that all cross-references are correct. A final review for any missing disclosures is also performed, once numerical data is added. Any errors, omissions, or required changes are discussed with client management.

When the process functions well, all additional disclosures and associated additional audit work required are identified well before year-end and agreed with all parties. If there are no changes in the entities' operations or accounting standards since the pre year-end review, the final financial statements should not change from the draft agreed before year-end.

The FRP was deemed critical, as the financial statements are the only external work product of the audit – and is visible to client management, shareholders and other stakeholders. In a regulated environment (such as the U.S. mutual 40 Act funds) time restrictions (60 days from year-end) require that financial statements must be filed with the SEC unless an extension is granted, making timeliness a critical factor.

3.2.3 Overall review process (ORP)

The ORP review process is a multi-stage review process which provides the required oversight of all tasks and ensures that these are properly documented in the audit work

papers. The review process ensures that the audit has been undertaken as per the pre-determined norms (think of this as a control mechanism of the audit process). There may be one or more levels of review based on a multitude of factors, for example, how experienced the 'preparer' is, or risk of the associated task. Some tasks are mandated to be reviewed by specific levels in the organization's hierarchy – for example, partners must review the financial statements and then document that review. A summary of the review process levels and sequencing is set out in figure 3.4.

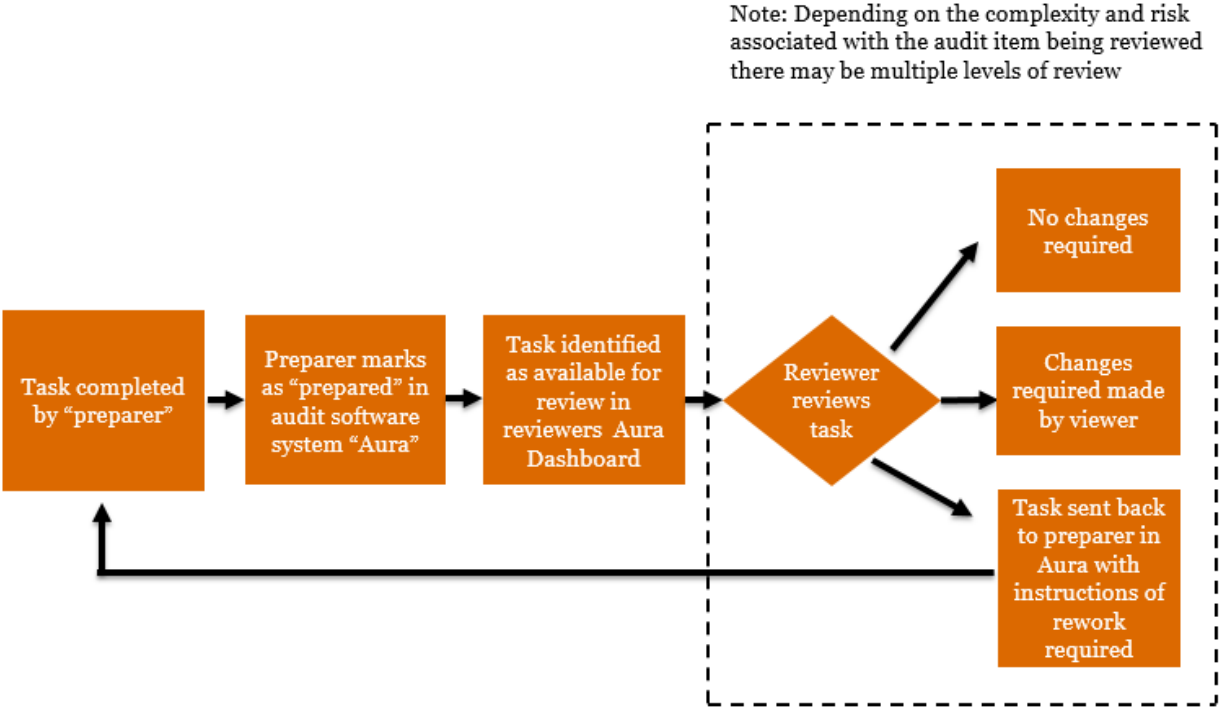


Figure 3.4: Overall review process flow

The overall review process underpins every other aspect of the audit. When an audit task is completed by a preparer it must be reviewed by at least one 'reviewer', who will occupy a more senior position. The preparer marks any given task as 'prepared' in the electronic audit system. Once marked as 'prepared', the audit step is included in the reviewer's audit

software dashboard as 'ready for review'. The reviewer checks the audit documentation included in the audit software for completeness, clarity and other quality measures. Following this review there are three scenarios. Firstly, that there is no additional work required and no questions arising, in which case the reviewer marks the work 'reviewed' on the audit software. If there is no further level of review then work is complete at this point.

Secondly, if minor revisions are required, the reviewer performs these without involving the preparer. Work is then marked as 'reviewed' in the audit software. As with the first scenario, if there is no further level of review, work is now complete.

Finally, as a result of the review, significant rework may be identified, or questions arise that require input from the preparer. In this scenario, work is electronically 'sent back' to the preparer, accompanied by an electronic note detailing the questions and/or additional work required. The preparer will respond to this by amending work, and the review process begins again. As noted above, for areas of particular complexity or high levels of risk more than one level of review is required. Areas requiring multiple reviews are often identified and set up in the audit software during audit planning; occasionally such areas are identified during the substantive audit work phase and routed to appropriate reviewers later in the audit process.

The overall review process happens repeatedly throughout all stages of the audit. The overall review process impacts all other areas of the audit, and an efficient process significantly impacts the overall efficiency of an audit. When the overall review process works well, then all work is reviewed on a timely basis, issues are identified early and discussed internally, as well as with the client. Work is completed on time and any

additional work or delays are identified early and communicated to the client. When delays are caused by the client's staff, these can be brought to management's attention in a timely manner.

4 PILOT STUDY: DESIGN, FINDINGS AND HYPOTHESES

GENERATION

Given the lack of publicly available information about the application of LSS to the investment fund audit industry, Firm A decided to first execute a pilot study, before engaging in a larger scale field experiment. Both the pilot study and the field experiment were based in the US subsidiary of Firm A and were aimed at improving the efficiency of audits in the asset management environment. For this reason, their scope included all the three main operational processes associated with investment fund audits previously described— prepared by client listing (PBCL), financial statement process (FSP) and the overall review process (ORP). The pilot study involved 10 engagement teams and pursued three main objectives: (1) to assess the applicability of LSS in the investment fund audit operations of Firm A, (2) to quantify the improvement potential of LSS and (3) to identify challenges and best practices prior to a larger scale roll out. Details about design, execution and findings of the field experiment are reported in the next chapter (see figure 4.1 for overview of the timeline of activities for the pilot study).



Figure 4.1: Timeline of pilot study

4.1 Engagement team sample

The substantive phase of the pilot study was undertaken between October 2014 and April 2015 and consisted of 10 engagement teams. All the engagement teams that participated in the pilot study were located in the Boston office of Firm A, in order to simplify the execution of the pilot. They were also established teams, in order to avoid variation of performance due to team inexperience. All teams also included specialists across different levels of expertise and responsibility, including partners—the highest hierarchical level in Firm A (see Figure 4.2).

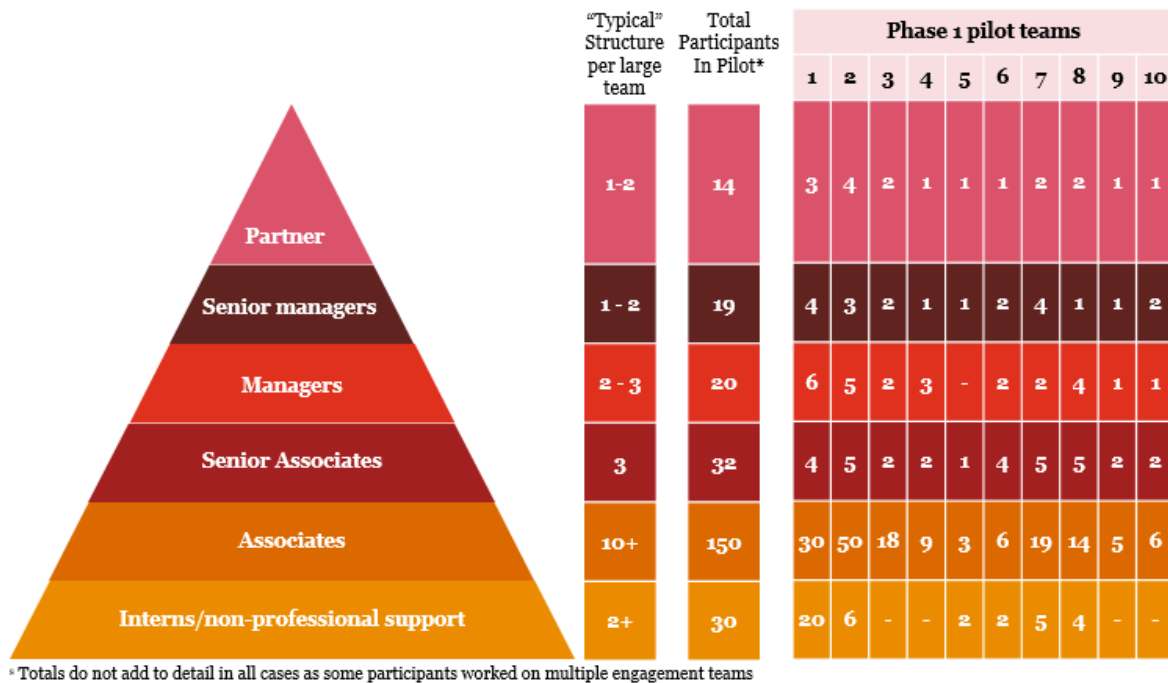


Figure 4.2: Composition of pilot teams

Despite these common characteristics, the engagement team sample was structured to reflect a range of varying engagement types and sizes, in order to identify whether there

were any specific challenges or opportunities in implementing LSS in differing contexts. The pilot engagement teams sample included seven 40 Act funds teams, two corporate entities teams and one alternative engagement team. The higher representation of 40 Act teams reflected their relative importance as a revenue stream for Firm A. Engagement teams' size ranged from 14 to 585 funds, with an average of 120 funds. This difference reflected the different sizes of the clients served by the teams, as captured also by the expected hours required to complete audit work, which ranged from 2,000 to 53,500. Lastly, teams differed in the extent to which their activities had a seasonal peak, captured by what is known as cycles per year. Cycles per year is a measure of how many year-ends are subject to audit on a specific engagement. For investment management advisor engagements this is typically one, for 40 Act and alternative fund engagements this is a number between one and 12 (as theoretically a series of funds may have a year-end for each calendar month). Figure 4.3 provides an example of how fund cycles relate to annual audit effort. In this illustration, the fund complex contains 237 funds grouped into five annual cycles.

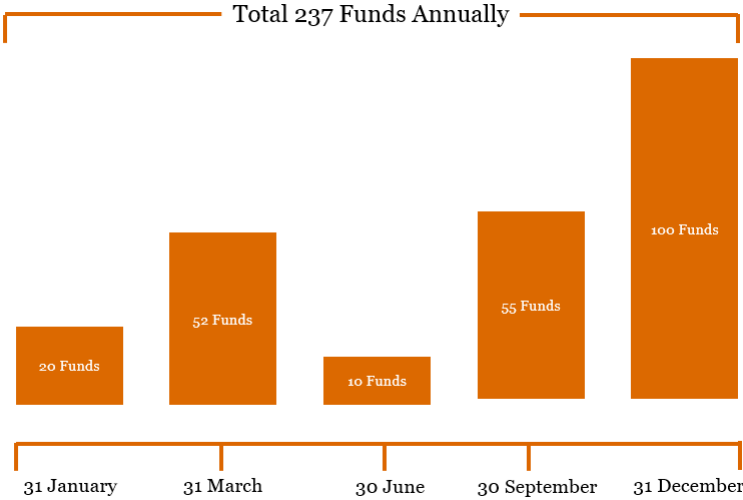


Figure 4.3: Example illustration of fund complex multiple audit cycles.

4.2 Pilot deployment

The engagement teams identified as suitable for the pilot were approached by the author and the objectives of conducting the pilot study were discussed with the responsible engagement leader (partner). The purpose of such discussions was to create transparency with respect to the objectives of the study, discuss logistics and required team inputs/commitment and to generate interest amongst the teams that were to participate in the pilot study. In a nutshell, the purpose of this early step was to obtain buy-in from team leaders and members.

4.2.1 Delivery of LSS training

Prior to the study, the audit practice of Firm A had not implemented or attempted to implement LSS, Lean Philosophy or Six Sigma. Hence, no internal LSS knowledge was available to train the target engagement teams. For this reason, four 'Black-Belt' LSS expert trainers and consultants were recruited on a contract basis to provide technical support and guidance to engagement teams implementing LSS. Training was delivered face-to-face to all teams, taking advantage of their common location. Trainers met remotely with engagement teams when needed. All trainers were expert LSS consultants³.

³ Subsequent to the pilot study, a decision was made to use trainers to deliver LSS consulting to clients. The revenue accruing from these consulting activities largely covered the salaries of the trainers, resulting in no material net cost being incurred by Firm A because of the program. Whilst some limited travel expenses were incurred, overall the cost in providing LSS training and support was insignificant. Costs associated with review and evaluation were largely time-based and related to existing staff – no additional staff/partners were employed, so although overtime levels for these individuals increased, no additional salary expense was incurred.

A series of workshops were held for individual engagement teams (these workshops encompassed staff at all levels from interns to partners) to introduce them to LSS concepts and approaches, overcome perceived barriers to adoption of LSS and brainstorm the potential efficiencies and new working methods to be applied to that individual engagement. Emphasis was put on securing representation at these workshops from all levels of team members, since typically more junior team members are the 'doers' (performing tasks) with detailed knowledge of processes undertaken, client nuances and other practical matters. More senior team members (who typically act as 'reviewers') are required to authorize new ways of working and to ensure that proposed efficiencies did not compromise quality. Furthermore, engagement partners were asked by the LSS trainers before the workshop to lead the team in deconstructing the existing approach in order to demonstrate that criticism of previous working practices was welcome and remove the concerns some junior staff members may have had about implicitly criticising senior engagement team members when identifying areas for improvement.

The presence of the LSS trainers also ensured an environment that inspired and encouraged representatives of all levels of a team to think outside the box and to not feel constrained by the existing working practices in the team.

This training process, held over two and a half days, was of vital importance, as for most of the members of the participating engagement teams, LSS was a completely unfamiliar concept. The training process focused on three main elements. Firstly, ***providing evidence of the benefits of the LSS process*** via a live 'processing exercise' including the introduction of lean tools and principles including the 'five why's', fishbone diagrams and value stream mapping; Secondly, ***identifying redundancies*** (work that was not

required) and pain points (work that was particularly onerous to complete) of the existing processes. As discussed above, each team was required to consider three processes (PBCL, FRP and ORP) with other processes added, subject to time. Redundancies were identified by teams mapping the existing process using removable coloured post-its with red-coloured notes denoting particularly time-consuming activities. Once the existing process was mapped, engagement teams jointly identified alternative approaches, mapping out a 'future state' process, that included identifying additional resources or actions (such as changes in client processes). An action plan was developed for each accepted improvement idea, with team members taking part in specific actions necessary for transforming the engagement teams' current approaches to a lean approach within the required timeframes.

Engagement teams then set about implementing identified process improvements, aided by LSS trainers and supervised by engagement leaders. Finally, **ongoing support** was provided. Each team was assigned a dedicated LSS trainer (the same individual who had conducted the training for the team) for ongoing support to ensure expected progress was made and to ensure that the previously agreed upon actions were implemented without any issue. Following the creation of an action plan, LSS coaches would meet with engagement teams weekly during the audit planning phase prior to substantive work to assess progress on the agreed upon plan, assist in the resolution of issues and provide other relevant tools or solutions devised by other engagement teams.

4.2.2 How engagement teams formulated and implemented improvements via LSS

Several mechanisms were put in place to facilitate the implementation of LSS and to support engagement teams. This was deemed important, as the substantive audit phases

were the first time teams had implemented LSS, and this timeframe coincided with the busiest time of year, leaving engagement teams with very little spare capacity. The support provided included the organization of group meetings with LSS coaches, setting up an intranet support site and making LSS coaches available as resources for individual engagement teams.

After the training, these 10 participating engagement teams executed the audits as per their newly devised action plans between January and April 2015. Conference calls of 30 minutes to an hour in duration were held at the end of January, February, March and April of 2015. The participating engagement teams were required to send a team representative to these, which also included LSS coaches. These calls focused on the practicalities of completing the audit process and sharing solutions to common issues. The purpose of the conference calls was threefold. Firstly, to identify common issues experienced by engagement teams in implementing LSS. Secondly, to share best practices, solutions and experiences across engagement teams – this enabled quicker resolution of known issues and the early identification of newly experienced issues. Additionally, for issues common to all or a large number of engagement teams, centralized resources could be deployed. Finally, the calls enabled the central team to monitor progress and ensure that engagement teams were broadly on track.

To further ensure the smooth exchange of information, encourage cohesive troubleshooting exercises and to enable peer-to-peer communication amongst the participating engagement teams, an intranet page was created for participating engagement teams using the web-based proprietary SPARK system. This was also used as a repository to post templates, solutions to common problems and best practice documents, as a forum

to ask questions that would be answered by LSS specialist consultants or other teams, as well as a vehicle to allow engagement teams to connect with each other in order to share ideas. The purpose of the SPARK site was to have a one-stop-shop for documents and tools useful to teams and to prevent duplication of solutions to common problems. The site also allowed for real time communication and identification of issues without teams waiting for the next group call if the matter was urgent. The LSS consultants monitored content on the site.

LSS consultants were allocated specific engagement teams to provide one-to-one coaching and to check progress against the agreed plan. Consultants were allocated engagement teams they had previously trained so that there was familiarity with them and their associated plans. Consultants spent time at client sites or other locations where engagement teams were working and reported to the engagement partner and to the central team on progress and any issues arising.

Formal debriefing sessions were held with each of the participating engagement teams in Spring/Summer 2015 in order to assess learning points for the upcoming larger-scale field experiment and pilot metrics. The findings of the pilot study indicated a set of issues related to the existing processes. These problematic sections of the process were then either modified or replaced by newly devised actions plans. These revised plans were then tested during the field experiment to explore whether implementation of the LSS approach improved the audit performance of the engagement teams across Firm A.

4.2.3 Measurement: tracking engagement teams' effort and outcomes

A fundamental driver of efficiency in the audit practice is the time spent by each engagement team in serving the assigned clients. Less time spent by the team reduces the cost of a closed-priced auditing service, thereby enhancing profitability. However, quality must be maintained, so any reduction in time spent cannot be detrimental to audit quality. Given the importance of this time metric, Firm A monitors closely the hours taken to complete audit work. Every partner and staff member is responsible for completing an electronic timesheet on a daily basis detailing what time was spent on a specific client and various non-client activities. Compliance with this requirement was tracked and sanctions were in place for individuals who repeatedly failed, without good excuse, to submit a daily timesheet on a timely basis. This process was well established within Firm A and engrained with its employees' daily routine. As a result, more than 98% of timesheets were submitted on the same day, and the vast majority of the balance the following day. As a result of this reporting, each team was able to accurately identify the hours incurred in completing work in 2015 and compare this to its equivalent effort in 2014. Employees with different roles and levels of experience had different hourly standard rates (for example, new associates may have a charge-out rate of \$180 per hour, senior managers \$350 per hour etc.). However, the relative time effort of employees across different pay levels is quite similar across engagement teams, with the lion's share of work being performed at the lower levels. For this reason, the variation of the total number of hours recorded by an engagement team in audit work from 2014 to 2015—eventually adjusted for changes in scope and organization of work—can be considered as an adequate measure of performance variation in the pilot period for each team.

4.3 Findings

4.3.1 Overall improvement of the engagement teams' performance

At the end of the pilot stage, a successful evaluation of the pilot study (based upon the indicative savings calculated as time saved, multiplied by a standard rate) led to the progression to the larger scale field experiment. The comparison made to the prior year was adjusted for two factors. Firstly, changes in scope (i.e. more or less work requested by the client – typically as a result of new funds opened or funds closed impacting the number of audits undertaken) were adjusted for to provide a valid comparison to the prior year. Specifically, at the beginning of the budget year, scope of work planned for 2015 was translated in budget hours. The difference between 2015 budget hours and 2014 actual hours was detracted from 2015 actual hours to remove the effect of variations in scope. Additionally, an adjustment was made for work performed in an offshore centre located in an Asian low-cost country (known as GADM – global audit delivery model). Based on previous records from Firm A, work performed in the offshore centre took approximately 50% more time than equivalent work performed in the United States, albeit at a significantly lower cost per hour. Additional time is incurred in the duplication costs associated with sending and checking work sent overseas and in the lower levels of familiarity that GADM staff have with the client and the nature of the specific task.

The aggregate hours taken to complete audit work for the ten engagements included in the pilot study in 2014 amounted to 200,056, while the adjusted hours for these engagements in 2015 was 189,762. This represents an efficiency improvement of 10,294 hours, or 5.15%. Given a blended employee rate (calculated as the aggregate cost of work incurred on asset management clients recorded by the electronic timesheet system

divided by total hours taken to complete asset management clients) this equates to savings of approximately \$2m. The distribution of time savings across engagement teams in the pilot is visualized in figure 4.4.⁴

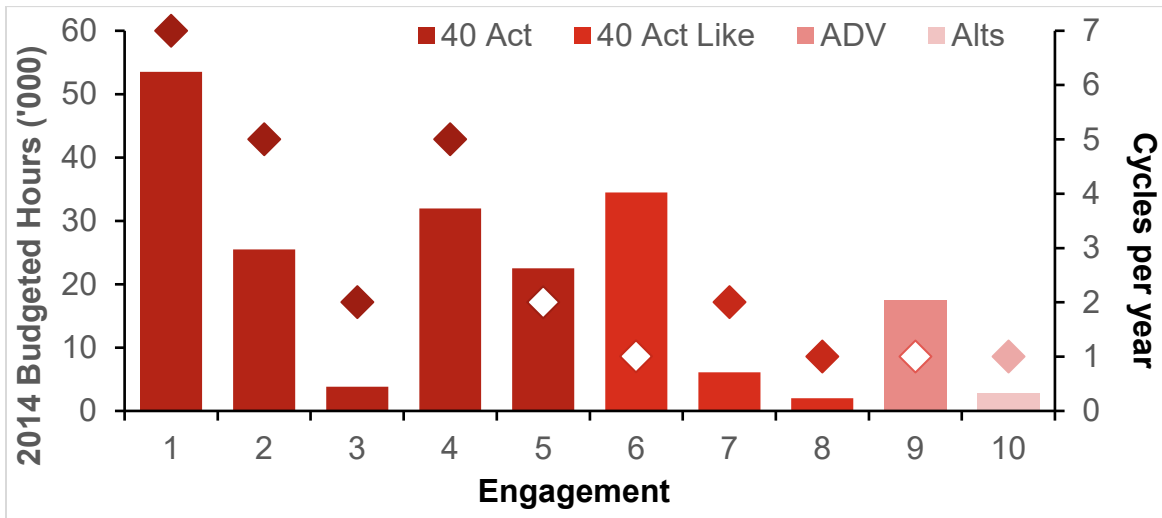


Figure 4.4: The change in hours required to complete audit work in 2014 and 2015 by participating engagement team (positive change indicates a reduction of hours).

The limited number of pilot teams allowed for an in-depth investigation of which specific improvement initiatives originated from the LSS exercise. Since the teams interacted either directly or through the LSS trainers, their improvement initiatives tended to converge into a common set of process changes. We report hereafter these changes for the PCBL, FRP and ORP.

⁴ A number of additional benefits from LSS, beyond time savings, were identified in the pilot, and are discussed in section “4.4.5 Ancillary benefits”.

4.3.2 Specific improvement initiative relative to PCBL

Figure 4.5, below, set out the PBCL process and pain points. Figure 4.6 sets out the reengineered processes established with the aim of driving efficiency by ensuring the completeness and accuracy of the PBCL.

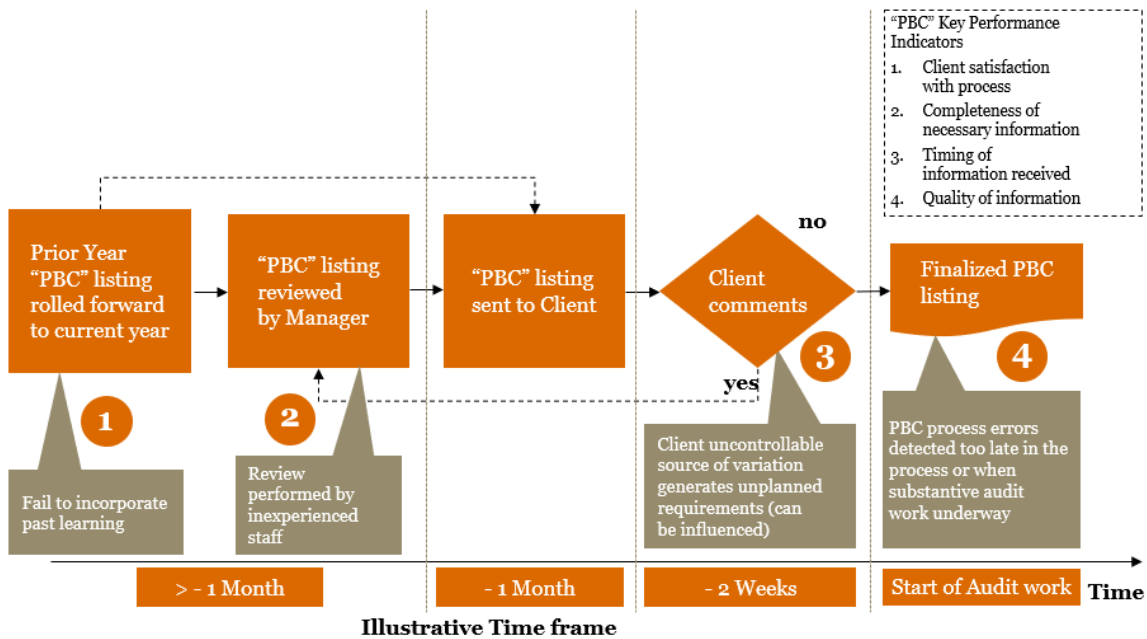


Figure 4.5: PBCL Process and pain points

Set out below are the improvements applied by the different pilot teams.

# Pain Point Addressed	Process	Pilot Engagement Team									
		1	2	3	4	5	6	7	8	9	10
1	(PI -1) Detailed prior year work-paper review to ensure completeness and accuracy of PBC listing and document update	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
2	(PI -2) Meeting with client management prior to substantive work to agree PBCs/format/due dates/escalation protocols and accountability metrics	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
3	(PI - 3) Conversion to a Electronic Web Based “PBC” System “Connect”			☑	☑		☑			☑	
3	(PI -4) Management buy-in agreement reached with management to PBC items and due dates	☑	☑						☑	☑	
4	(PI -5) Client debrief – debriefing of PBCL process with management	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑

Figure 4.6: Reengineered PBCL processes

There are five variables associated with the PBCL:

Timely detailed prior-year work paper review and industry list comparison (PI-1):

The PBCL process starts with a roll forward of the prior year listing, updated for dates, etc. for the current year. This document provides a baseline that the current year PBCL is built upon. The PBCL is prepared for each client individually. An ‘industry standard’ listing was produced by the central LSS team leveraging leading practices from several engagements—pilot engagement teams also compared their PBCL listing against this industry-standard listing to identify omissions and enhancements. A detailed review of the PBCL was expected before the client’s year end. This comparison is designed to provide insights about the fatal flaws that may be present in the list of tasks mentioned in the PBCL process. Completing the PBCL prior to year-end ensures that time is not spent on this activity during busy season. For illustrative purposes, if this review has been properly conducted, and the client’s operations/regulatory standards not change before

year-end, then there should be no need for ad hoc or incremental information requests during the audit.

Management update/timely escalation (PI-2): Agreement of a PBCL escalation procedure with client management and regular update meetings between Firm A staff and management to discuss progress. As an example, agreement may be obtained for any items requested on the PBCL delayed by more than five working days from the agreed date of receipt be directly reported to client management. Such an agreement incentivizes junior client staff to provide information on time so as to avoid being identified to their management as the cause of delay and the likely additional audit cost passed on to the client firm.

Furthermore, shortly after the year-end of the entity subject to audit an update is requested from management on whether there have been any changes to the entity's operations. Such changes may require additional (or the deletion of) audit procedures and changes to the financial statements. For the team to complete the audit efficiently it is critical that any changes to the business requiring a change to audit strategy are identified on a timely basis after year-end.

Use of 'Connect' System (PI-3): The "Connect" system is a web-based tool that provides feedback to both the client, as well as Firm A, about the existing and/or impending delays and associated responsibility, thus facilitating the complete and timely transmission of information and resolution of any questions arising in respect to this information. 'Connect' has reporting functionality available both to Firm A and its clients that enhances transparency and accountability in relation to the provision of information in accordance with agreed timeframes. As an example, client management of the audit team can obtain

self-service a real-time status report of information provided, outstanding information customized by date, highlighting overdue items and a host of other options. For these reasons, the use of this system is expected to reduce the time engagement teams need to devote to complete audit work.

Management buy-in (PI-4): Explicit agreement for the items included on the PBCL as well as expected delivery dates was sought from senior client management. Due dates for each item requested is included in Connect System and any overdue items or items close to submission date are highlighted in red or orange respectively to allow for easy identification. Formal agreement ensures that data is available on time and that the two parties can be held accountable for any delivery failures. Client management agreement should be obtained prior to year-end to allow for proper resource planning based upon the agreed dates that information will be available and provided.

Client debrief (PI-5): A debriefing meeting is held with Firm A staff and client management. This debriefing typically occurs after the current year and hence does not have much influence on current year's performance but is a vital tool to identify the flaws in the process that are present in current year and correct for subsequent periods. Therefore, this debriefing is likely to most improve the performance of the client in future by identifying and rectifying the flaws that exist in the current system. It is suggested, however, that knowledge by all parties that a debriefing discussion will be held may also drive increased compliance with commitments made in the current year.

4.3.3 Specific improvement initiative relative to FRP

Figure 4.7 below set outs the FRP process and pain points. Figure 4.8 details the reengineered processes established to accelerate review of the draft financial statements to before year-end, including obtaining management agreement to the draft. Since this review is conducted before year-end there is the possibility that there are changes to the entity's operations requiring additional disclosure, or that accounting standards or regulatory clarifications necessitate additional or different disclosure. In the absence of a change in operations or new regulatory requirements, the draft agreed before year-end should be used without alteration once data is available for the entity. Since the presentation and disclosures have been previously agreed, finalizing the financial statements should require very little time in the peak season.

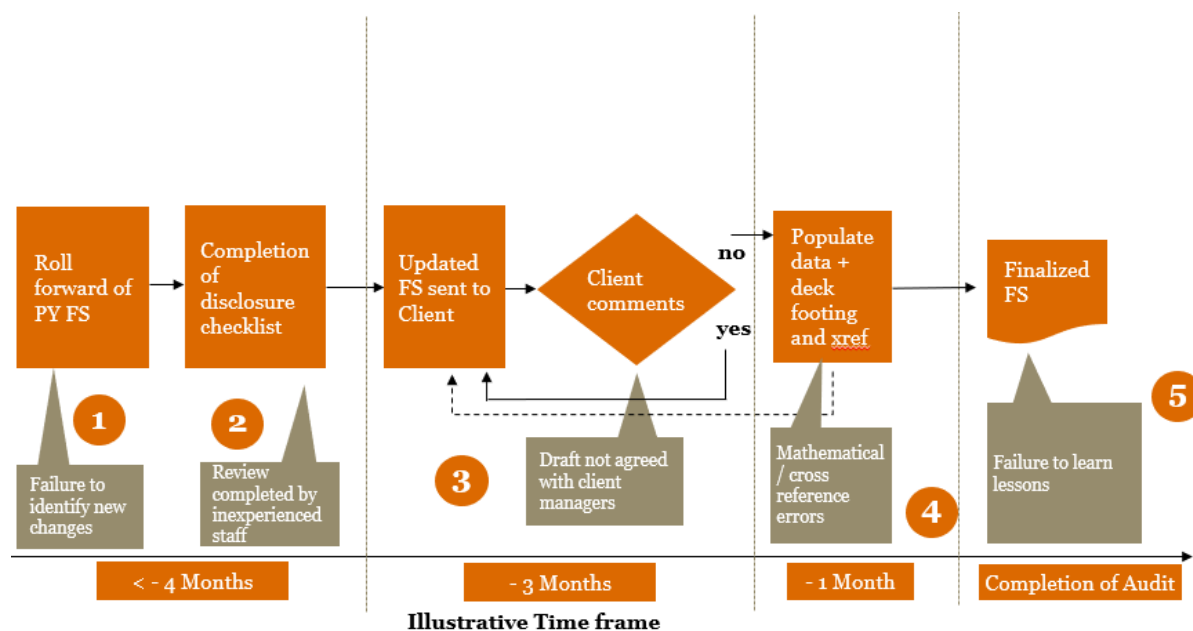


Figure 4.7: Revised financial reporting process.

Set out below are the improvements applied by the different pilot teams.

# Reengineered Process	Process	Pilot Engagement Team									
		1	2	3	4	5	6	7	8	9	10
1	(PI -6) Timely PY FS roll forward and review for compliance with current year requirements	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2	(PI -7) Use of Automated Disclosure Checklist and review by all levels of the engagement team. Changes to clients business operations incorporated	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2	(PI - 8) Comparison of draft FS with industry peers to identify any missing disclosures	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
3	(PI -9) Client management approval of the draft FS prior to YE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
4	(PI -10) Use of automated footing tool to agree mathematical accuracy, cross referencing and reconciliation to audit work	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
5	(PI -11) Debrief with client management of the FS process - with action plan to address points arising in subsequent cycles	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Figure 4.8: Reengineered FRP processes

There are six variables associated with FRP:

Timely prior year financial statement roll forward (PI-6): The FRP process begins with a roll forward to the prior year financial statements (unless there are known significant changes to the facts and circumstances applicable to the entity). This roll forward process involves updating dates and disclosures to the financial statements. Prior to year-end data prior year balances are removed. Current year balances require input when information is available after year end. Work related to the roll forward is often performed by an offshore delivery center (GADM). The draft rolled forward financial statements are then reviewed for completeness with current year preparation requirements and any known changes to the entity’s operations that would require changes to disclosure. This process seeks to identify whether any additional disclosures are required and if so what additional audit steps and client information is needed.

All level review of automated disclosure checklist (ADC) and support (PI-7): The ADC is an electronic system that contains all required disclosures tailored for an entities specific situation. Users of the system answer a checklist; the ADC identifies which disclosures are required, based on user inputs, and the staff member then compares ADC output to the actual disclosures contained in the draft financial statements. Any differences should be brought to the attention of the engagement leadership. Generally, there should only be additions over and above disclosures made in the prior year in the case of new accounting standards being implemented or when changes to an entity's operations occur. Any other changes due to required disclosure missing in the previous year (PY) triggers an additional review to consider the PY statement. The all-level aspect of this process ensured that any changes (or lack of changes) were agreed by the whole engagement team, including managers and partners—preventing last-minute changes later in the audit. This process seeks to pull forward the work associated with thoroughly reviewing the financial statements, as well as identifying audit/financial statement changes early on to eliminate redundant work and identify where a change in audit work is required outside the peak season.

Peer/industry comparison (PI-8): The draft financial statements are compared to similar peer companies as a final check against missing disclosures. Such comparisons assist in drafting changes required, and identifying changes required early in the process. Engagement managers and partners should be involved in this process to ensure complete agreement to the format of the draft financial statements. Changes from the prior year may be required because of new requirements or changes in the entity's operations.

Pre-year-end client sign off (PI-9): Once the draft financial statements have been rolled forward, the ADC completed and reviewed by firm A and a comparison made to peer organizations, they are sent to client management for approval. A key point of this step is to obtain client approval for any required/recommended changes and to obtain details of changes in an entity's operations, or confirmation that there were no changes that would impact the financial statements. This step should be completed prior to year-end to allow for planning of any additional work required.

Footing tool check (PI-10): Footing is a term used to mean that mathematical accuracy and cross references have been checked and agreed. Firm A leverages an automated footing tool that works in certain circumstances dependent on format and complexity of the financial statements. For example, financial statements are uploaded to a system. The system output is a copy of the financial statements with added details of mathematical/cross reference checks performed and details of any discrepancies identified. In the absence of such automated tools, the accuracy of the financial statement will be manually tested by personnel often located in offshore delivery centers. At this stage the numerical data contained in the financial statements is also reconciled to the audit file, typically by offshore delivery center personnel. Furthermore, a check is performed to ensure that there are no additional categories or balances that may require changes to the financial statements. As noted in PI-9 pre-year-end, the team have checked with management regarding changes in an entity's operations or balances, but receipt of final numerical data gives Firm A the ability to validate that no additional disclosure or audit work is required. Any omissions identified as a result of comparing data to the previously agreed financial statements results in internal discussions within

Firm A to agree required language, and subsequently discussion with an agreement by client management.

Client debrief (PI-11): The process of preparing the financial statements should be discussed with the management of the client firm. The purpose of this conversation is to identify any opportunities for improvement in subsequent years as well as to note areas that worked well. In many instances the same client personnel are responsible for the production of information requested in the PBCL, so the debrief of the FRP is held at the same time as for that process (i.e. PI – 5).

4.3.4 Specific improvement initiative relative to ORP

Figure 4.9 below set outs the ORP and associated pain points. Figure 4.10 details the reengineered processes designed to be responsive to these pain points. Traditionally, the ORP would occur when substantive audit work is performed and reviews can only occur after it is carried out. However, the revised process involved setting up a system to enable ‘real time’ and ‘face-to-face’ reviews and required that those carrying out the ORP and the reviewer be identified in advance and time scheduled for both activities. This planning involved expenditure of time pre busy-season but the increased organization was anticipated to save time during the peak season.

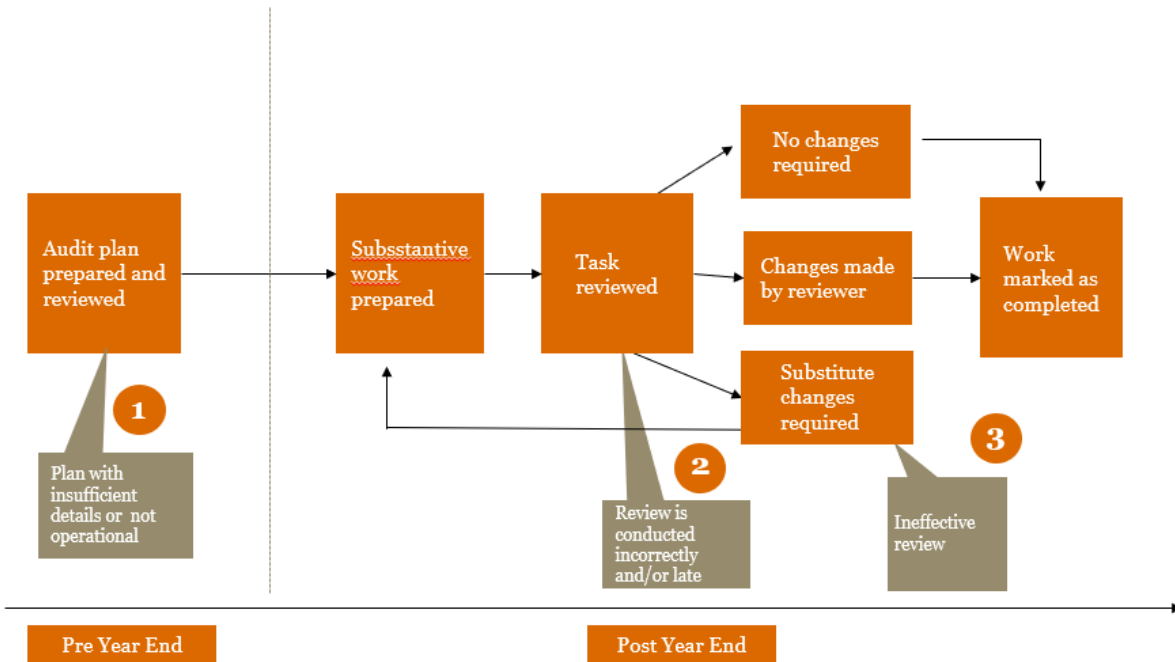


Figure 4.9: Details of revised overall review process.

# Reengineered Process	Process	Pilot Engagement Team									
		1	2	3	4	5	6	7	8	9	10
1	(PI -12) Detailed plan prepared - at level of individual tasks, preparer and reviewer responsibilities and timelines agreed			☑	☑	☑	☑	☑	☑	☑	☑
2	(PI -13) Face-to-face review process established to be conducted within 48 business hours and compliance measured	☑	☑	☑	☑		☑	☑	☑	☑	
3	(PI - 14) Reviewer sign off time scheduled and progress versus expectations publically measured	☑		☑	☑	☑	☑	☑		☑	☑
3	(PI -15) Timely, in person reviews established as an up-front objective, added to relevant team members performance plans	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑

Figure 4.10 Reengineered ORP processes

There are four variables associated with the overall review process:

Detailed plan prepared (PI-12): This process required the preparation of a detailed plan for each audit task prior to year-end. As such, for an individual engagement team each

area of the audit was broken down to specifically identify individuals performing tasks of preparer(s) and reviewer(s). For example, senior associate X is expected to mark cash-related audit steps as 'prepared' on XX January, and manager Y would perform a review of this work within 48 working hours. These dates and actual dates would be recorded on a team calendar available to all team members. Additionally, this plan was expected to be codified and agreed by all team members. During the substantive phase, the progress of actual work versus planned work was expected to be monitored by engagement teams on a "huddle board" – a whiteboard in the team room – and issues/successes discussed for approximately 15 - 20 minutes each morning in short team meetings of all team members, called 'huddles'. Such a plan allowed for the dynamic re-allocation of expected time (if needed), facilitated in-person reviews and timing of workflow.

Face-to-face review protocols established (PI-13): Review of work can occur remotely, as all work is documented electronically. This process established an expectation that work would be reviewed on a face-to-face basis. Furthermore, all work was expected to be reviewed within 48 working hours of completion. This would enable misunderstandings and errors to be swiftly corrected and hopefully avoided in future work. Coaching, to aid development, would be provided in real time. Additionally, the number of team members and the quality of their work were scrutinized, and they were accountable for output produced. Any issues would thus be identified quickly and could be corrected.

Senior review sign-off time scheduled (PI-14): This process required that review time be scheduled (according to the plan outlined in PI-12) with senior reviewers. The purpose of scheduling time in advance was to ensure that reviews occurred on a timely basis and that reviewers had enough time and were located physically on site in order to review

work in 48 working hours face-to-face with preparers. The performance of reviewers in achieving sign off within 48 working hours was monitored by the engagement team lead senior associate and included on a “huddle board” visible to all team members, while actual results vs the plan were discussed daily. This engendered a constructive competitive mindset where both preparers and reviewers wanted to achieve targets.

Real-time face-to-face review communicated as expected metric (PI-15): This process captures whether the real time, face-to-face protocol was being followed or not. Prior to the start of an engagement, each team member set a number of goals in an electronic appraisal system, and performance against these goals was assessed after work was completed. All team members were required to include this goal as a written performance metric to be assessed on an individual basis after completion of the engagement their appraisals. Following this protocol was expected to drive timeliness of completion of audit work and provided close to real time feedback for staff, preventing repetition of mistakes and hence lowering remediation costs. This also improved morale and staff experience of engagements.

It was anticipated that if the ORP was implemented as described above that efficiencies should be realized as a result of a number of factors. Firstly, any errors made by preparers would be quickly identified with 48 hours. Corrective action could be taken quickly, and rework minimized. Secondly, reviews would occur throughout the process and not at the end of the audit when deadlines and time pressure make correcting erroneous work particularly problematic—especially if this involves seeking additional information from client management. Thirdly, as a result of timely review any additional training/guidance given to team members would prevent future errors occurring on work performed.

Fourthly, the face-to-face nature of the ORP was expected to lead to additional transparency of preparers' work quality and quantity and reduce unproductive time. Finally, the in-person reviews were expected to provide additional coaching and training for preparers - minor amendments made by reviewers without reverting back to preparers would be otherwise unknown to those preparing the work when a review occurred remotely.

4.3.5 Ancillary benefits

In assessing the pilot study, several ancillary benefits to Firm A were identified as a result of implementing LSS. These benefits fell into two categories: (1) training spillover on engagements and processes other than those embraced by the pilot, and (2) the LSS initiative's effect on employee morale and engagement.

Once trained in LSS it was observed that team members, especially more junior members, saw the approach as intuitive and identified a number of opportunities to leverage LSS methodology and core ideas (e.g. the concept of "waste") to improve other engagements. This approach resulted in team members proactively asking managers/partners of other clients if they could apply LSS to engagements not included in the study. Team members identified as strong advocates of LSS said a key benefit for them was the elimination of wasted time that allowed for a better work-life balance whilst maintaining quality. Junior team members are well positioned to identify waste as they are largely 'preparers' of work not 'reviewers', who are a step removed from day-to-day methodology and practices. Team members proactively adopting LSS on other engagements also benefited from recognition via Firm A's bonus system when efficiencies were identified. Such bonuses included an annual rating and linked

'performance' bonus, as well as immediate 'spot bonuses' of smaller amounts, as well as public recognition. Numerous examples of application of LSS methodologies elsewhere were identified.

Furthermore, LSS implementation resulted in an anecdotal observation of an increase in team member morale. In debriefing with pilot engagement team's members – in particular associates and senior associates expressed an appreciation for the LSS focus on waste elimination. Most of the 'waste' is represented by tasks performed by more junior team members, waste that frequently resulted in significant levels of overtime in busy season. Associates enjoyed the challenge in their primary role in identifying solutions and found the support of Firm A an encouraging change and empowering. A further common sentiment expressed was that following the training and utilization in the current year, team members had identified further improvements and refinements for the following year.

4.3.6 Limitations of the pilot and need for a large-scale study

The pilot study entailed a heavy investment in training. Additionally, since all engagement teams were located in Boston it was significantly easier logistically for LSS coaches to meet with engagement teams in person, and also to check on progress and be available for impromptu questions/queries/support. The pilot study involved 10 participant engagement teams, while the field experiment began with more than 100 engagement teams (subsequently reduced to 97) geographically spread throughout the United States. Based upon the pilot study, it was determined that 2.5 days of individual training per team would not be sustainable for a larger-scale improvement initiative. Besides cost concerns, the logistical difficulties of having a large number of team members located for an

extended period at a training venue made the scaling of the pilot approach problematic. A lighter, more focused training was therefore needed for scaling up the LSS initiative. In October 2015 national training was to be held for all asset management audit team members at manager grade and above in Atlanta, Georgia. It was decided that a two-hour introductory session to LSS would be held at this venue to introduce the concept to a wide audience in an efficient manner. Subsequently, a single day of training was held at various offices. A number of engagement teams were required to attend training out of their home market if they were located in a smaller asset management territory.

During the pilot study it was apparent that even with 10 engagement teams participating, within the same country, under close supervision by LSS coaches, there would still not be 100% adoption of all improvement initiatives with respect to the PBCL, FRP or ORP processes.

Finally, each team had to decide how to implement those improvements they considered important, as well as the methodology involved in their specific work context, where there were often-divergent facts and circumstances. Teams worked with clients and needed their clients to provide information and agree to process changes. Obviously, each client had differing priorities, concerns and often a different historical practice. Unlike in a manufacturing or other repetitive process environment, it is not possible to be completely prescriptive in how a process should be undertaken. As a simple example, the PBCL process involves getting client approval for the revised PBCL. In some engagement teams, this will be done in person, others via phone, some will email client management. Timing will be impacted by other client deadlines, vacation schedules, sickness etc. Some clients will approve in hard copy form, others only want electronic documents. Individual

clients may have particular concerns about accelerating timetables, given their own resource constraints – others still will welcome earlier deadlines if that means the audit is completed sooner. There are a significant number of other factors that impact how client approval will be addressed, as well as the client's reaction to proposed changes. This is to be expected, since the essence of professional services is human interaction. It is therefore important to investigate whether the advantages of LSS training can stand up to these individual engagement teams' variations in implementation of improvement initiatives.

5. FIELD EXPERIMENT (JUNE 2015 – JULY 2016)

5.1 Goals of the field experiment

Following the conclusion of the pilot study, and considering the necessary amendments to scale up for the field experiment in June 2015, the larger scale field experiment began. The field experiment pursued three objectives. First, to establish if a reduced amount of LSS training could result in substantial improvements in engagement team efficiency, as observed in the pilot. This question was motivated by the fact that it was not practical to replicate the intensive training provided during the pilot phase at scale across multiple cities (see Section 4.4.6). Second, the field experiment aimed to investigate the effect of turnover of LSS trained personnel on engagement team efficiency. This further objective was motivated by the interest in quantifying how the significant levels of personnel rotation prevalent in the auditing industry affects LSS improvement projects. Third and last, the field experiment was meant to evaluate the generalizability of best practices identified in the pilot to a broader sample of teams. Given the homogeneous nature of audit work performed by different teams, Firm A's management was interested in evaluating to which extent solutions identified in the pilots (see sections 4.3.2 through 4.3.4) were beneficial to engagement teams beyond the pilots.

5.2 Sample

The field experiment consisted of a significantly larger number of engagements (total population 102 engagements, subsequently reduced to 97) in comparison to the pilot study (10 engagements) as well as an expansion of the numbers of engagement offices. The field study sample included 102 engagement teams, accounting for most of 2015

revenues of the US subsidiary of Firm A that this study focuses on⁵. The remaining teams were excluded because they were geographically diverse, compared to the rest of Firm A's US asset management engagement teams. For all practical purposes it can be considered that the survey covered almost all the population of teams for the studied subsidiary and industry sector of Firm A. The ten engagement teams that participated in the pilot study were also included in this set of teams chosen for the main study. In addition to Boston, engagements were selected in New York City, Chicago, Baltimore and other smaller offices, providing US geographical coverage.

The engagement teams included in the field study represented a range of differing engagement sizes (from total engagement hours of 525 hours to 117,000 hours) broken down into three broad categories of engagement: 1940 Act funds; alternative funds and; corporate advisors – as described in section 5.5.2)

During the experiment, a number of engagement teams were deemed “non-responsive” i.e. a lack of communication was reported, despite numerous attempts, and as a result, these engagement teams were excluded from the sample population—details by type of engagement are set out below in table 5.1 below.

Entity Type	Initial Sample	Deemed “Non responsive”	Net Population
Fund Engagements	52	(3)	49
Corporate Advisor Engagements	20	(1)	19
Alternative Fund Engagements	30	(1)	29
TOTAL	102	(5)	97

⁵ Exact figure is not provided due to confidentiality requirements.

Table 5.1: Total population of field experiment.

Non-responsive engagements have been excluded from the metrics, together with a couple of teams with outlying values of changes in actual hours from 2015 to 2016 due to anomalous situations. A final sample description is presented in table 5.2, below:

Entity Type	Final Sample	Average Hours per Engagement	Location of Engagement Teams
Fund Engagements	50	30,079 [70%]	Atlanta (1) Boston (21), Boston/Hartford (1), Boston/LA (1), Boston/Raleigh (1), Baltimore (1), Chicago (3), Houston (1), New York City (12), New York/Baltimore (2), Philadelphia (2), San Francisco (4)
Corporate Advisor Engagements	17	18,607 [17%]	Boston (9), Boston & NYC (1), Baltimore (1), Houston (2), New York City (5), San Francisco (1)
Alternative Fund Engagements	28	9,064 [13%]	Boston (3), Chicago (3), New York City (21), San Francisco (2)
TOTAL	95	21,549	-

Table 5.2: field experiment population metrics

The engagement level of effort that was required across these three different types of engagement differed from each other. The average engagement time per team across all teams to complete their respective audits in 2015 was 21,549 hours. 40 Act fund teams recorded on average 30,079 hours per engagement, consequently they represented approximately 70% of total hours included in the study. Similarly, the engagement teams that were engaged in auditing advisor engagements and alternative fund engagements spent, on average 18,607 hours (approximately 17% of the total hours) and 9,064 hours (approximately 13% of the total hours) respectively, to audit the entities that were under their purview.

Engagement team structure was consistent with that set out in the pilot phase (see Figure 4.2). Team composition typically includes a partner (known as an engagement leader), a senior manager, managers and a team of associates and senior associates appropriate to the amount of audit work and entities subject to audit.

5.3 Process (concentrated LSS approach)

Figure 5.1 below sets out the key activities that occurred during the field experiment conducted between June 2015 and July 2016. The field experiment occurred directly after the pilot study and built on lessons learnt from the pilot study, as well as incorporating changes required for a larger scale roll out.



Figure 5.1: Timeline of the field experiment.

5.3.1 Engagement with the teams

As for the phase 1 pilot, we deemed achieving “buy-in” critical to the success of the experiment. Given the expanded number of engagements proposed to be included in the field experiment and the fact that the engagement teams were based in a number of offices around the country, we took advantage of an existing annual audit training as an

opportunity to provide introductory LSS training for engagement teams and to answer questions. This training, conducted in Atlanta, brought all audit managers and above together for three days in a single location. A mandatory 120-minute session was scheduled for all selected engagement teams, and the training was repeated three times over two days to control audience size and ensure that scheduling conflicts would not prevent attendance. The training session consisted of a series of testimonials from pilot team engagement leaders, along with a high-level overview of the program. Forty-five minutes was set aside for a role-playing exercise where engagement teams worked together to learn practical skills in process redesign. Details of local office training were also set out, along with commitments and expectations by role. As in the pilot phase, all engagement teams were preexisting teams.

5.3.2 Delivery of training

Local office training – because of the size and diverse geographical positions of the teams in the sample, the training was provided across different locations, encompassing the Boston, New York, San Francisco and Chicago offices. Engagement teams based in Hartford travelled to Boston, while team's resident in Baltimore, Atlanta and Philadelphia traveled to New York, and the engagement team based in Los Angeles participated in the San Francisco training. The single joint team in Raleigh was covered by Boston-based engagement staff. The team based in Houston received training via a combination of video conference and live commentary, as an LSS consultant lives locally. This approach ensured that the effects of location-specific factors affecting the overall findings were minimized. During the pilot, 2.5 days of team-specific training was given to all participants, but as a result of the expanded number of teams, this was not deemed feasible for the

field experiment. Training in this phase was conducted in a single day and team members at all levels for each team, including those who participated in the two-hour national training provided in Atlanta. On average, 28% of team members received this training (median 25%, interquartile range 15-38%). No pre-reads or other expectations were established beforehand.

The training format was consistent for all participants. Engagement teams were seated at tables together and the idea was that over the course of the day participants would work on the processes and issues they had encountered. The training began with an overview of process improvement tools, followed by a discussion in table groups of the applicability of this approach to their engagements. Subsequently, table groups worked through in turn the three mandatory process improvement areas (prepared by client listings, financial reporting process and the overall review process) – each process was taken in turn and LSS consultants moved between table groups to ensure that engagement teams were making progress. Specifically, the LSS consultant required teams to implement the process improvement initiatives identified in the pilot but left them free to identify further improvement actions. Following the guided review of each process, a debrief session was held where lessons learned and ideas for overcoming obstacles were shared. At the end of the training day, engagement teams had a written plan to improve each of the mandatory processes, as well as a toolkit to allow them to identify and improve other engagement team specific processes.

5.3.3 How engagement teams formulated and implemented improvement (example of how two different engagement teams used LSS tools)

A number of resources were made available to engagement teams to assist in the adoption of LSS, including LSS consultant-led training, calls with other participant engagement teams, the SPARK knowledge-sharing intranet site, and an LSS consultant coach.

Use of LSS consultants. The firm employed a number of LSS 'black-belt' consultants who were charged with leading training courses, as well as following up with individual engagement teams proactively, in addition to weekly calls hosted from the third week in October, November and the first half of December (when engagement teams are generally planning engagements).

Planning weekly calls. Following the pilot conducted in the previous year, the intensive planning phase (from the third Week in October to the second week of December) was identified as a particularly critical period in which processes could be changed. January, known as the busy season, is a time of intensive work, generally precluding engagement teams from redesigning processes. During this planning phase, weekly one-hour calls were held where common problems were raised, with solutions offered, tools demonstrated and a question & answer session held. Engagement teams that requested specific help that could not be provided over the phone were contacted separately by consultants and issues resolved.

Busy season update monthly calls. A series of 60-minute calls were held at the end of January, February, March and April to help resolve any issues and to facilitate sharing

leading practices. These calls were heavily focused on the practicalities of completing work.

Provision of an LSS coach. As in the pilot phase, each team was allocated a consultant in a coaching role. These individuals were tasked with supporting engagement teams to ensure they were able to successfully implement the change agenda defined by the team in the training phase. Consultants were resident in the San Francisco, Boston and Houston offices and would travel to other locations as needed or work remotely with teams.

SPARK intranet. The intranet site developed during the pilot program was expanded during field experiment to include a full listing of participating teams and contacts. In order to facilitate inter-office dialogue between engagement teams, the site also featured a Q&A section where a consultant or other engagement teams would help solve problems. This site also served as a repository containing approved best practice templates and other resources. Engagement teams that participated in the pilot study were allocated the same coach they had used during the pilot study.

Team debrief. A debrief was held with each team by the associated consultant following the completion of work in order to assess progress and identify areas of improvement.

Whilst the tools available to all participating engagement teams were identical, the practical implication of a process improvement varied from team to team, each of which was faced with differing facts and circumstances, as well as client preferences and expectations. A practical example was provided by obtaining client approval of the interim draft financial statements (one requirement of the FRP). Once the financial statements

had been rolled forward and updated and prior to year-end, a discussion with client management should occur to ensure that (a) they agreed with any proposed changes (or agree that none were required) and (b) they provided details of any changes in the entity's operations in the year (or known forthcoming changes).

By way of illustration, two teams are used as an example, one based in Boston and one in New York, which had decided to reorganize their financial review process to ensure compliance with the abovementioned objectives. The team based in Boston (1) sent the proposed first draft to client management two weeks before an (2) in-person meeting was held at the client's premises in Boston to discuss and finalize the first draft financial statements. During the meeting questions were raised and answers provided both by Firm A and client management. Following the in-person meeting, (3) a revised second draft was sent electronically by Firm A, and (4) the client proposed revisions electronically via a third draft, which were discussed via (5) a phone call. A final draft was sent electronically by firm A to client management, who responded with their approval via email. This process was streamlined by the second team, based in New York, which (1) electronically sent a proposed first draft to client management responsible for financial statement production based in Kansas City. (2) The team received minor amendments from the client electronically and, if applicable, (3) communicated electronically their agreement or raised any points for further discussion in respect to these amendments and thereafter finalized the financial statements.

5.3.4 How engagement teams' activities and outcomes were tracked

LSS coaches were responsible for checking progress and ensuring that engagement teams were implementing the LSS process according to their engagement plan. LSS

coaches reported progress for their assigned engagement teams to the LSS central team. After the conclusion of the field experiment, the LSS central team was responsible for collating the hours and other data necessary to gauge whether there has been an improvement in efficiency. This activity was, as for the pilot, based on elaboration of the time sheets that were completed daily by the team members (see next section).

5.4 Measurement

The key performance indicators utilized to assess the field experiment were logically driven by the goals of the experiment itself. This required, first of all, assessing whether team hours decreased from 2015 to 2016 for each team, eventually controlling for appropriate covariates. Second, to investigate how turnover affected team productivity gains, measures were created to track which team members received LSS training, as well as how many of them left the team during the period. Third, measures were developed to track the implementation of improvements identified in the pilot for the three core audit processes (PCBL, Financial Reporting Process and Overall Review Process), so as to evaluate their impact on the improvement of engagement team productivity. Each team was impacted by specific facts and circumstances – some of which are client-driven and outside the control of firm A. As a result, it was expected that there would be some variation in adoption or improvement processes between engagement teams. As for all mandatory process standards, adoption is never perfect, and it tends to vary across teams (Staats et al., 2016). We exploited this general phenomenon associated to operating standards to empirically evaluate the impact of these outcomes of the LSS pilot.

5.4.1 Dependent and independent variables

Variation in engagement teams' actual hours. Team hours are the hours recorded in aggregate for team members based upon daily time sheet information. Specifically, at the end of a day, each worker completed a timesheet including how many hours they have spent on client projects. Each client and each client project has a unique code against which time is charged as incurred. We subtracted team total hours in 2015 from team total hours in 2016 in order to evaluate whether the treatment (i.e., the concentrated LSS training) yielded an advantage in the form of reduced team hours compared to the previous year for each team. Since variations in the scope of work for each team, as well as variations in activities outsourced to the service center based in India (GADM) would have an effect on variation in team hours, we controlled for these variables (see Control variables section). LSS Blackbelts were tasked with facilitating the collection and codification of information relating to processes, though they were not audit subject matter experts, engagement teams provided detailed subject information where needed.

PCBL completeness and timeliness (PCBLC&T). This variable captured the extent to which an audit team implemented improvements aimed at ensuring that the client provided all the requisite information for the audit no later than when it was needed for the relevant audit process activity. We measured PCBLC&T through five dichotomous items (set out in detail in section 4.4) that captured the improvement areas identified through the pilot study. Specifically, these items referred to (1) whether the “connect” web-based PBCL system was used; (2) the data requested in an individual engagements' PBCL was compared with the best practice list accepted at the industry level before the focal year; (3) the explicit agreement of client management for the revised PBCL; (4)

whether the PBCL escalation procedure for errors, omissions and delays in providing information had been agreed with management of the client organization and; (5) if a debrief of the PBCL process was held between Firm A and client management at the end of the audit process. The PCBLC&T score was hence computed by summing these dichotomous items, and hence is limited to a score ranging from zero to five.

Financial reporting correctness (FRC). This variable captures the extent to which the financial statements reviewed by an audit team were accurate and complete, that is, correct in all material respects. We measured FRC through six dichotomous items (see section 4.4 for additional details) that captured the improvement areas identified through the pilot study. Specifically these items referred to (1) whether the prior year financial statements were rolled forward early in the process by the offshore delivery center and whether these financial statements had been reviewed for completeness within current year preparation requirements; (2) whether the rolled forward financial statements and automated disclosure checklist (ADC) was reviewed by the client manager and the engagement partner during the planning process; (3) this variable set out whether a comparison of draft financial statements to best practices and peer entity financial statements had occurred; (4) this variable captured whether the draft current year financial statements had been agreed by senior client management. It included obtaining client agreement with respect to any changes and/or access to any additional information related to the financial statements that might be necessary for Firm A to perform the audit; (5) this variable captures whether the automated footing and cross referencing tool to check the mathematical accuracy and cross referencing in the financial statements was used and; (6) whether the process of preparing the financial statements was debriefed

with the management of the client firm following the audit. The FRC score was hence computed by summing these dichotomous items, and hence was limited within zero and six.

Review process compliance (RPC). This variable captures the extent to which all the activities comprising the audit process have been executed and documented in compliance with regulatory standards. We measure RPC through four dichotomous items that capture the improvement areas identified through the pilot study. Specifically, these items refer to (1) preparation of a detailed responsibility listing in the audit planning phase. This variable checks whether for an individual engagement team each area of the audit was broken down to specifically identify the individuals performing the tasks of preparer(s) and reviewer(s) and that this plan was codified; (2) establishment of face-to-face review protocols: whether the engagement team set the expectation and established a performance metric that all prepared work would be reviewed within 48 working hours; (3) whether senior reviewer time was scheduled and compliance monitored and; (4) whether face-to-face review between preparers and reviewers of work occurred or not. The RPC score was hence computed by summing these dichotomous items, and hence is limited within zero and four.

Number of LSS-trained and untrained team members who left. Details of team members who left engagement teams were maintained. Team members may leave a team because of cessation of employment with Firm A or through redeployment to another engagement team. Departing team members impact efficiency as historical knowledge of that engagement is no longer available (if the team member has left firm A) or is not readily available (if they have been redeployed). Furthermore, if an LSS-trained

team member leaves the team, LSS skills and knowledge of redesigned processes is lost to the engagement.

5.4.2 Control variables

Scope changes. Scope changes are percentage variations in the budget of audit work hours expected to complete 2016 audit work, compared to actual hours used to complete 2015 audit work for each engagement team. In a 40 Act or alternatives fund context this typically arises because of a greater or lesser number of funds subject to audit (itself a result of advisors opening or closing funds based upon investor demand). For an advisor entity, audit scope changes are driven by changes in the complexities or size of the advisors' business. Scope changes are recorded by engagement teams as these must be agreed with the client (and a fee impact agreed) prior to work commencing.

Changes in utilization of offshore center. Adjustment was made for work performed in an offshore center (known as GADM – Global Audit Delivery Model). Work performed in this offshore center takes more time than equivalent work performed in the United States (albeit at a significantly lower cost per hour) due to activities associated with sending/checking work sent to the GADM, as well as the lack of familiarity of GADM staff with the client and the specific task undertaken. Hence, to be able to compare 2015 hours to 2016 hours, we compiled information about the variation of GADM hours in 2016 relative to 2015 for each engagement team. This information is readily available, because all work performed by GADM is coded to an individual engagement team and recorded on that engagement teams' charge code – the same code where time recording is also aggregated. Details of hours and the associated monetary impact are recorded.

Pilot team. Ten engagement teams participated in in the pilot study. All ten engagement teams also participated in the field experiment. These engagement teams were separately identified in the data recorded.

Team size. The number of team members could have an effect on variations of engagement team actual hours. However, this number does not indicate how much each member worked. For this reason, we added this control in robustness checks performed.

Engagement type. The type of engagement (i.e., alternative funds, corporate advisor, and 40 Act funds, see Section 3.1) may have a confounding effect in the estimation of regression parameters, because audit work across entities is more homogeneous for 40 Act funds, and less for advisory engagements, with alternative funds somewhere in between). Volume of activity is also highest for 40 Act funds and lowest for advisory engagements. We capture this potential disturbance with two control variables: ADV and ALTS. ADV is set to one when the audit is of a funds advisor, zero otherwise. ALTS is set to one when the audit is an alternative fund, and zero otherwise.

Other. Besides these controls, we investigate whether regression results are sensitive to the location of the audit team and to the eventual involvement of the audit team in the pilot study. For this reason, we capture the location of the team with the variables (NY = New York Area & Other East Coast excluding Boston/Hartford, BOS = Boston Area & Hartford, Mid-west & Texas and San Francisco & West Coast).

5.5 Findings

Correlations means and standard deviations for the main variables in the study are reported in Table 5.3.

	DeltaH~5	Delta_~5	Scopee~s	ADV	ALTS	team_s~e	Train_~L	PCB_LST	REV_PRC	FIN_REP
DeltaHo~2015	1.0000									
Delta_G~2015	0.5753	1.0000								
ScopeexRat~s	0.3804	-0.0329	1.0000							
ADV	0.1274	-0.0157	0.0189	1.0000						
ALTS	0.1977	0.2147	0.0134	-0.2983	1.0000					
team_size	-0.4803	-0.4888	0.0597	-0.0542	-0.2360	1.0000				
Train_Leav~L	0.0729	-0.1364	-0.1034	-0.0968	0.0306	0.0526	1.0000			
PCB_LST	-0.2616	-0.2422	0.1029	0.1129	-0.3511	0.4045	0.0717	1.0000		
REV_PRC	-0.2201	-0.2025	-0.0429	0.0323	-0.2991	0.2282	0.1402	0.7476	1.0000	
FIN_REP	-0.1427	-0.1200	0.0691	0.1134	-0.3366	0.0816	0.0403	0.2203	0.2565	1.0000

Table 5.3: Field Experiment Model Results

In the next sections we report the main analyses we executed to address the three goals of the field experiment. Subsequently we report a number of robustness checks that were performed.

5.5.1 Overall performance improvement of the engagement teams

This question gets to the heart of the matter – does LSS improve efficiency? Is LSS worth adopting in the context of a professional services organization? To investigate these questions, we first tested wither the distribution of *variation in team actual hours* of 2016 relative to 2015 is negative and significantly different from zero. The result of a simple T-test indicates that indeed this was the case. Team actual hours on average decreased by 540 hours from 2015 to 2016. From a financial standpoint, such acceleration represents a monetized time saving of approximately \$107,000 per engagement. Results of the T-test are reported in Table 5.4.

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One-sample t test
-----
Variable |      Obs      Mean      Std. Err.      Std. Dev.      [95% Conf. Interval]
-----+-----
DeltaH~5 |         95    -540.2526     154.9833     1510.591    -847.9756    -232.5296
-----+-----
      mean = mean(DeltaHours_2016_2015)                t = -3.4859
Ho: mean = 0                                           degrees of freedom = 94

      Ha: mean < 0                Ha: mean != 0                Ha: mean > 0
Pr(T < t) = 0.0004                Pr(|T| > |t|) = 0.0007                Pr(T > t) = 0.9996

```

Table 5.4: Field experiment T-Test results.

Other than efficiencies resulting from the adoption of LSS, there were a number of potential drivers to be controlled. Within-team factors that affected variation in actual hours were primarily due to (1) changes in scope (more or less work requested by clients) and (2) differences in the levels of use of an offshore center (GADM) based in Kolkata, India. Changes in team size were highly collinear, with changes in scope, as team staffing is adjusted when work for the upcoming season is planned. The effect of treatment controlling for covariates is set out in table 5.5.

Source	Partial SS	df	MS	F	Prob>F
Model	1.053e+08	2	52647420	44.35	0.0000
ScopeexRateChanges	34133015	1	34133015	28.76	0.0000
Delta_GADM_HRS_2016_2015	74452591	1	74452591	62.72	0.0000
Residual	1.092e+08	92	1186980.8		
Total	2.145e+08	94	2281883.7		

DeltaHours_2016_2015	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
ScopeexRateChanges	12327.09	2298.767	5.36	0.000	7761.537 16892.64
Delta_GADM_HRS_2016_2015	.4826333	.0609395	7.92	0.000	.3616021 .6036645
_cons	-321.136	123.1263	-2.61	0.011	-565.6754 -76.59654

Table 5.5: Field experiment - Effect of treatment controlling for covariates.

Controlling for both scope changes and differences in utilization of the offshore center resulted in an efficiency gain of 321 hours (representing \$63,558 when the value of time is monetized at a standard weighed rate) per engagement on average. As noted above, average hours for engagement teams in the field experiment pilot were 21,329, so the gain represents an expected efficiency improvement of 1.5%. This efficiency gain should

translate to a direct increase in profit. ***If net profit margins are 30%, this gain would amount to an increased net profit of 4.86%.***

The coefficient of changes in scope indicates that a 1% increase in the scope of work requested increases a team's total hours taken to complete work by 128 hours on average. The coefficient related to the use of the offshore center in India is 0.48, so for each additional offshore center hour total hours increased by almost half an hour. Again, this is broadly consistent with practical experience. The use of an offshore center should be expected to increase the total number of hours consumed. Initially the US-based team had to prepare work to be offshored in a understandable and standardized format, which takes additional time. Further losses of efficiency occur in India, where the team had less day-to-day familiarity with the client and specific nuances of the audit, needing to check work before sending it back to the US, where a further check took place. This process resulted in friction costs and additional review time. In any case, the regression coefficient was completely in line with the internal ballpark estimation that for every hour performed offshore total hours would increase 50%, so the finding from the data is broadly consistent with this expectation.⁶

From Table 5.5 it can be seen that in comparison to baseline 40 Act engagements, expected additional hours taken with respect to corporate advisor engagements (an incremental 716 hours) are significantly above those taken by alternative fund engagements (an incremental 384 hours – albeit results for alternative funds are not

⁶ Despite the increase in overall time there are considerable wage rate arbitrage advantages to using engagement teams in India, given the lower rates of compensation, such that overall cost is reduced.

statistically significant). This result is in line with expectations, as 40 Act engagements have a greater number of funds per complex subject to audit resulting in significantly more opportunity for task repetition than exists in alternative fund engagements. Advisor engagements have the lowest level of repetitive steps and hence the higher number of hours taken is in line with expectations.

5.5.2 Effect of number of LSS-trained team members turnover

The second purpose of the study was to get a more precise estimation of the value of LSS training on the actual hours a team needs to complete the assigned yearly audits. In particular, given the high turnover and internal mobility of team members, it was of interest to understand how losing LSS-trained personnel affected team performance. To this end, we evaluated both the effect of LSS trained team members as well as LSS team members lost.

The effect of the number of LSS trained people on team hours variation is probably associated to team size: larger teams will train more people on LSS. As expected, these two variables are highly correlated ($r=0.66$). We therefore cannot disentangle the effect of the number of LSS trained people from the effect of team size. We hence opt for controlling for team size. However, what is of most interest is the effect of LSS team members leaving their teams. In this case, multicollinearity with team size is not an issue ($r=0.06$). We hence include the variable 'Train_Leave_TOTAL' in the regression model.

Source	SS	df	MS	Number of obs	=	95
-----+-----				F(6, 88)	=	23.11
Model	131212892	6	21868815.3	Prob > F	=	0.0000
Residual	83284180.4	88	946411.141	R-squared	=	0.6117
-----+-----				Adj R-squared	=	0.5853

Total | 214497072 94 2281883.74 Root MSE = 972.84

DeltaHours_2016_2015	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Delta_GADM_HRS_2016_2015	.3926348	.0634202	6.19	0.000	.2666005	.5186692
ScopeexRateChanges	13245.14	2068.954	6.40	0.000	9133.531	17356.75
Train_Leave_TOTAL	298.378	97.11118	3.07	0.003	105.3899	491.366
team_size	-17.09145	5.141342	-3.32	0.001	-27.30879	-6.874113
ADV	599.9283	276.7607	2.17	0.033	49.92447	1149.932
ALTS	231.7895	240.1982	0.96	0.337	-245.5541	709.133
_cons	-275.1013	197.7396	-1.39	0.168	-668.0671	117.8645

Table 5.6: Updated Regression Model

The result of the regression model indicates that for every LSS-trained employee, given team size, the team experiences an increase of actual hours (or a reduction of time savings) corresponding to 298 hours. Since this number is quite close to the observed performance benefits of LSS, this result indicates that short term mobility of LSS-trained personnel is extremely damaging to team performance improvement. High turnover, therefore, is indeed a major hindrance for the benefits of LSS training in this type of professional services. To rule out the possibility that this effect instead captures the adverse consequences from turnover, we also ran a model where we investigated the effect of the number of non-LSS trained employees leaving (untrained_LeaversTOTAL). As shown in Table 5.7 this variable has a marginally significant effect on the dependent variable ($p=.075$) and a much smaller effect size ($\beta=110$).

Source	SS	df	MS	Number of obs	=	95
-----+-----				F(6, 88)	=	20.70
Model	125554289	6	20925714.8	Prob > F	=	0.0000
Residual	88942783	88	1010713.44	R-squared	=	0.5853

-----+-----						
				Adj R-squared	=	0.5571
Total		214497072	94	2281883.74	Root MSE	= 1005.3
-----+-----						
DeltaHours_2016_2015		Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
-----+-----						
Delta_GADM_HRS_2016_2015		.395747	.0669789	5.91	0.000	.2626405 .5288534
ScopeexRateChanges		12833	2131.013	6.02	0.000	8598.061 17067.94
untrained_LeaversTOTAL		110.0377	61.1201	1.80	0.075	-11.42565 231.5011
team_size		-23.77119	6.428697	-3.70	0.000	-36.54688 -10.99551
ADV		514.4705	285.1201	1.80	0.075	-52.14568 1081.087
ALTS		320.6683	251.0191	1.28	0.205	-178.1795 819.5161
_cons		-235.5627	204.9767	-1.15	0.254	-642.9107 171.7854

Table 5.7: Effect of non-LSS employees leaving

5.5.3 Effect of LSS-driven PCBL completeness and timeliness practices.

Firstly, we note a high correlation ($r=0.75$) between the PBCL and ORP scores (see table 5.8), preventing inclusion of these two variables in the same regression model. Hence, we will evaluate in isolation the effect of improvements in each of the three main processes for engagement teams. Whilst it may be expected that ‘compliant’, engagement teams will perform a higher ratio of all processes, there is nothing inherent that links the PBC process and overall review process. Examination of partial regression plots from OLS estimation indicates the presence of heteroscedastic errors for these variables. For this reason, the following models use robust errors.

Linear regression	Number of obs	=	95
	F(7, 87)	=	20.68
	Prob > F	=	0.0000
	R-squared	=	0.6236
	Root MSE	=	963.3

-----+-----
| Robust

DeltaHours_2016_2015	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Delta_GADM_HRS_2016_2015	.3917816	.0701582	5.58	0.000	.2523345	.5312287
ScopeexRateChanges	13616.32	4597.759	2.96	0.004	4477.773	22754.86
Train_Leave_TOTAL	312.9697	102.4758	3.05	0.003	109.2879	516.6515
team_size	-14.31752	6.419291	-2.23	0.028	-27.07655	-1.558481
ADV	629.7184	305.0239	2.06	0.042	23.45045	1235.986
ALTS	117.4084	255.7764	0.46	0.647	-390.9749	625.7917
PCB_LST	-124.6588	63.95721	-1.95	0.055	-251.7807	2.463114
_cons	154.2652	222.9471	0.69	0.491	-288.8663	597.3966

Table 5.8: Correlation between variables in field experiment model.

Regression results indicate that compliance with the improvement practices identified in the pilot had a statistically significant impact on the reduction of actual hours of engagement teams ($p=0.05$). It must be considered that across the board, adoption of these practices was quite high: out of the five specific practices, 55 teams implemented all, eight implemented four, four implemented three, 20 implemented two, six implemented one, and two teams none. Based on this distribution, the effect of implementation of all two vs five improvement initiatives in the PBCL process drives efficiencies by 374 (124.6×3) hours, which corresponds to savings of \$74,052 per engagement team.

To better interpret point estimates from the regression model, we plotted predicted values of the dependent variables at different levels of the independent variable PCBLC&T variable. As the plot illustrates, the result is much more significant for engagement teams that perform three to five of the specific improvement initiatives. This result is expected, as the higher the proportion of sub processes performed, the more complete the compliance with LSS in respect to the production of a PBC listing.

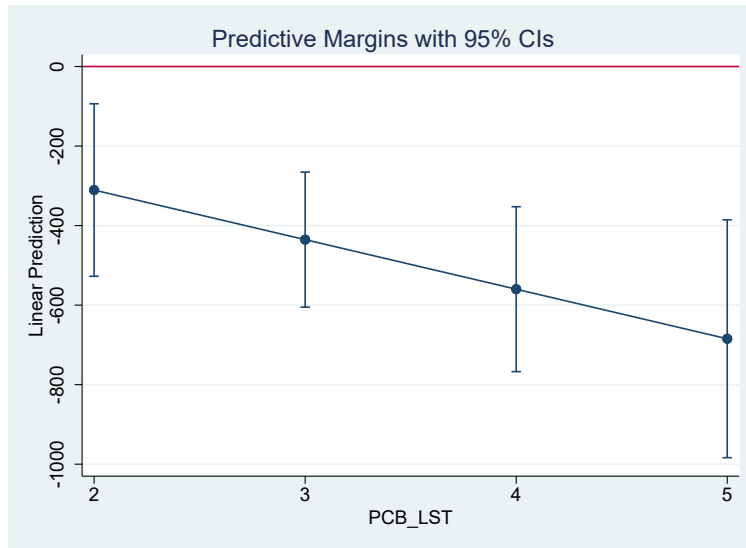


Figure 5.2: Predicted values of variation in team hours at different levels of PBC listing completeness and timeliness

5.5.4 Effect of LSS-driven financial reporting correctness practices

The financial reporting process also has a marginally significant effect ($p=0.07$) on the reduction of engagement team hours, as set out in table 5.9. This effect is negative, as expected ($\beta_{FRC}=-215$).

Number of obs = 94
 F(7, 86) = 17.53
 Prob > F = 0.0000
 R-squared = 0.5980
 Root MSE = 1000.6

	Robust					
DeltaHours_2016_2015	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Delta_GADM_HRS_2016_2015	.3995827	.0726073	5.50	0.000	.2552441	.5439213
ScopeexRateChanges	13210.76	4465.479	2.96	0.004	4333.685	22087.84
TrainedTOTAL	-63.66395	31.65708	-2.01	0.047	-126.5961	-.7317663
Train_Leave_TOTAL	375.5528	117.7604	3.19	0.002	141.4528	609.6527

ADV		656.5826	273.2608	2.40	0.018	113.3582	1199.807
ALTS		190.8544	233.7671	0.82	0.417	-273.8591	655.568
FIN_REP		-209.1569	113.0078	-1.85	0.068	-433.8089	15.49512
_cons		759.9096	567.6859	1.34	0.184	-368.6126	1888.432

Table 5.9: Effects of financial reporting correctness on variation of audit team hours

To better interpret point estimates from the regression model, we plotted predicted values of the dependent variables at different levels of the independent variable FRC variable. As most engagement teams (85%) displayed a high level of FRC (i.e., five or six), point estimates are significant only at these values. Specifically, an increase of FRC from five to six is associated to a reduction of point estimates of variation in team hours from -461 to -671, which corresponds to monetary savings of \$41,580.

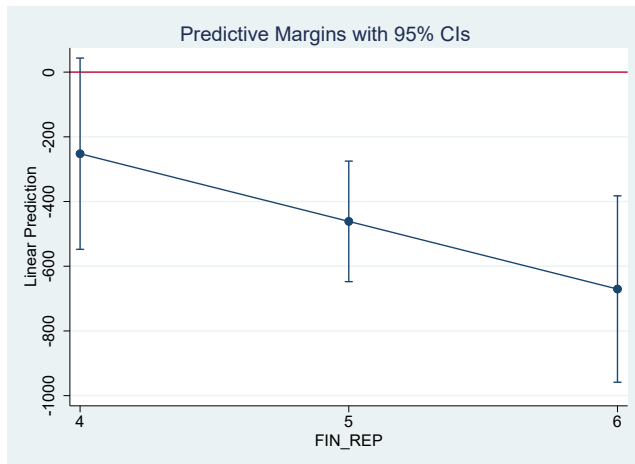


Figure 5.3: Predicted values of variation in team hours at different levels of financial reporting correctness.

5.5.5 Effect of LSS-driven review process compliance practices

With respect to the overall review process, it can be seen from table 5.10 that this is not statistically significant, though as expected directionally the data indicates that implementation of this process leads to efficiencies.

Number of obs = 95
 F(7, 87) = 17.68
 Prob > F = 0.0000
 R-squared = 0.5952
 Root MSE = 999.01

DeltaHours_2016_2015	Coef.	Robust Std. Err.	t	P> t	[95% Conf. Interval]	
Delta_GADM_HRS_2016_2015	.3968614	.0733727	5.41	0.000	.2510253	.5426976
ScopeexRateChanges	12869.58	4460.724	2.89	0.005	4003.404	21735.75
TrainedTOTAL	-61.63186	31.64785	-1.95	0.055	-124.5354	1.271682
Train_Leave_TOTAL	380.2627	115.7969	3.28	0.001	150.1038	610.4217
ADV	635.8292	279.9344	2.27	0.026	79.42925	1192.229
ALTS	227.8341	252.8936	0.90	0.370	-274.8193	730.4876
REV_PRC	-126.4609	79.11385	-1.60	0.114	-283.7083	30.78641
_cons	35.16888	296.5039	0.12	0.906	-554.1648	624.5025

Table 5.10 Effects of overall review process compliance on variation of audit team hours.

To better interpret point estimates from the regression model, we plotted predicted values of the dependent variables at different levels of the independent variable RPC variable. As most engagement teams (83%) displayed a high level of RPC (i.e., five or six), point estimates are significant only at these values. Specifically, an increase of FRC from four to five is associated with a reduction of point estimates of variation in team hours from -499 to -625, which corresponds to monetary savings of \$24,948.

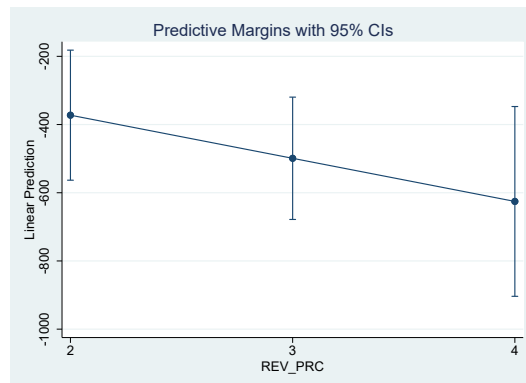


Figure 5.4: Predicted values of variation in team hours at different levels of overall review process compliance.

5.5.5 Post hoc analyses and robustness checks

Since the pilot teams were involved in the field experiment, we re-ran our models controlling with a dummy for the situation where an engagement team was also involved in the pilot. We never found the effect of this dummy on the dependent variable to be significant, and for this reason we report it only as a robustness check.

Since teams were distributed across multiple locations, we decided to check whether the location of a team had a bearing on the results of the study. We included team location as a separate dummy (e.g. Boston, New York, etc.) in all the models, but did not find any significant effect or change in the statistical conclusions.

We also checked whether the specification of the dependent variable affected the results. Specifically, we calculated a percentage hour reduction as $(2016 \text{ hours} - 2015 \text{ hours}) / 2015 \text{ hours}$ and ran the models with this variable. Again, we reached the same statistical conclusions as those previously discussed.

Lastly, while the audit industry is affected by severe seasonality, not all engagement teams have the same amount of seasonality. To capture the extent to which a team's auditing work was seasonal, we collected a variable that captures how many different end-years were included in a fund complex. End-year dates are the target times for auditing a specific engagement. A team with only one end-year date would necessarily have a seasonal peak around this date. Conversely, a team with multiple end-year dates would be less subject to a seasonal peak. We captured this phenomenon with the variable "cycles per year". Since this variable is collinear with team size ($r=.52$) we removed team size from the regression, which results are reported in Table 5.11.

Number of obs = 94
 F(6, 87) = 20.91
 Prob > F = 0.0000
 R-squared = 0.5905
 Adj R-squared = 0.5623
 Root MSE = 1004.8

DeltaHours_2016_2015	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Delta_GADM_HRS_2016_2015	.4159981	.0621588	6.69	0.000	.2924507	.5395455
ScopeexRateChanges	12716.69	2151.172	5.91	0.000	8440.997	16992.37
train_leavers_percentage	2083.584	644.7679	3.23	0.002	802.0377	3365.13
Cyclesperyear	-118.5521	52.60706	-2.25	0.027	-223.1144	-13.98991
ADV	383.4339	314.7398	1.22	0.226	-242.1456	1009.013
ALTS	90.01144	271.5222	0.33	0.741	-449.6683	629.6912
_cons	-313.9108	236.5561	-1.33	0.188	-784.0918	156.2701

Table 5.11: Cycles per year

As shown in the table, the effect of the number of year-end dates (cycles per year) is significant ($p < .05$) and in the expected direction ($\beta = -119$). This indicates that teams that face a greater concentration of work in a seasonal peak (that is, lower value of cyclesperyear) are subject to reduction benefits from the LSS experiment.

6. CONCLUSIONS

This study investigated the applicability of LSS to professional service work in the context of the investment fund auditing industry. While it is known that LSS can benefit knowledge intensive operations such as software engineering (Staats, Brunner and Upton, 2011), until now it has been unclear whether such benefits could be achieved in conditions of high turnover, high seasonality and long cycle times—conditions that are all present in the studied context. We discuss here the implications of the findings from the study for theory and practice, while also acknowledging its limitations.

6.1 Theory implications

Both the pilot study and, most importantly, the field experiment indicate that LSS can significantly improve the efficiency of investment fund auditing operations. This result is not to be taken for granted, because the high rotation of personnel threatens to offset the benefits from LSS training. In the field study, 11% of personnel left the engagement teams, as did 7% of LSS-trained personnel. Despite this loss of expertise, the average reduction of work hours per team, adjusted for changes in scope and the use of an offshored service center, is 321 hours, equivalent to an average reduction of 1.5% of worked time. This is not to say that turnover did not affect team performance. In fact, turnover has serious effects on these performance improvements: the loss of a trained employee on average increased team hours by 298 hours, a number that is close to the abovementioned savings. This finding mirrors the Japanese context, where lean was first developed. In Japan, firms have traditionally emphasized lifetime employment, and hence experienced low turnover levels (Koike, 1988). This study hence highlights a potentially

important boundary of validity to the generalizability of LSS benefits: on the one hand, LSS can be a tool for performance improvement in contexts characterized by high turnover, but at the cost of a significant reduction in performance improvement compared to settings where turnover is low. In an age where employment relations look set to become increasingly volatile, such a boundary condition can be a concern for organizations interested in leveraging LSS to better engage their workforce into continuous improvement initiatives.

This study also provides preliminary insights relative to the applicability of LSS in settings characterized by high volume variability. As previously observed, LSS originated in environments such as the automotive industry, where seasonality was not as strong as in the auditing industry. Indeed, the lean approach hinges on the stabilization of output to maximize the effectiveness of the pull logic governing operational activities. By contrast, it is common in the auditing industry to observe a demand peak such that two thirds of operational activities are concentrated in one third of the year. It is therefore interesting to discover that, notwithstanding this adverse characteristic of the auditing industry, most of the engagement teams reduced the hours needed to complete their work. However, the post hoc investigation revealed that performance improvements were stronger for teams with lower seasonality (i.e. more cycles per year). In the studied setting, engagement teams responded to the problem of seasonality by moving improvement and preventive activities from the seasonal peak. However, other activities that are part of the “control” stage of the DMAIC cycle needed to be executed during the seasonal peak and were hence subject to possible uncompliant behaviors. In fact, we found that teams with low seasonality were able to better comply with the mandated improvements in the three

core audit processes. That is, the variable “cycles per year” (a proxy for low seasonality) was positively correlated to PBCL completeness and timeliness ($r=0.32$, $p<1\%$) to financial reporting correctness ($r=0.31$, $p<1\%$) and to review process compliance ($r=0.23$, $p<5\%$).

A third important implication of the field study concerns the replicability of results obtained from the pilot by teams in the field experiment. The pilot identified a set of actions that could improve the three core audit processes—PCB listings, financial reporting and the overall process review. These actions were captured by the three variables: PBCL completeness and timeliness, financial reporting correctness, and review process compliance. While the field study teams were free to explore how to use LSS tools for improvement, they were also mandated to implement these actions. Results from the field experiment found a positive and significant effect of PBCL completeness and timeliness ($\beta=-125$, $p=.05$) and financial reporting correctness ($\beta=-209$, $p=.07$) on the hours worked by the team. The effect of review process compliance was also positive, but with lower statistical significance ($\beta=-126$, $p=.11$). Overall, these results indicate that when LSS is implemented across teams or units that have similar responsibilities, the mantra of worker-initiated continuous improvement must be taken with due caution. Given the similarity of tasks across teams, it makes sense to use early waves of LSS improvements to set standards that can later be rolled out to larger populations of teams or units.

The weaker support for the benefits of review process compliance is surprising. The overall review process affects every audit task undertaken—at each step a task is prepared and reviewed by at least one reviewer who is more senior in tenure to the preparer. Anecdotal feedback from teams identified the reworked overall review process

improvements as the most beneficial, in terms of both efficiency and individual learning by staff members. However, it also entailed increased face-to-face time, as well as richer and more in-depth coaching, which may have detracted from the time savings in the field experiment. It remains an open question whether review process compliance drove subsequent efficiencies beyond what was measured in the field experiment.

6.2 Implications for operational improvement at Firm A following the field experiment

This study demonstrated that LSS can be applied in a professional service environment such as that of Firm A, and that efficiencies can be realized as a result. Given the ever-increasing pricing transparency and competition in the industry, in the future, participant firms will need to adopt LSS in order to maximize their competitiveness. More than just a one-off increase in profitability, LSS offers a methodology for constant iterative improvement, resulting in a cultural change that fosters the drive for ever-better processes at all levels in the organization. In the same way that today it is an accepted necessity for world-class manufacturers to use a process improvement methodology, this may also become common practice in the professional services sector. That said, this project made Firm A aware of the need for adapting LSS methods such as the DMAIC improvement meta-routine to the context of professional services (see Appendix 8).

Expanding LSS methods within Firm A, however, was not an automatic decision. The pilot study was initially conducted in 2015, and since this time there has been a considerable improvement in technology associated with automation, specifically technologies such as robotic process automation (RPA) and latterly intelligent process automation (IPA). These technologies offer business process automation tools that while termed robots are

in essence algorithms that allow for the automation of repetitive tasks. RPA tools are often seen as a threat to offshoring centers, as the tasks most likely to be outsourced (i.e. tasks that are repetitive and do not require judgement) are often the tasks most suitable for automation. Awareness of RPA software tools has increased significantly since 2015 and during this time the capabilities of these tools have also matured. Additionally, a large consulting and software business ecosystem has been established around RPA, and this has led to the identification of successful case studies that have then seen rapid adoption across entire industries. Furthermore, RPA tools are increasingly accessible for non-specialists to program and utilize directly without the involvement of specialist coders. As a result of the evolving changes in awareness and capabilities of RPA technology and a more informed viewpoint of LSS tools and the associated impact on the business, Firm A implemented LSS leveraging through a number of different models over time, as represented in figure 6.1.

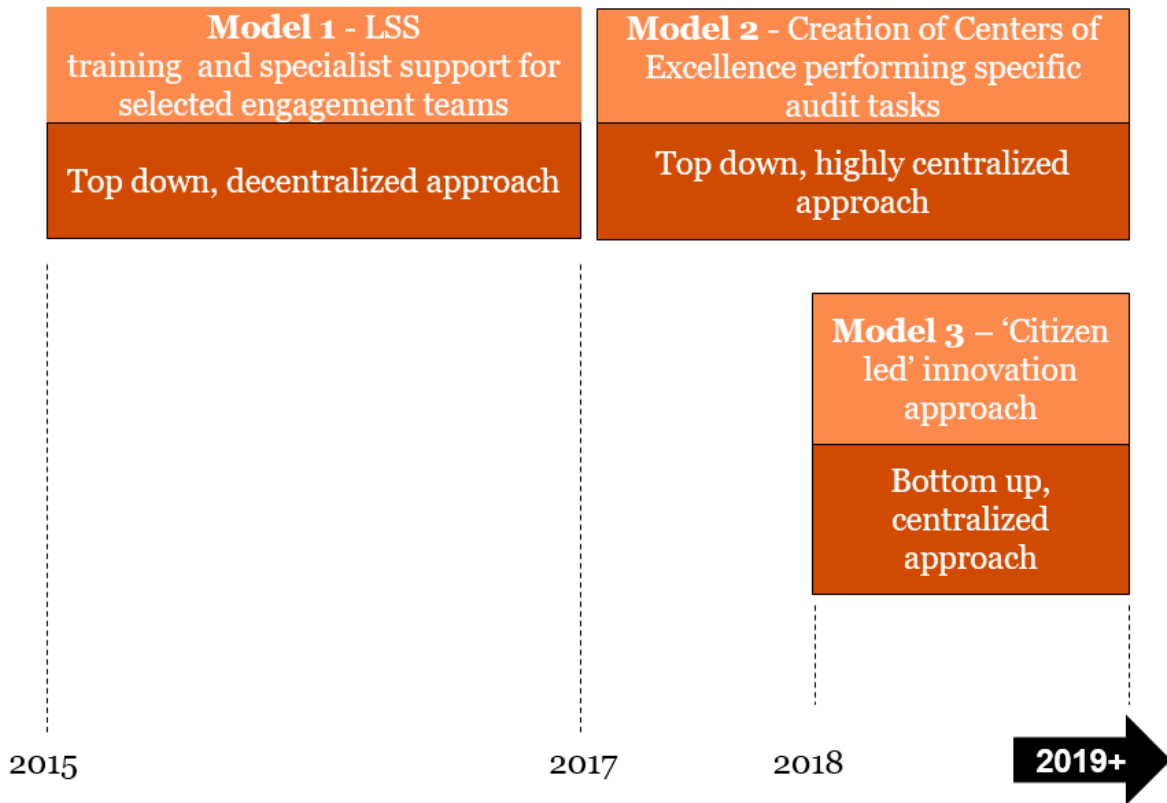


Figure 6.1: Evolution over time of LSS Models employed by Firm A.

Model 1 (2015 -2017). Model 1 is a top down approach where processes selected for LSS improvement were predetermined (though engagement teams were encouraged to use the tools and techniques gained on other engagements outside of the study and on other processes). During the pilot study and field experiment studies, the model implemented was that of training individual engagement teams in LSS techniques, providing support from LSS specialists and the provision of forums for engagement teams to learn from each other and share experiences. The larger field experiment study highlighted the increased costs and logistical challenges of scaling up LSS training from 10 engagement teams to over 100. Firm A staff were generally unfamiliar with LSS concepts and as a result training was required to provide a background in the techniques

and tools that would be utilized, as well as the application of these tools to the specific facts and circumstances of individual engagements. Given that there are thousands of individual engagement teams in the business overall, this was seen as a significant cost and logistical hurdle to a wider adoption of LSS. Simultaneously, RPA tools were becoming more commonplace and mature—as noted above. These factors precipitated a transition to model 2 in 2017, following the completion of the field experiment study.

Model 2 (2017 – present). Model 2 is a highly centralized top-down approach to process improvement. Model 2 involved the creation of ‘centers of excellence’ (CoEs), hubs where certain tasks were centralized and RPA tools deployed where practical. Initially there were two such centers, with a third opening in late 2018, all of them in the United States. CoEs are located in areas served by leading universities able to provide large numbers of high performing graduates. In addition to the centralization of geographical location, the CoEs also resulted in a change in approach: whereas Model 1 approach was for entire processes to be selected for review and LSS improvement (for example the overall review process), Model 2 had a narrower and more iterative focus. In this model, certain audit tasks were identified (for example cash reconciliations, i.e. the audit of cash balances and matching of bank balances to cash positions in an entities’ books and records—see appendix 3 for a description). Over time, as experience and capacity was gained, more audit tasks were added to those performed by the CoEs. This resulted in a hybrid model where local engagement teams would perform the audits locally but CoEs performed certain audit work for in scope audit tasks. The evolution in RPA/IPA technology led to the build out of Model 3—it should be noted however, that Model 2 is still operational and expected to remain so. Model 3 operates alongside model 2.

Model 3 (2018 – present). Model 3 is best described as a decentralized ‘bottom up’ approach to identifying efficiencies and improving processes. In addition to the development of CoEs, advances in the usability and firm A’s familiarity with RPA/IPA tools have led to the promotion of a citizen led innovation model. This augments, but does not replace, the CoEs developed in Model 2. The essence of the citizen led approach is to allow staff members interested in developing their understanding of cutting-edge technology to volunteer as candidates for in-depth specialist training creating. Candidates are then selected for training in blocks over a two-year period in a number of tools. These staff are termed ‘digital accelerators’ and the expectation is that they will apply their newly gained knowledge to solving business problems and increasing efficiency. Staff can choose the aspect of technology they are most interested in, including RPA/IPA, data analysis, machine learning/artificial intelligence and natural language processing. Basic LSS tools are also taught to enable staff to break down processes for improvement, quantify inefficiency and determine whether any changes made have improved efficiency. After initial training staff return to their day jobs and the intent is that they then solve issues faced in their work with the new skills and knowledge they have acquired. Additionally, a digital ‘app store’ has been created to act as a repository and to facilitate the distribution of robots/tools created (after appropriate quality review). As a result, LSS is embedded in Firm A’s CoEs (Model 2) and a component of training provided to digital accelerators (Model 3) providing top down and bottom up approaches to leveraging LSS methodology in the business.

6.3 Conclusions

LSS can be applied successfully to professional service work, but its benefits can be seriously undermined by turnover and volume variability.

It is important to create a mechanism to transfer LSS-originated best practices among teams, avoiding the risk of different LSS teams reinventing the wheel. Some best practices may lead to the automation of professional service work via RPA tools. In other cases, RPA tools become the basis of an augmented toolbox that LSS-trained employees can use to give them heightened autonomy in improvement work.

As a standalone methodology, LSS has little meaning for professional services organizations, but within the context of a broader automation initiative, it is critical that processes operate efficiently and effectively prior to automation, since automation sets processes in stone, making change more difficult. In turn, automation is increasingly necessary for many entities to remain competitive, including professional services organizations. It is likely that the trend towards automation will continue, and in turn the importance/relevance of LSS and other process improvement methodologies will continue to increase.

LSS/automation = key to competitiveness

6 CONCLUSIONES

En este estudio se ha investigado la potencial aplicación de LSS en el trabajo de servicios profesionales en el contexto de la industria de la auditoría de fondos de inversión. Si bien es sabido que LSS puede beneficiar a operaciones intensivas en conocimiento tales como la ingeniería de software (Staats, Brunner y Upton, 2011), hasta ahora no estaba muy claro si tales beneficios se podrían lograr en condiciones de alta rotación, elevada estacionalidad y tiempos de ciclo largos, condiciones todas ellas presentes en el contexto estudiado. Analizamos aquí las implicaciones de los hallazgos del estudio a efectos de la teoría y de la práctica, si bien reconociendo sus limitaciones.

6.1 Implicaciones de la teoría

Tanto el estudio piloto como, de manera más importante, el experimento de campo indican que LSS puede mejorar significativamente la eficiencia de las operaciones de auditoría de fondos de inversión. Este resultado no debe darse por supuesto, dado que la elevada rotación del personal amenaza con contrarrestar los beneficios de la formación en LSS. En el estudio de campo, un 11 % del personal abandonó los equipos de encargo, tal como el 7 % del personal formado en LSS. A pesar de esta pérdida de *expertise*, la reducción media de las horas de trabajo por equipo, ajustada a los cambios en el alcance y en el uso de un centro de servicios deslocalizado, es de 321 horas, el equivalente a una reducción media en el 1,5 % del tiempo trabajado. Esto no equivale a afirmar que la rotación no afectara al rendimiento del equipo. De hecho, la rotación ejerce un fuerte impacto en las mejoras del rendimiento: de media, la pérdida un empleado formado incrementó las horas de trabajo del equipo en 298 horas, un número cercano a los

ahorros anteriormente mencionados. Este hallazgo refleja el contexto japonés, donde se implantó *lean* por vez primera. En Japón, las compañías han apostado tradicionalmente por el trabajo vitalicio, por lo que experimentan una rotación escasa (Koike, 1988). Así, este estudio subraya un límite potencialmente importante para la validez de una generalización de los beneficios de LSS: por un lado, LSS puede ser una herramienta para la mejora en el rendimiento en contextos caracterizados por una elevada rotación, pero a costa de una reducción significativa en la mejora del rendimiento en comparación con los contextos con una rotación reducida. En una época en la que las relaciones laborales son crecientemente volátiles, tal condición límite puede ser motivo de preocupación para las organizaciones interesadas en aprovechar LSS para implicar a sus recursos humanos en iniciativas de mejora continua.

Este estudio también proporciona algunas pistas preliminares en lo tocante a la potencial aplicación de LSS en contextos caracterizados por una elevada variabilidad de volumen. Tal como se ha observado anteriormente, LSS nació en entornos como la industria automovilística en los que la estacionalidad no era tan intensa como en la industria de la auditoría. Sin duda, el enfoque *lean* depende fundamentalmente de la estabilización de la producción para maximizar la eficacia de la lógica *pull* que gobierna las actividades operativas. En contraste, en la industria de la auditoría es habitual constatar un pico en la demanda de tal naturaleza que dos tercios de las actividades operativas se concentran en un tercio del año. Es interesante, pues, descubrir que, a pesar de esta característica adversa de la industria auditora, la mayoría de los equipos de encargo redujeron el número de horas necesario para completar su trabajo. No obstante, la investigación *post hoc* muestra que las mejoras en el rendimiento fueron mayores en los equipos con una

estacionalidad más reducida (esto es, con más ciclos por año). En el contexto estudiado, los equipos de encargo respondieron al problema de la estacionalidad trasladando las actividades preventivas y de mejora a momentos fuera del pico estacional. Sin embargo, las actividades que forman parte de la etapa de “control” del ciclo DMAIC debían ejecutarse durante el pico estacional, por lo que estaban sujetas a posibles conductas de incumplimiento. De hecho, hemos constatado que los equipos con una baja estacionalidad pudieron cumplir mejor las mejoras exigidas en los tres procesos de auditoría fundamentales. Esto es, los “ciclos variables por año” (equivalentes a una baja estacionalidad) mantuvieron una correlación positiva con la exhaustividad PBCL y la puntualidad ($r=0.32$, $p<1\%$), con la precisión de los informes financieros ($r=0.31$, $p<1\%$) y con el cumplimiento del proceso de revisión ($r=0.23$, $p<5\%$).

Una tercera implicación de importancia en el estudio de campo es la referida a la posibilidad de replicar los resultados obtenidos del piloto por los equipos en el experimento de campo. El piloto identificó un conjunto de acciones capaces de mejorar los tres procesos de auditoría fundamentales: los listados PCB, los informes financieros y la revisión general del proceso. Estas acciones se capturaron por medio de tres variables: exhaustividad y puntualidad de PBCL, precisión de informe financiero y cumplimiento del proceso de revisión. Si bien los equipos del estudio de campo tuvieron la libertad de elegir la forma en que iban a usar las herramientas LSS de mejora, también se les impuso la ejecución de esas acciones. Los resultados del experimento de campo certificaron un efecto positivo y significativo en la exhaustividad y puntualidad de PBCL ($\beta=-125$, $p=.05$), así como la precisión en los informes financieros ($\beta=-209$, $p=.07$) en las horas trabajadas por el equipo. El efecto en el cumplimiento del proceso de revisión

también fue positivo, pero con una menor relevancia estadística ($\beta=-126$, $p=.11$). En general, estos resultados indican que, cuando se implanta LSS en equipos o unidades que tienen responsabilidades similares, se debe tener cierta precaución con el mantra de la mejora continua iniciada por trabajadores. Dada la similitud entre las tareas de los equipos, tiene sentido emplear las primeras oleadas de mejoras LSS para fijar estándares que puedan extenderse posteriormente a equipos o unidades de mayor tamaño.

Sorprende el débil impulso que reciben los beneficios del cumplimiento del proceso de revisión. El proceso de revisión general afecta a todas las tareas de auditoría ejecutadas: existe al menos un revisor de categoría más sénior que el preparador, dedicado a revisar las tareas preparadas en cada uno de los pasos. Los testimonios anecdóticos de los equipos identificaron las nuevas mejoras generales en el proceso de revisión como las más beneficiosas, tanto en términos de eficiencia como de aprendizaje individual de los miembros del personal. No obstante, también conllevó un mayor tiempo cara a cara, así como una tutela más profunda y detallada que quizá detrajera del ahorro de tiempo en el experimento de campo.

6.2 Implicaciones para la mejora operativa de la Compañía A tras el experimento de campo

Este estudio demuestra que se puede aplicar LSS en un entorno de servicios profesionales tal como es el de la Compañía A, y que se puede ganar eficiencia a resultas de ello. Dada la creciente transparencia en la fijación de precios y la competencia en la industria, las compañías participantes deberán adoptar LSS en un futuro para poder maximizar su competitividad. Más que una mejora aislada en los beneficios, LSS ofrece

una metodología para una mejora iterativa constante, lo que genera un cambio cultural que fomenta el impulso para alcanzar unos procesos perpetuamente mejorados en todos los niveles de la organización. Tal como los grandes fabricantes globales dan por sentada la necesidad de una metodología de mejora constante en los procesos, esto también puede convertirse en una práctica común en el sector de los servicios profesionales. Dicho esto, este proyecto hizo que la Compañía A fuera consciente de la necesidad de adaptar métodos LSS, tales como la meta-rutina de mejora DMAIC, al contexto de los servicios profesionales (Apéndice 8).

No obstante, ampliar los métodos LSS en el seno de la Compañía A no fue una decisión automática. El estudio piloto se llevó a cabo inicialmente en 2015, y desde entonces se han llevado a cabo mejoras considerables en la tecnología de automatización, concretamente en tecnologías como la automatización de procesos robóticos (RPA, según sus siglas en inglés) y, últimamente, la automatización de procesos inteligente (PA, según sus siglas en inglés). Estas tecnologías que ofrecen herramientas de automatización de procesos empresariales, si bien se califican de robóticas, son esencialmente algoritmos que permiten la automatización de tareas repetitivas. Las herramientas RPA suelen considerarse una amenaza para los centros de deslocalización, dado que las tareas más adecuadas para la deslocalización (esto es, las tareas repetitivas que no requieren de una toma de decisiones) suelen ser las más propicias para la automatización. El conocimiento de las herramientas de software RPA ha aumentado significativamente desde el año 2015, y durante ese tiempo también se ha producido una maduración de las capacidades de tales herramientas. Además, se ha desarrollado un amplio ecosistema de consultoría y software empresarial en torno a la

RPA, y esto ha conducido a la identificación de casos de estudio exitosos que, posteriormente, se han adoptado rápidamente en industrias enteras. Es más, las herramientas RPA son cada vez más accesibles para usuarios no especializados, de tal forma que pueden programarse y utilizarse directamente sin la asistencia de especialistas en programación. A consecuencia del cambio registrado en el conocimiento de la tecnología RPA y sus capacidades, y de una visión más rica de las herramientas LSS y el impacto que conllevan para el negocio, la Compañía A implantó el aprovechamiento LSS a través de diversos modelos a lo largo del tiempo, tal como se representa en la imagen 6.1.

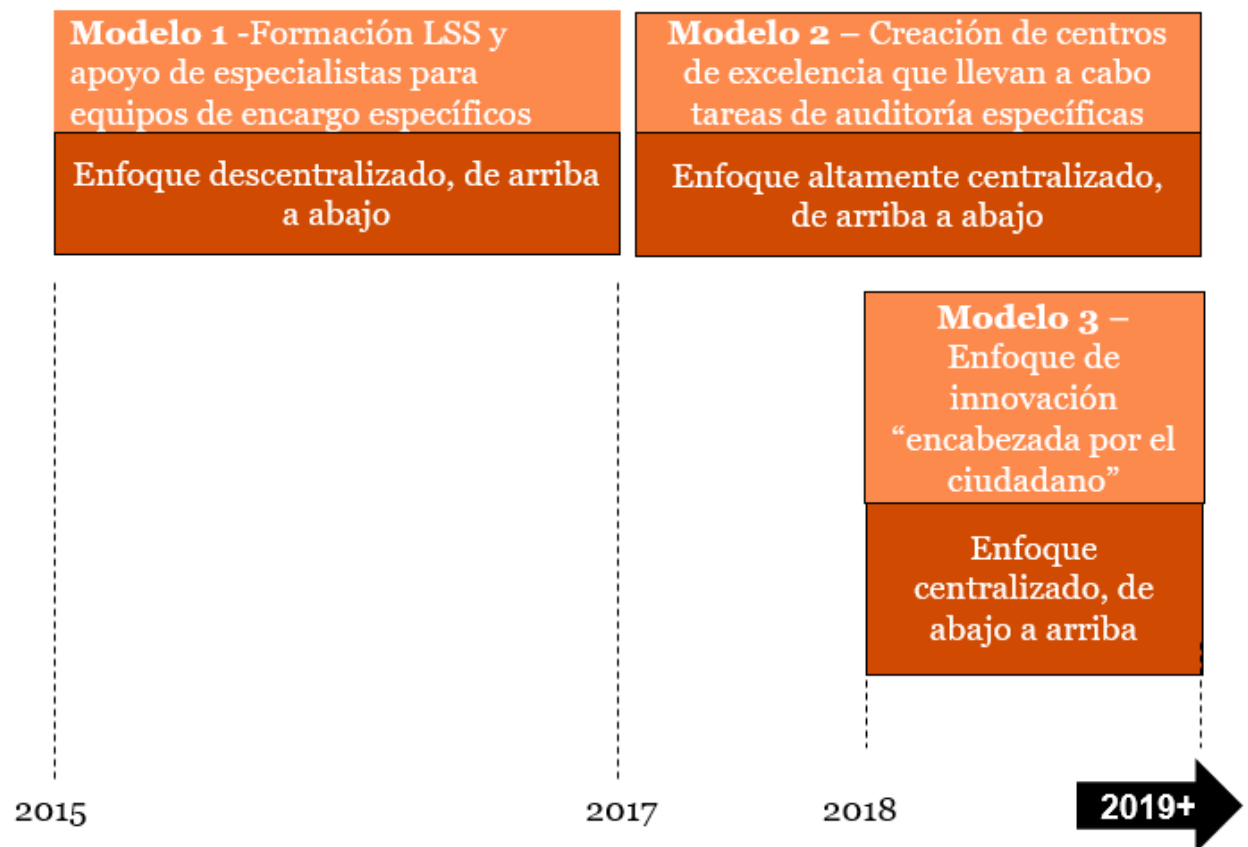


Imagen 6.1: Evolución a lo largo del tiempo de los modelos LSS empleados por la compañía A

Modelo 1 (2015 - 2017). El modelo 1 es un enfoque de arriba a abajo en el que los procesos seleccionados para una mejora LSS estaban preestablecidos (aunque se animaba a los equipos de encargo a que usaran herramientas y técnicas obtenidas a través de otros encargos ajenos al estudio, así como otros procesos). Durante el estudio piloto y los estudios de experimento de campo, el modelo que se implantó fue el de la formación en técnicas LSS a equipos de encargo individuales. Además, se proporcionó apoyo de especialistas en LSS y foros para que los equipos de encargo aprendieran mutuamente y compartieran experiencias. El experimento de campo más amplio reveló el aumento en los costes y los desafíos logísticos derivados de escalar la formación LSS de 10 equipos de encargo a más de 100. Por regla general, el personal de la Compañía A no estaba familiarizado con los conceptos LSS y, debido a ello, fue necesaria una formación que les mostrara el trasfondo de las técnicas y las herramientas que iban a utilizarse, además de la aplicación de estas a las circunstancias y cuestiones específicas de cada equipo de encargo. Dado que, en términos generales, hay miles de equipos de encargo en el negocio, esto se consideró un coste significativo y un obstáculo logístico para una adopción más generalizada de LSS. De manera simultánea, las herramientas RPA se iban volviendo más habituales y avanzadas, tal como se ha señalado anteriormente. Estos factores precipitaron una transición hacia el modelo 2 en 2017, una vez completado el estudio del experimento de campo.

Modelo 2 (2017 – presente). El Modelo 2 es un enfoque de los procesos de mejora altamente centralizado, de arriba abajo. El Modelo 2 implicó la creación de “centros de excelencia” (CdE), nodos en los que se centralizaron ciertas tareas y la implantación de herramientas RPA resultaba práctica. Inicialmente, había dos centros de ese tipo, a los que luego se sumó otro más en 2018, todos ellos en EE. UU. Los CdE están localizados en áreas que cuentan con un tejido universitario capaz de suministrar licenciados de alto rendimiento. Además de la centralización de la ubicación geográfica, los CdE también supusieron un cambio de enfoque: mientras que el enfoque del Modelo 1 consistía en seleccionar procesos al completo para su revisión y mejora LSS (por ejemplo, el proceso de revisión general), el Modelo 2 tenía un enfoque más delimitado e iterativo. En este modelo, se identificaron varias tareas de auditoría (por ejemplo, las conciliaciones de caja, esto es, la auditoría de los balances de caja y el cotejo de los balances bancarios con las posiciones de caja en los libros contables y los registros de las entidades; véase el apéndice 3 para una descripción). A lo largo del tiempo, a medida que la experiencia y la capacidad iban en aumento, se fueron añadiendo más tareas al cómputo total de tareas realizadas por los CdE. Esto tuvo como resultado un modelo híbrido en el que los equipos de encargo locales llevaban a cabo auditorías locales, pero los CdE llevaban a cabo cierto trabajo de auditoría para las tareas de auditoría a su alcance. La evolución en la tecnología RPA/IPA condujo al desarrollo del modelo 3. No obstante, conviene tener en cuenta que el Modelo 2 sigue operativo, y se espera que siga así. El Modelo 3 opera junto con el Modelo 2.

Modelo 3 (2018 – presente). La mejor descripción del Modelo 3 es como un enfoque descentralizado, “de abajo a arriba” para identificar eficiencias y mejoras de procesos.

Además del desarrollo de los CdE, los avances en usabilidad y la familiarización de la Compañía A con las herramientas RPA/IPA han conducido a un modelo de innovación encabezada por el ciudadano. Esto amplía, sin llegar a sustituir, los CdE desarrollados en el Modelo 2. La esencia del enfoque encabezado por el ciudadano es permitir que los miembros del personal interesados en profundizar en su comprensión de la última tecnología se ofrezcan como voluntarios para la formación exhaustiva como especialistas. A continuación, los candidatos se seleccionan para la formación en bloques en una serie de herramientas durante un periodo de dos años. Este personal recibe la consideración de “aceleradores digitales” y la expectativa es que apliquen sus nuevos conocimientos a la resolución de problemas de negocio, así como a la mejora en la eficiencia. El personal puede elegir el aspecto tecnológico en el que esté más interesado, incluyendo RPA/IPA, análisis de datos, aprendizaje de máquinas/inteligencia artificial y procesamiento del lenguaje natural. También se enseñan herramientas LSS básicas para capacitar al personal para desglosar procesos mejorables, cuantificar la eficiencia y determinar si los cambios aplicados han mejorado esta última. Tras la formación inicial, el personal vuelve a sus trabajos diarios y la idea es que entonces utilicen sus nuevas habilidades y conocimientos para resolver los problemas afrontados en su trabajo. Además, se ha creado una “tienda de apps” digital como repositorio, a fin de facilitar la distribución de los robots/herramientas que se han creado (tras la preceptiva revisión de calidad). Como resultado de ello, se integra LSS en los CdE de la Compañía A (Modelo 2) y se ofrece un componente de formación a los aceleradores digitales (Modelo 3) que proporciona enfoques de abajo a arriba y de arriba a abajo para aprovechar la metodología LSS en la empresa.

6.3 Conclusiones

LSS se puede aplicar exitosamente al trabajo en servicios profesionales, pero sus beneficios pueden verse seriamente comprometidos por la rotación y la variabilidad en el volumen.

Es importante crear un mecanismo para transferir las mejores prácticas de origen LSS entre los equipos para evitar el riesgo de que distintos equipos LSS reinventen la rueda. Algunas de las mejores prácticas pueden conducir a la automatización en el trabajo de los servicios profesionales a través de herramientas RPA. En otros casos, las herramientas RPA se convierten en la base de un conjunto de herramientas ampliado a disposición de los empleados con formación LSS para darles una mayor autonomía en el trabajo de mejora.

LSS, entendido como metodología independiente, no significa mucho para las organizaciones de servicios profesionales, pero en el contexto de una iniciativa de automatización más amplia es de vital importancia que los procesos operen eficiente y efectivamente antes de la automatización, ya que esta última tiende a fijar los procesos, lo que dificulta el cambio posterior. A su vez, la automatización es cada vez más necesaria para que muchas entidades, incluyendo las organizaciones de servicios profesionales, mantengan su competitividad. Es probable que la tendencia hacia la automatización se mantenga y, a su vez, la importancia/relevancia de LSS y otras metodologías de mejora de procesos no deje de aumentar.

LSS/automatización = clave para la competitividad

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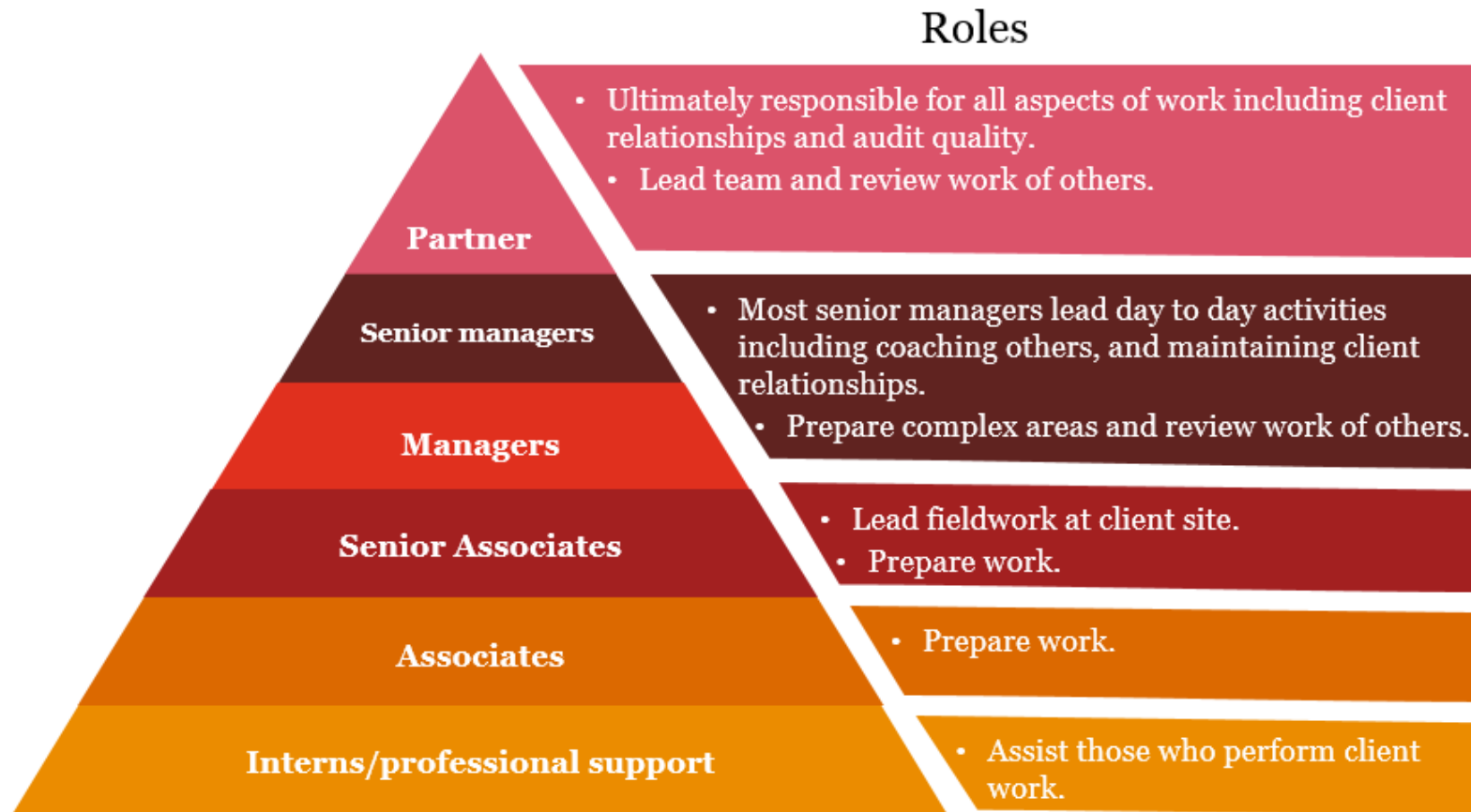
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APPENDICES

Appendix 1: Roles by staff level



Appendix 2: Overview of the audit process

Review Process		
<p>A review process occurs at every stage throughout the audit. For every task there is a preparer and at least one reviewer. Certain tasks judged to be of heightened risk or materiality have multiple reviewers.</p>		<ul style="list-style-type: none"> Evidence of preparation and review of each individual task is recorded by audit software system. Reviewers must have seniority to the preparer Some tasks must be reviewed by minimum designated levels or higher (for example managers or partners)
PBC Listing	Financial Statement Preparation	Substantive Procedures and Completion (NOT INCLUDED IN SCOPE OF REVIEW)
<p>Document detailing information required to complete the audit. Sent to client management.</p>	<p>Production of finalized Financial Statements ("FS") . Includes preparation of draft FS before YE and completion of finalized FS post YE</p>	<p>Engagement team undertake and document substantive audit work required to issue FS</p>
<ul style="list-style-type: none"> If available roll-forward prior year listing Obtain an update of entity activities from client management Add new information needed as a result of (a) internal - changes in the nature of the entity and/or (b) external changes in audit, financial reporting, regulatory or other standards Compare to industry/peer entity PBC lists for completeness Internal review and sign off process Agree PBC list content and dates for information to be provide with client management Agree escalation protocol with management Upload PBC listing, assign client responsibilities for information and due dates to "Connect" System Debrief process with client management 	<p>Pre Year End</p> <ul style="list-style-type: none"> Roll-forward of PY FS if available Discuss entity operations changes with client management Perform peer/industry FS comparison Complete automated disclosure checklist - to assess completeness and accuracy of disclosures Agree changes with management <p>Post Year End</p> <ul style="list-style-type: none"> Check for any additional internal or external changes since initial draft Check FS for mathematical accuracy, internal consistency and agreement with audit work Finalize agreement with client management Debrief process with client management 	<ul style="list-style-type: none"> Execution of audit procedures to verify the accuracy, completeness, existence, rights and obligations, and presentation of the financial statements All work is completed, documented and reviewed in accordance with generally accepted auditing standards Completion activities are finalized including obtaining a legal letter and management representation letter

Appendix 3: Example activity—audit of cash in the context of the three mandatory LSS processes.

Review Process	
<ul style="list-style-type: none"> Review cash related items included on the PBC listing for completeness and accuracy Assign responsibility for YE preparation of cash related items and assign reviewer 	<ul style="list-style-type: none"> Prepare budgeted time to prepare/ review cash Review substantive procedures performed Review cash disclosure included in the financial statements

PBC Listing
<ul style="list-style-type: none"> Request list and contact details of all bank accounts and loan facilities open at year end. Request list of all opened / closed financial arrangements in the year. Request bank reconciliations and associated support to be available before substantive procedures.

Financial Statement Preparation
<ul style="list-style-type: none"> Test statement of cash flows to support. Agree disclosure of foreign cash, restricted cash in financial statements. Perform automated disclosure checklist (“ADC”) on cash items. Test all other cash related disclosures (i.e. Presentation of gross vs net, current assets vs non current)

Substantive Procedures & Completion (NOT INCLUDED IN SCOPE)
<ul style="list-style-type: none"> Send bank confirmations. Review bank confirmation responses and reconcile to FS and Trial Balance. Test bank reconciliation and supporting reconciling items Ensure no co-mingling of funds. Review bank statements for undisclosed related parties. Review journal entries.

Appendix 4: Issues identified during pilot changes for main study

1	Eliminate Waste	Process/Other reference	Description
a	Teach Everyone to ask "the five whys"	LSS Training	One of the tools engagement teams were trained in
b	Encourage Everyone to look for small forms of waste, not just big ones	LSS Training	Component of training - all team members from new joiners to partners trained together. Emphasis on identifying and eliminating the 7 'wastes'
c	Periodically review the structure and content of every job	PI-5, PI-11	Given longer cycle times structure and content is typically reviewed annually. For the 10 pilot teams 2 years of such review was performed. For other engagements a single review was performed. Individual processes were also reviewed annually (PBC listing, FS Preparation)
2	Specify the work		
a	Look for repeatable parts of the process and codify them	PI -1, PI -10, PI- 12	Where work would be repeated across engagements consistent tools were used codifying and standardizing the processes undertaken. Processes are also repeated between cycles of a single engagement.
b	Don't try to specify everything initially, if ever	3 activities selected (PBC listing, FS Preparation, Review Process)	Three processes (out of many) were selected initially for LSS review. These are processes applicable to every engagement.
c	Use data to get buy-in	Overall Programme	The results of the pilot study and large scale phase 2 rollout were data driven. All outcomes were assessed on the basis of hard data as well as engagement team feedback.
d	Keep studying the work that has been designated as tacit	Not done	A considerable amount of time involved in completing an audit is tacit in nature, to date no attempt has been made to systematize tacit knowledge - this may change as technology develops further
3	Structure communications		
a	Define who should be communicating, how often, and what	PI- 3, PI- 13, PI - 15	For significant interactions with the client a communication plan was prepared where none existed before. For routine interactions (internal to the firm and externally with clients) communication is already defined and well understood
b	Create a shared understanding	NA	There is no cross cultural misunderstandings likely to occur. The only non-US involvement relates to a delivery center based in Kolkata, India. This delivery center has been utilized for many years and is experienced in the demands of work. Hence 'creating a shared understanding' already exists and further amplification deemed unnecessary
c	Resolve disagreements with Facts, not opinions	Overall Programme	As a professional services firm outcomes are assessed based on hours taken for a particular task or other data where such data is available.

Appendix 5: Reconciliation of process improvements undertaken within LSS Framework

The table below reconciles process improvements undertaken within the framework of LSS for knowledge work, set out by Staats & Upton (2011).

1	Eliminate Waste	Process/Other reference	Description
a	Teach Everyone to ask "the five whys"	LSS Training	One of the tools engagement teams were trained in
b	Encourage Everyone to look for small forms of waste, not just big ones	LSS Training	Component of training - all team members from new joiners to partners trained together. Emphasis on identifying and eliminating the 7 'wastes'
c	Periodically review the structure and content of every job	PI-5, PI-11	Given longer cycle times structure and content is typically reviewed annually. For the 10 pilot teams 2 years of such review was performed. For other engagements a single review was performed. Individual processes were also reviewed annually (PBC listing, FS Preparation)
2	Specify the work		
a	Look for repeatable parts of the process and codify them	PI -1, PI -10, PI- 12	Where work would be repeated across engagements consistent tools were used codifying and standardizing the processes undertaken. Processes are also repeated between cycles of a single engagement.
b	Don't try to specify everything initially, if ever	3 activities selected (PBC listing, FS Preparation, Review Process)	Three processes (out of many) were selected initially for LSS review. These are processes applicable to every engagement.
c	Use data to get buy-in	Overall Programme	The results of the pilot study and large scale phase 2 rollout were data driven. All outcomes were assessed on the basis of hard data as well as engagement team feedback.
d	Keep studying the work that has been designated as tacit	Not done	A considerable amount of time involved in completing an audit is tacit in nature, to date no attempt has been made to systematize tacit knowledge - this may change as technology develops further
3	Structure communications		
a	Define who should be communicating, how often, and what	PI- 3, PI- 13, PI - 15	For significant interactions with the client a communication plan was prepared where none existed before. For routine interactions (internal to the firm and externally with clients) communication is already defined and well understood
b	Create a shared understanding	NA	There is no cross cultural misunderstandings likely to occur. The only non-US involvement relates to a delivery center based in Kolkata, India. This delivery center has been utilized for many years and is experienced in the demands of work. Hence 'creating a shared understanding' already exists and further amplification deemed unnecessary
c	Resolve disagreements with Facts, not opinions	Overall Programme	As a professional services firm outcomes are assessed based on hours taken for a particular task or other data where such data is available.

4 Address problems quickly and directly			
		Process/Other reference	Description
a	If a problem arises, ideally the person who created it should fix it	PI-12, PI-13, PI-14	Preparers of work were responsible for fixing any defects identified by reviewers. The review process happened in person facilitating this process - as opposed to reviewers fixing defects themselves
b	Problems should be solved where they occur	PI-12, PI-13, PI-14	Once completed work was reviewed by the reviewer in person with the preparer. Defects were identified and necessary remediation discussed. This cycle may be repeated.
c	Solve problems as soon as possible after they emerge	PI-13, PI-14, PI-15	Real time' feedback given on completed work (within 48 working hours) in order to identify defective work and coach staff on a timely basis.
5 Plan for an Incremental Journey			
a	Start Small	Overall Programme	An initial pilot of 10 engagements was selected prior to a larger scale roll out. Lessons learned were codified by LSS experts responsible for running the programme. Where opportunities for improvement were noted as a result of the pilot undertaken these were incorporated into the large scale roll out. It is a standard methodology to assess at the end of any project and identify areas that went well in addition to improvement areas, individuals are then tasked with identifying improvement remedies.
b	Codify the lessons learned	Standard operating procedure	In training all levels of engagement team members in LSS techniques the aim is that staff autonomously apply these tools to other processes to increase productivity
c	Keep Looking for new ways to work	Standard operating procedure	Three processes out of numerous total processes were selected for LSS review. These 3 processes were selected as being the most impactful.
d	Remember that the lean approach is not useful everywhere	Standard operating procedure	
6 Engage your managers			
a	Project managers and other midlevel leaders must train and motivate their teams	LSS Training	Buy-in was sought from leadership and engagement senior managers. Training was also provided to this group and a workshop held for each engagement with all levels from interns to partners involved
b	Senior leaders must be long-term champions	Ongoing	In order to fully embed LSS leadership must be committed to the program. In addition to feedback from more junior staff, financial results are used to demonstrate the value of LSS.

Appendix 6: Reconciliation of processes to LSS methodology

The table below reconciles process improvements undertaken with the framework of LSS for knowledge work set out by *Spear & Bowen (1999)*

	Process/Other reference	Description
1	All work shall be highly specified as to content, sequence, timing and outcome PI - 1, PI - 2, PI - 4, PI - 6, PI - 7, PI - 8, PI - 10, PI - 12, PI - 13, PI - 14, PI - 15	Specific facts and circumstances relevant to individual engagements result in lower levels of standardization than would be found in a typical manufacturing environment. However, audit steps common to all engagements have been standardized and documentation is standardized using audit software. The process improvements implemented were designed to ensure that timing of the performance of key aspects of work associated with the three activities selected were more standardized.
2	Every customer-supplier connection must be direct, and there must be an unambiguous yes-or-no way to send requests and receive responses. PI - 5, PI - 9, PI - 11, PI - 12, PI - 13, PI - 14, PI - 15	The key connections are between (1) External - engagement team members and clients (2) Internal - between 'preparers' of work and 'reviewers' of work. Process improvement activities focused on interactions with clients (external) ensuring these occurred and were timely, increased transparency via use of the 'Connect' system. Internal activities revolved around detailing individuals who would prepare each audit step, and who would review this - along with timing. Engagement teams were structured in order that prepared work would be reviewed within 48 working hours on a face-to-face basis - eliminating waste generated by remote review.
3	The pathway for every product and service must be simple and direct PI - 12, PI - 13, PI - 14, PI - 15	In professional services the 'production line' is virtual not physical. However, the components of 'production' - including the preparation of tasks and subsequent review were rethought and streamlined. The reviewers of work were predetermined in the planning phase to ensure that individual would have that capacity at the required time and also physically be present. Adjustments were made where necessary to ensure that face-to-face review within 48 working hours of preparation of work could be achieved.
4	Any improvement must be made in accordance with the scientific method, under the guidance of a teacher, at the lowest possible level in the organization Overall Process	A LSS specialist was assigned to each engagement team to provide guidance on LSS tools. A day long workshop was held with each team incorporating all team members from Interns to Partners. Our view is that staff 'at the coalface' are first to see and best placed to identify solutions to wastes identified. Leadership's role is to empower and provide support.

Appendix 7: Activities and associated processes subject to LSS review

Process Reference	Activity	Process Name
PI-1	PBC Listing	Use of 'Connect' system
PI-2	PBC Listing	Comparison of engagement PBC listing to industry peer PBC lists
PI-3	PBC Listing	Obtain client management buy-in
PI-4	PBC Listing	Establish protocol with client management for timely escalation of issues
PI-5	PBC Listing	Hold a debrief meeting with client management on PBC process
PI-6	FS Preparation	Timely roll-forward of prior year financial statements
PI-7	FS Preparation	Review by all levels of Automated Disclosure Checklist and support
PI-8	FS Preparation	Financial statement comparison to industry peer entities
PI-9	FS Preparation	Pre year end client management sign off on draft financial statements
PI-10	FS Preparation	Use of automated mathematical/Cross-reference tool
PI-11	FS Preparation	Hold a debrief meeting with client management on FS preparation process
PI-12	Review Process	Preparation of a detailed responsibility listing - in planning phase
PI-13	Review Process	Face-to-face review protocols established
PI-14	Review Process	Reviewer time scheduled at planning stage
PI-15	Review Process	Real-time face-to-face review communicated as an expected metric to assess performance
LSS	Lean Six Sigma Training	Training provided to engagement teams
Overall Programme		Applies to the way the firm and/or LSS program was set up

Appendix 8: Implementation differences & required changes

	Define	Measure	Analyze	Improve	Control
Purpose	Define the problem	Quantify the problem	Identify causes of the problem	Implement solution(s) to the problem	Maintain solution(s) to the problem
Task Performed	Establish facts, define goals and map current process	Measure current state and set baseline for improvement	Uncover root causes of an issue leveraging data	Identify, test and implement solution(s)	Embed change to make permanent improvement
Additional issues faced	None	Data is less readily available in comparison to a typical manufacturing context. The final 'product' - an audit is the result of a series of processes and sub-processes - data is only maintained on an aggregate level not individual components resulting in difficulties in baselining a specific process.	Whilst root causes can be identified using tools available (e.g. fishbone diagrams) data again presents itself as an issue in quantifying the impact of root causes identified and subsequently prioritization. Long cycle times (annual) also reduce the availability of historic trend data.	Improvements are hampered by a number of factors - seasonality reducing capacity of 'real time improvements', impact on employees of long cycle times, high turnover and expectation that staff do not perform the same role in subsequent cycles, team composition requires senior management buy in of all potential solutions. These factors elongate the timeline for improvements to be made, limit the ability to test solutions and identify on an iterative basis.	Teams are dynamic in their make up and change is expected - other than engagement leaders and senior managers no team member is expected to have the same tasks and responsibilities cycle-to-cycle. This results in a more challenging environment for embedding change.
Knowledge Work Example	None	LSS is predicated on the availability of data to identify issues and measure the efficacy of solutions. Whilst there is scope for improved data collection in professional services it should be noted that the context of largely verbal iterations with clients and between team members reduced the practicability of measuring everything. However, given the 'promote from within' culture - managers and partners have all performed basic audit work in their careers giving the whole team an instinct for how long a specific task should take and potential alternatives to improve efficiency allowing for a detailed and constructive discussion even in the absence of glandular task-level data. This reinforces the importance of discussing issues and improvements on a timely basis with the whole team present shortly after a cycle.	Fundamental less data is typically available for analysis in a professional services LSS implementation than would be the case in manufacturing. A team where all levels have previously performed that tasks in hand allows for rapid identification of root causes and suggestions for improved processes.	Training of whole team at all levels in LSS methodology and buy in on importance from the outset. Given longer cycle times a debrief on the current cycle and consideration must be given to LSS improvements for subsequent cycles immediately after the conclusion of the current cycle. Improvements should be documented, agreed and approved by the whole team in advance of the following cycle and before the team disbands. Staff must coach those who perform their roles in subsequent cycles to ensure the hand over of improvements and lessons learnt.	Once agreed improvements must be thoroughly documented and new team members trained if they are impacted. On many teams the core team includes staff from previous years - albeit performing differing roles enabling the transfer of knowledge. Given expected high turnover and the potential for redeployment of staff to other engagements a codified approach is required.

Leadership support, Provision of resources, training of staff

