Does Technology Adoption Save Regulatory Compliance Costs?

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ABSTRACT

We study whether digital technology streamlines the regulatory process and reduces the costs of complying with regulation. To identify the effect of digital technology on regulatory compliance costs, we leverage a quasi-experimental policy change which mandates the use of an internet-based flow management tool that enables insurers and regulators to exchange policy form and rate filing information. We find that digitization lowers the costs of complying with regulation. The average insurer per line of business and year in the highest quartile regarding the proportion of business under the mandate saves 4.8 percent of general expenses. Our results also suggest a fixed cost of adopting the technology, with larger cost-saving accruing to firms that adopt the new technology more widely.

Keywords: Insurance Regulation; Technology Adoption; Government Policy and Regulation
JEL Codes: D78, G22, G28

1 Introduction

In the past decades, digitization and the internet have impacted almost all economic activities and reduced a variety of economic costs. Besides the commercial world, government regulators are increasingly adopting digital technology to make the regulatory process more efficient. Yet new technology requires additional investment in human capital for both the regulator and the regulated entity, and it remains an open question whether technology adoption reduces the cost of regulation, at least in the short term. In this study, we estimate the impact of technology adoption on the costs of complying with product regulation in the U.S. property-liability (P/L) insurance market by exploiting quasi-experimental variation in when states adopt the technology.

The U.S. insurance industry provides an ideal laboratory to study the effects of regulation. The industry is large – with \$534 billion of direct premiums written in 2016, it comprises 2.88% of U.S. GDP[1]) – and heavily regulated – about half of the lines of insurance are subject to product regulation.[2] In contrast to other financial sectors that are subject to federal regulation, the insurance industry is primarily regulated at the state level and states experiment with different forms of regulation. A major action by state insurance regulators is the review and approval of insurance rates and policy forms, and there are substantial costs associated with complying with these regulations (Leverty and Liu 2019). As part of the National Association of Insurance Commissioners (NAIC)'s "Speed to Market" initiative, the NAIC developed an online platform for regulatory compliance, the System for Electronic Rate and Form Filing (SERFF). SERFF is a web-based flow management tool that enables insurers and regulators to exchange product filing and review information within the application.[3] The objective of SERFF is to standardize the form and rate filing process, improve regulatory

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[1]Data source: Federal Insurance Office (2017); Bureau of Economic Analysis (2017).

[2]Authors' calculation based on the U.S. insurer data (1992-2014). A line of insurance is classified as regulated if the insurer is required to obtain regulatory approval of their rating plans or policy forms prior to using them.

[3]SERFF also houses other Speed to Market tools, including the Uniform Product Coding Matrices and Uniform Transmittal Documents.

efficiency, and save financial and human resources for both regulators and insurers. Twenty-eight states mandated the adoption of SERFF, at different times, between 2007 and 2014.

This study exploits the variation in when and if states mandate the use of SERFF for insurer rate and product filings to cleanly identify the effect of technology on the costs of complying with regulation. While there may be heterogeneity in regulatory compliance costs across insurers, lines of business, states, and years, we argue that the adoption of SERFF is plausibly exogenous to other factors along these dimensions. Our empirical strategy uses fixed effects regression models to isolate the compliance costs from other operating expenses incurred by firms over 23 years, 1992-2014. As insurance firms may be heterogeneous in their ability to minimize compliance costs, firm fixed effects control for the average compliance costs of each firm. The compliance costs may also vary by the line of business (e.g., auto liability or homeowners insurance), and line fixed effects control for the average compliance costs of each line. Finally, compliance costs may vary over time, and year fixed effects control for the average compliance costs for each year.

This study makes three contributions to the literature. First, while there is extensive research on how regulation affects the regulated entity's technology adoption in environmental economics and financial economics (Popp et al. 2010; Böhme et al. 2015), little research has been conducted on how the adoption of technology by regulators impacts market participants. This study provides empirical evidence on whether a mandate to use technology for regulatory purposes reduces the costs of complying with regulation. Second, this study adds to the literature on the costs of insurance regulation. Several studies document substantial costs associated with state insurance regulation (Grace and Klein 2000; Pottier 2011; Leverty 2012). We extend this literature by estimating how the introduction of digital technology affects the costs of complying with regulation. Finally, this study also joins the broad literature on the economics of digitization (e.g., Goldfarb et al. 2015; Goldfarb and Tucker 2019) and provides additional evidence on whether the adoption of information technology reduces firm's operating costs in an economically important industry.

2 Institutional Background

2.1 Policy Form and Rate Filing System

In this section, we discuss the institutional features of the U.S. P/L insurance industry that make it an ideal environment to study the compliance costs of regulation and technology adoption.[4] In the U.S., insurance is regulated at the state level. Each state has an insurance department that oversees the regulation of insurance. A substantial part of insurance regulation focuses on the rates and policy forms of insurance policies to ensure they comply with state laws and are reasonable and fair for consumers.

The regulation of policy forms and rates is conducted through a filing system in each state. The process starts with a filer (an insurer or third-party consultant) submitting the proposed rates and policy form to the regulator. Then the insurance department will review the rate and form filing information and decide whether to approve the filing or request further. The state insurance commissioner has the ultimate authority.[5]

Traditionally, the state filing system is paper-based and it creates substantial compliance costs and inefficiency. Numerous documents need to be copied and mailed between the filer and the regulator. This is especially true for multi-state insurers who need to make a separate filing in each state in which they operate for the same policy.

2.2 SERFF

To improve the efficiency of insurer filing the policy forms and rates with regulators, state regulators and the NAIC started a "Speed to Market for Insurance Products" initiative in the mid-1990s. The initiative led to the establishment of the System for Electronic Rate and

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[4]See Klein (2005) for an extensive discussion on insurance regulation in the U.S.

[5]The timeline of filing and approval differs by state. In states with a prior-approval system, the insurer must receive the regulator's approval before the policy can be used in the market. In states with a file-and-use system, a policy can be used in the market without the regulator's approval, but the insurer must file the rates and forms a certain number of days prior to using the policy. In states with a use-and-file system, the filing only needs to be done after the use of the policy. In almost every state, a filing is required for a policy to be used.

Form Filing (SERFF) in 1998. SERFF is an internet platform designed to streamline the rate and form filing and review process. The NAIC has promoted SERFF as a major Speed to Market tool since its first product release.

SERFF replaces the traditional paper-based system by digitizing the entire filing process. Filers log onto SERFF, identify the filing requirements promulgated by each state, and submit an electronic filing to the regulator with all supporting documents uploaded in a digital format. The regulator receives the filing on SERFF and can start reviewing them instantly. In the case where a change is needed, the regulator can contact the filer using a messaging system in SERFF, and the filer can make changes and submit a revised filing in SERFF. In short, SERFF provides a one-stop interface for regulators and insurers to exchange information and complete rate and form filings electronically.

When the first version of SERFF was released in 1998, eight states and sixteen insurers participated. A total of 294 filings were made in 1998. In 2000, an enhanced version of SERFF was released and it quickly expanded across the states in the early 2000s. By the end of 2004, SERFF was accepted in 49 states and the District of Columbia and over 1,400 insurers were licensed to use SERFF. Many states have mandated the use of SERFF for insurance rate and form filings. Under a SERFF mandate, insurers can no longer make paper filings and must file their proposed rates and forms via SERFF. Between 2007 and 2016, 31 states have enacted SERFF mandate in P/L insurance. Florida is the only state that does not accept SERFF, as it adopts its own electronic filing system named I-File (later replaced by the Insurance Regulation Filing System (IRFS)).

On the one hand, SERFF has several advantages over the traditional filing system. First, SERFF improves the efficiency of the information exchange by providing a single online platform for insurers and regulators to communicate, manage, and store product filings electronically. Insurers no longer need to mail hard copies of product information to the regulator and wait for a response in the mail. Second, SERFF makes insurer compliance more manageable, as insurers have easy access to the current filing requirements promulgated by

the state, which helps insurers submit more accurate and complete filings. Moreover, SERFF is particularly helpful to multi-state insurers, as they can comply with the regulations in different states in a much easier fashion and even use a single filing if it meets the regulatory requirements of those states. Industry reports suggest the adoption of SERFF leads to considerable cost savings, including a reduction in internal IT and database maintenance costs and product filing worker hours (NAIC 2016).

On the other hand, insurers incur fixed and variable costs when they transition from the traditional filing method to SERFF. For an insurer to implement SERFF, it needs to spend resources on staff training and possibly upgrade its technology. Also, insurers pay a filing fee for each filing they make, either on a pay-as-you-go basis or paying for a "block" of filings at a lower price in advance.[6] Insurers vary in when (and to what extent) they transfer to SERFF from the traditional method. Some insurers (e.g., the sixteen original participating firms) implement SERFF as soon as it becomes available and well before SERFF is mandated, while other insurers implement SERFF when it is mandated. Some multi-state insurers that are subject to a SERFF mandate in some states but not others may implement SERFF in the states with mandates, but not in the others, while other multi-state insurers completely transfer to SERFF once they are subject to a SERFF mandate in one state.

3 Data and Sample

3.1 Regulation and SERFF Data

We obtain information on which states mandate SERFF and the effective dates of the mandate from the official NAIC-SERFF website.[7] Table 1 shows the states that mandate SERFF and the year of enactment. To be consistent with our annual insurer data, we classify the SERFF mandate at the year level; if the mandate comes into effect in the middle of year t,

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[6]As of May 2019, the pay-as-you-go rate is $13.50 per filing, and the prepaid rate is $9.50/$8.00/$6.50 per filing for a block of 500/1,000/1,500 filings.

[7]https://www.serff.com/documents/serff_participation_mandates.pdf.

we define the first year of the mandate to be t+1. The classification at the year level may introduce measurement error, which would bias us against finding any significant SERFF effect on insurers.

3.2 Insurer Data

We compile a data set of all U.S. property and liability insurers from the National Association of Insurance Commissioners (NAIC) statutory annual report database over 23 years, 1992-2014. This database is the most comprehensive source of insurer information available for the U.S. insurance market. For each year, we collect the firm-line level premium and expense data from the Insurance Expense Exhibit and firm-line-state level premium data from the Exhibit of Premiums and Losses ("State Page"). The Exhibit of Premiums Written (Schedule T) is used to identify whether an insurer is licensed in a state. Unlicensed insurers are exempt from product regulation and thus not affected by SERFF mandate.

3.3 Measuring Regulatory Compliance Costs

The direct costs of regulatory compliance under form and rate regulation for insurers include the expenses, salaries, and consulting fees associated with making form and rate filings to the state (Grace and Klein 2000; Leverty 2012).

The ideal data for studying compliance costs of product regulation would be insurer expenses associated with regulatory compliance at the firm-line-state-year level since the SERFF mandate is applied at the state-year level. The NAIC database, however, does not provide a separate category of expenses for regulatory compliance, nor does it break down expenses at the firm-line-state-year level. We address these challenges in two ways.

First, while we do not have a single expense item dedicated to regulatory compliance, all compliance-related expenses are contained in the Acquisitions, Field Supervisions, and Collection(AFSC) expenses and the general expenses reported by insurers. The AFSC expenses consist of all expenses incurred in the production of new and renewal insurance business,

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including operating costs of agencies and branches, writing new policy forms, data processing, clerical, secretarial, office maintenance, supervisory, and executive duties. General expenses are also relevant because they include all expenses that are not assigned to other expense groups per the NAIC statutory accounting principles. Therefore, the combination of the AFSC and general expenses captures all the expenses related to an insurer's general operation, including compliance costs.

Note that these expenses also include costs that are not linked to regulatory compliance, such as advertising, employee welfare, rent, and equipment. This does not impact the measurement of compliance costs in the fixed effects models, as the models identify the *change* in expenses, rather than the expenses themselves. To accurately measure the compliance costs, we rely on an assumption: changes in the expenses (e.g., rent) that are unrelated to complying with product regulation across firms, lines, and time are uncorrelated with the SERFF mandate enforced by the state, which is plausibly true.

Specifically, we use the NAIC expense data to construct a general expense ratio, which we use as the dependent variable in our regressions. This ratio is defined as:

$$General\ Expense\ Ratio = \frac{\text{General Expenses Incurred + Other AFSC expenses Incurred}}{\text{Net Premiums Written}},$$

Second, since we estimate the costs of complying with product regulation at the firm-year and firm-line-year level, we measure an insurer's exposure to treatment, the SERFF mandate at both levels. *SERFF Proportion* is the proportion of an insurer's direct premiums written in states with SERFF mandate.

We note that using the SERFF mandate rather than the actual insurer usage of SERFF will likely bias the estimated effect of SERFF towards zero. This is because an insurer may start using SERFF voluntarily before the mandate. In this case, the mandate will not impact this insurer, and our estimates will be biased against finding a significant influence of SERFF on insurer expenses, even if they exist.

3.4 Sample and Descriptive Statistics

Our final sample is an unbalanced panel of insurers in 14 lines of insurance[8] from 1992 to 2014, with a total of 2,813 insurers and 157,531 firm-line-year observations. The data include all lines of property-liability insurance except financial/mortgage guaranty, fidelity/surety, credit, and warranty. In constructing the sample, we exclude firms with negative assets or liabilities and those with policyholder surplus less than $1 million. Risk retention groups are also excluded because they are mostly exempt from regulation by nondomiciliary states (Born et al. 2009; Leverty 2012). At the firm-line-year level, we require net premiums written to be at least $100,000 and positive total expenses and general expenses. Expense ratios are winsorized at the first and ninety-ninth percentile to reduce the effect of outliers.

Table 2 presents the summary statistics. Panel A shows the summary statistics at the firm-year level, and Panel B shows the summary statistics at the firm-line-year level. At the firm-year level, 21 percent of the observations have at least some business under the SERFF mandate, and the average proportion of SERFF business (measured by direct premiums written) is 0.08. The average loss ratio is 0.67, and the average total expense ratio is 0.35. The loss ratio and total expense ratio are adjusted by present value factors to ensure comparability across lines (Cummins and Danzon 1997; Phillips et al. 1998).[9] At the firm-line-year level, 20 percent of the observations have at least some business under SERFF mandate, and the average proportion of SERFF business is 0.08. The average loss ratio is 0.76, and the average general expense ratio is 0.19, indicating that about one-fifth of premiums represent insurer operating expenses, including regulatory compliance costs.

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[8]We group lines from the NAIC database into 14 lines based on prior studies (e.g., Deng et al. 2017) with modifications. The categorization of lines is shown in Table A.1.

[9]Specifically, we apply the Taylor separation (Taylor 1977) to estimate yearly proportions of loss development for each line, using loss data from the A. M. Best Aggregates and Averages and risk-free interest rates from the FRED database of the Federal Reserve Bank of St. Louis.

4   Empirical Design

Ensuring compliance with product regulation can be costly to insurers, and a stated goal of technology adoption in regulation is to improve efficiency and reduce costs (NAIC 2016). It remains an open question of whether technology adoption reduces regulatory compliance costs. On the one hand, a new system with more advanced technology may streamline the regulatory process and reduce the human and financial resources spent on regulatory compliance. On the other hand, the regulated entity may need to spend resources on learning and adjusting to the new system. We provide empirical evidence on whether the mandated use of SERFF in the insurance market reduces regulatory compliance costs.

4.1   Empirical Strategy

The identification strategy exploits the quasi-experimental shock of the mandated use of SERFF for insurance product regulation (i.e., rate and form filings). Twenty-eight states mandated SERFF in the P/L insurance market from 2007 to 2014. The cross-sectional and time-series variation in these mandates, combined with the exogenous nature of the mandates establishes causality. Additional variation results from multi-state insurers being able to do business in some states on a licensed basis and in other states on an unlicensed basis, and only licensed business is subject to product regulation. As a result, unlicensed business does not involve using SERFF at all, providing additional variation in an insurer's exposure to SERFF.

An empirical challenge for identification is that we do not know how multi-state insurers adopt SERFF when only part of the insurer's business is subject to a SERFF mandate. Suppose an insurer operates in Georgia and Kansas. Georgia mandated the use of SERFF in 2007, while Kansas mandated it in 2009. In 2007, the insurer could use SERFF for its filings in both states or use SERFF in Georgia only. Insurers will adopt different strategies for implementing SERFF.

To address this challenge, we construct two independent variables, *Any SERFF* and *SERFF Proportion* to measure the impact of the SERFF mandate on insurers. *Any SERFF* captures the effect when an insurer has at least some business under a SERFF mandate, while *SERFF Proportion* measures the proportion of an insurer's business under a SERFF mandate.

An insurers's implementation of SERFF may also vary by the line of business. For example, insurers operating in lines with greater regulatory scrutiny may transition to SERFF sooner than those in lines with less stringent regulation. Therefore, we analyze the effect of the SERFF mandate on insurer expenses at two levels, the firm-year level and the firm-line-year level. At the firm-year level, an insurer is treated as a whole and the estimation is based on the assumption that the insurer does not adopt different strategies for implementing SERFF across lines. At the firm-line-year level, the unit of analysis is a firm-line observation, and the estimation is based on the assumption that an insurer's strategy for implementing SERFF in one line is independent of its strategy in another line. We recognize that neither assumption holds perfectly in the real world, and the reality may lie somewhere in between. Therefore, these two frameworks complement each other and when combined, they provide an upper and a lower bound of the estimate of SERFF's effect on insurer expenses.

Our coefficient estimates on the effect of technology adoption may be biased towards zero for two reasons. First, some insurers transition to SERFF before the SERFF mandate is enacted. Second, insurers in Florida may use other digital platforms to file rates and policy forms, but our measures of technology adoption only captures the use of SERFF. In both cases, there will be measurement errors that would bias us against finding any significant effect of technology adoption on insurer expenses.

4.1.1 Firm-Year Level Analysis

First, we conduct the analysis at the firm-year level, using fixed effects regression models to isolate the impact of the SERFF mandate on insurer's costs of complying with product

regulation. As there can be heterogeneity in insurer ability to minimize compliance costs, we include firm fixed effects to control for the average costs of each firm and year fixed effects to control for yearly shocks on compliance costs in the industry. We estimate the following regression:

$$Y_{it} = \beta_1 Any\ SERFF_{it} + \gamma X_{it} + \lambda_i + \theta_t + \epsilon_{it}, \tag{1}$$

where Y_{it} is the general expense ratio of firm i in year t. $Any\ SERFF_{it}$ is an indicator variable of whether firm i has any business in a state that mandates SERFF in year t; X_{it} is a vector of control variables including size (natural logarithm of net premiums written by firm i in year t) and entry and exit behavior for firm i in year t; λ_i, θ_t are firm and year fixed effects, respectively; and ϵ_{it} is the error term. The standard errors are clustered at the firm level to allow within-firm correlations.

The variable of interest is $Any\ SERFF$. It is possible that a SERFF mandate forces an insurer to fully adopt SERFF in all the states where it writes business, and thus this variable captures the primary effect of the SERFF mandate. A positive coefficient β_1 is consistent with the hypothesis that technology adoption increases compliance costs, and a negative coefficient β_1 would imply that technology adoption reduces compliance costs. If the coefficient β_1 is not significantly different from zero, it suggests that either SERFF mandate does not have a significant impact on the compliance costs, or the cost-saving effects are canceled out by the additional learning and adjusting costs for SERFF adoption.

It is also possible that multi-state insurers do not adopt SERFF all at once, but rather gradually switch to SERFF as it is mandated in the states in which they operate. To investigate whether this is the case, we estimate the following regression with the variable of interest to be $SERFF\ Proportion$.

$$Y_{it} = \beta_2 SERFF\ Proportion_{it} + \gamma X_{it} + \lambda_i + \theta_t + \epsilon_{it}, \tag{2}$$

where $SERFF\ Proportion_{it}$ measures the proportion of business that is subject to SERFF

mandate for firm i and year t; all other variables are defined in the same way as in Regression (1).

A positive coefficient β_2 is consistent with the hypothesis that technology adoption increases compliance costs, and a negative coefficient β_2 would imply that technology adoption reduces compliance costs. If the coefficient β_2 is not significantly different from zero, we would conclude that the proportion of business under SERFF mandate does not affect the compliance costs for insurers.

4.1.2 Firm-Line-Year Level Analysis

While the firm-year level analysis captures the SERFF effect on compliance costs for an insurer as a whole, a multi-line insurer may implement SERFF differently across lines. To explore the cross-line heterogeneity within a firm, we use the firm-line-year level data to estimate the following regressions, adding line fixed effects to control for the average compliance costs within each line of business:

$$Y_{ilt} = \beta_1 Any\ SERFF_{ilt} + \gamma X_{ilt} + \lambda_i + \delta_l + \theta_t + \epsilon_{ilt}, \tag{3}$$

$$Y_{ilt} = \beta_1 SERFF\ Proportion_{ilt} + \gamma X_{ilt} + \lambda_i + \delta_l + \theta_t + \epsilon_{ilt}, \tag{4}$$

where Y_{ilt} is the general expense ratio of firm i in line l and year t. $Any\ SERFF_{ilt}$ is an indicator variable of whether firm i has any business in a state that mandates SERFF in line l and year t; X_{ilt} is a vector of control variables including size (natural logarithm of net premiums written by firm i in line l and year t) and entry and exit behavior for firm i in line l and year t; λ_i, δ_l, and θ_t are firm, line, and year fixed effects, respectively; and ϵ_{ilt} is the error term. The standard errors are clustered at the firm level to allow within-firm correlations.

5 Effects of Technology Adoption on Regulatory Compliance Costs

5.1 Firm-Year Level Results

Table 3 shows the results of the firm-year level regressions. The primary finding is that SERFF reduces insurer expenses. In Regression (1), the coefficient on *Any SERFF* is negative and statistically significant at the 10 percent level. Given that the average expense ratio in the sample is 0.205, the coefficient implies that a SERFF mandate in at least one state in which an insurer operates lowers the average insurer's expense ratio by 5.85% (-0.012/0.205 = -5.85%). In Regression (2), the coefficient on *SERFF Proportion* is negative and statistically significant at the 5 percent level, suggesting a negative relationship between the proportion of business subject to a SERFF mandate and insurer expenses.

To explore the possibility of a nonlinear effect of *SERFF Proportion*, we include *SERFF Proportion Squared* in Regression (3). The coefficients on *SERFF Proportion* and *SERFF Proportion Squared* are -0.099 and 0.083 respectively, and both coefficients are statistically significant at the 5 percent level. The fitted quadratic function of *SERFF Proportion* is a U-shaped curve, which achieves a minimum at 0.596 (0.099/(2*0.083) = 0.596). Thus, the expense saving effect of SERFF is the strongest when an insurer's *SERFF Proportion* equals 0.596.

In Regression (4), we further explore the effects of different proportions of SERFF business by regressing the general expense ratio on quartile indicator variables of *SERFF Proportion*, and the reference group is the insurers who have no business that is subject to a SERFF mandate. The coefficients on the second, third, and fourth quartile of *SERFF Proportion* are -0.016, -0.025, and -0.018, and statistically significant at the 10, 1, and 5 percent levels, respectively. Pairwise F-tests show that the coefficients on Q2, Q3, and Q4 are statistically significantly different from Q1 at the 5 percent level, while these three coefficients are not significantly different from each other. If an insurer's *SERFF Proportion* is in the fourth

quartile of the distribution (which is a *SERFF Proportion* between 0.64 and 1), its expenses are, on average, lower than an insurer that has no business that is subject to a SERFF mandate by 0.018, an effect size of 8.78%.

In Regressions (5)-(8), we add the proportions of business in each line of insurance to control for possible heterogeneity across lines within a firm-year. The results are robust to the inclusion of insurer business mix. We also find evidence of economies of scale in regulatory compliance, as the coefficient on *Firm Size* is negative and statistically significant. Also, we find that insurer expenses increase with the number of states in which it does business, which is consistent with previous literature on the costs of complying with multiple insurance regulators (Grace and Klein 2000; Leverty 2012).

5.2   Firm-Line-Year Level Results

Table 4 shows the results of the firm-line-year level regressions. SERFF reduces regulatory compliance costs when an insurer writes a large proportion of business in states with a SERFF mandate. In Regression (1), after controlling for differences in the strategy for implementing SERFF by line, the coefficient on *Any SERFF* is not statistically different from zero, which suggests that the SERFF mandate in at least one state in which an insurer operates does not have a significant effect on its compliance costs. In Regression (2), the coefficient of *SERFF Proportion* is -0.012 and statistically significant at the 5 percent level, suggesting a negative relationship between the proportion of business under SERFF mandates and insurer expenses.

To explore the possibility of a nonlinear effect of proportion, we include *SERFF Proportion Squared* in Regression (3). The coefficients on *SERFF Proportion* and *SERFF Proportion Squared* are -0.028 and 0.016, respectively. While neither of them is statistically significant (possibly due to their correlation), a joint F-test rejects the hypothesis that both coefficients are equal to zero (p-value = 0.04), suggesting that the inclusion of these two variables provides power in explaining the general expense ratio.

In Regression (4), which includes the four quartiles of *SERFF Proportion*, the coefficient on the indicator of the first quartile (*SERFF Proportion* between 0 and 0.10) is 0.009 and statistically significant at the 5 percent level. The coefficient on the indicator of the fourth quartile (*SERFF Proportion* between 0.64 and 1) is -0.009 and statistically significant at the 10 percent level. Pairwise F-tests show that the coefficient on the first quartile indicator is significantly different from other quartiles at the 5 percent level, and the second, third, and fourth quartile indicators do not differ from each other. Compared to an insurer who does not have any business under a SERFF mandate, the general expense ratio of the average insurer with a proportion of SERFF business that is in the fourth quartile (*SERFF Proportion* between 0.64 and 1) is lower by 0.009, an effect size of 4.81% (0.009/0.187 = 4.81%). This translates to about $400,000 per year for an average firm-line observation in the fourth quartile.

In Regressions (5)-(8), we add the square of *Number of States* to control for possible nonlinear effects of the number of states on compliance costs. The results are largely unchanged, except that the coefficient on *SERFF QT=1* is not significantly different from zero in Regression (8). Overall, the results suggest that there are fixed costs associated with adopting the technology, but cost savings emerge as SERFF is implemented more widely by the insurer.

6   Conclusion

This study examines a quasi-natural state-level experiment of technology adoption in product regulation in the U.S. P/L insurance industry. We find evidence suggesting that mandated use of an internet application, SERFF, reduces insurer expenses. The effect of SERFF mandate seems to be nonlinear: it imposes additional costs when the insurer starts using SERFF for product filings, and the expense savings appear after the insurer applies SERFF on a sufficiently large proportion of business.

At the firm-year level, the estimated cost savings of SERFF for an average firm in the fourth quartile of the distribution of business subject to a SERFF mandate is 8.78%, and on the firm-line-year level the estimate is 4.81%. A possible explanation of the difference between these two estimates is that we do not know to what extent insurers implement SERFF differently across lines. If insurers always implement SERFF simultaneously across all the lines that they write in, the estimate of 8.78% might be closer to the real effect size, but if insurers implement SERFF differently across lines, the estimate of 4.81% would be more reliable. Thus, these estimates represent the upper and lower bound of the cost-saving effect associated with SERFF. Both estimates indicate that digitization significantly reduces the costs of complying with regulation.

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Table 1: SERFF Mandate Year for P/L Insurance by State

State	Mandate Year
AL	2008
AR	2011
AZ	2016
CA	2015
CO	2009
CT	2011
DC	2008
DE	2008
GA	2007
IA	2008
IL	2012
KS	2009
MA	2009
ME	2010
MI	2009
MN	2008
MO	2016
NE	2010
NH	2008
NJ	2009
NM	2010
NV	2011
OH	2010
OK	2010
RI	2008
SC	2012
SD	2007
UT	2008
VT	2009
WA	2009
WV	2009

Notes: The table shows the year when SERFF is mandated for property-liability insurance product filing across states that have mandated SERFF by April 2018. Data Source: NAIC (2018)

Table 2: Summary Statistics

Panel A: Firm-Year Level

	Mean	SD
Any SERFF	0.21	0.40
SERFF Proportion	0.08	0.22
Net Premiums Written (MN)	206.34	1115.33
Loss Ratio	0.67	0.19
Total Expense Ratio	0.35	0.17
General Expense Ratio	0.20	0.21
Firm-Year Observations	35,440	

Panel B: Firm-Line-Year Level

	Mean	SD
Any SERFF	0.20	0.40
SERFF Proportion	0.08	0.22
Net Premiums Written (MN)	44.24	329.85
Loss Ratio	0.76	2.75
Total Expense Ratio	0.34	0.15
General Expense Ratio	0.19	0.17
Firm-Line-Year Observations	157,531	

Notes: Panel A shows the mean and standard deviation of main variables at firm-year level (1992-2014). *Any SERFF* is an indicator of whether the insurer writes business under SERFF mandate. *SERFF Proportion* is the proportion of premiums written under SERFF mandate. *Total Expense Ratio* is the ratio of all underwriting expenses (excluding loss adjustment expenses) to net premiums written. *General Expense Ratio* is the ratio of general expenses to net premiums written. *Entry 1st Year (2nd Year)* equals one if an insurer is in its first (second) year of entry; *Exit Last Year (2nd Last Year)* equals one if an insurer is in its last (second last) year before exiting.

Panel B shows the mean and standard deviation of main variables at firm-line-year level (1992-2014). Entry 1st Year (2nd Year) equals one if an insurer is in its first (second) year of entry into a line; Exit Last Year (2nd Last Year) equals one if an insurer is in its last (second last) year before exiting a line. Data sources: NAIC (1992-2018).

Table 3: Effects of SERFF Mandate on General Expense Ratio: Firm-Year Level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Any SERFF	-0.012*				-0.013*			
	(0.006)				(0.006)			
SERFF Proportion		-0.021**	-0.099***			-0.018**	-0.099***	
		(0.009)	(0.036)			(0.009)	(0.036)	
SERFF Proportion Sq.			0.083**				0.086**	
			(0.036)				(0.036)	
SERFF QT=1				-0.000				-0.002
				(0.007)				(0.007)
SERFF QT=2				-0.016*				-0.018**
				(0.009)				(0.009)
SERFF QT=3				-0.025***				-0.025***
				(0.010)				(0.010)
SERFF QT=4				-0.018**				-0.016**
				(0.008)				(0.008)
Firm Size	-0.117***	-0.117***	-0.117***	-0.117***	-0.118***	-0.118***	-0.118***	-0.118***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Number of States	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.003***	0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
% of Business in Each Line	No	No	No	No	Yes	Yes	Yes	Yes
Entry & Exit	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean of Dependent Variable	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
R-squared	0.646	0.646	0.646	0.646	0.648	0.648	0.649	0.648
Firm-Year Observations	35,540	35,540	35,540	35,540	35,540	35,540	35,540	35,540

Notes: The table shows the results of fixed effect regressions of the general expense ratio with firm-year level observations (1992-2014). *Any SERFF* is an indicator of whether the insurer writes business under SERFF mandate. *SERFF Proportion* is the proportion of premiums written under SERFF mandate. *Firm Size* is the natural logarithm of the net premiums written by an insurer in a year. *Number of States* counts the number of states where a firm makes product filings. Robust standard errors are clustered at the firm level and reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Effects of SERFF Mandate on General Expense Ratio: Firm-Line-Year Level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Any SERFF	-0.001				-0.002			
	(0.004)				(0.004)			
SERFF Proportion		-0.012**	-0.028			-0.013**	-0.034*	
		(0.005)	(0.018)			(0.005)	(0.018)	
SERFF Proportion Sq.			0.016				0.022	
			(0.017)				(0.017)	
SERFF QT=1				0.009**				0.007
				(0.004)				(0.004)
SERFF QT=2				-0.003				-0.005
				(0.005)				(0.005)
SERFF QT=3				-0.005				-0.006
				(0.005)				(0.005)
SERFF QT=4				-0.009*				-0.010**
				(0.005)				(0.005)
Firm-Line Size	-0.035***	-0.035***	-0.035***	-0.035***	-0.035***	-0.035***	-0.035***	-0.035***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Number of States	0.002***	0.002***	0.002***	0.002***	0.003***	0.003***	0.003***	0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of States Sq.					-0.000***	-0.000***	-0.000***	-0.000***
					(0.000)	(0.000)	(0.000)	(0.000)
Entry & Exit	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Line Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean of Dependent Variable	0.187	0.187	0.187	0.187	0.187	0.187	0.187	0.187
R-squared	0.446	0.446	0.446	0.447	0.447	0.447	0.447	0.447
Firm-Line-Year Observations	157,531	157,531	157,531	157,531	157,531	157,531	157,531	157,531

Notes: The table shows the results of fixed effect regressions of the general expense ratio with firm-line-year level observations (1992-2014). *Any SERFF* is an indicator of whether the insurer writes business under SERFF mandate. *SERFF Proportion* is the proportion of premiums written under SERFF mandate. *Firm-Line Size* is the natural logarithm of the net premiums written by an insurer in a line and year. *Number of States* counts the number of states where a firm makes product filings in a line. Robust standard errors are clustered at the firm level and reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.1: Line of Insurance Category

Line Group	Line of Insurance in the Sample	Original Line in NAIC Data	Note
Personal	Homeowners / Farmowners	Farmowners multiple peril	
		Homeowners multiple peril	
	Private Passenger Auto Liability	Private passenger auto no-fault (personal injury protection)	
		Other private passenger auto liability	
	Private Passenger Auto Physical Damage	Privatepassenger auto physical damage	
	Special Property	Fire	
		Allied lines	
		Earthquake	
		Glass	
		Burglary and theft	
Commercial	Commercial Multiple Peril	Commercial multiple peril (non-liability portion)	
		Commercial multiple peril (liability portion)	
	Financial /Mortgage Guaranty	Mortgage guaranty	Not used
		Financial guaranty	Not used
	Other Liability	Other liability	
		Other liability - occurrence	
		Other liability - claims made	
	Products Liability	Products Liability	
	Commercial Auto Liability	Commercial auto no-fault (personal injury protection)	
		Other commercial auto liability	
	Commercial Auto Physical Damage	Commercial auto physical damage	
	Fidelity/Surety	Fidelity	Not used
		Surety	Not used
	Special Liability	Aircraft (all perils)	
		Boiler and machinery	
	Credit	Credit	Not used
	Warranty	Warranty	Not used
Workers' comp	Workers' compensation	Workers' compensation	
Med Mal	Medical Professional Liability	Medical Professional Liability	
Ocean Marine	Ocean Marine	Ocean Marine	
Inland Marine	Inland Marine	Inland Marine	

Notes: The table shows the categorization of lines of insurance in this study.