Software Adoption Through the Lens of Directed Technological Change*

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Abstract

Business software and associated technological tools are becoming ubiquitous, but we have little evidence on why firms voluntarily adopt them. To address this, we study how accounting software adoption by private firms responds to labor market conditions. We first show that adoption is increasing in accounting wages and decreasing in the number of accountants in a given market. We confirm this finding in a Bartik-style estimation that exploits the passage of the Sarbanes-Oxley Act and differences in states' pre-Act exposure to public company accounting labor markets. Software adoption frees up accountants to focus on operational and strategic tasks, and enables the implementation of management accounting practices such as inventory management and demand planning. Adoption also reduces the seasonality of accounting labor demand. Our results illustrate how labor market scarcity can induce technology adoption, consistent with models of directed technological change.

JEL Classification: M41, M48, G30, G31, L51, O33, J23
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1. Introduction

Technological advances are transforming commerce—the tools available to firms, the mix of labor and capital employed in operations, and the tasks performed by employees (Kogan et al. 2023; Kalyani et al. 2025). These developments have raised questions from both researchers and practitioners around the drivers of technology adoption, as well as the outlook for professionals and students amidst continued technological advances (Friedman, Sutherland, and Vetter 2025). One body of work focuses on regulation as an important adoption driver, as firms implement software and other tools to comply with new reporting standards (Kim et al. 2023) or internal control requirements (Charoenwong et al. 2024), and monitor employee behavior for industry violations (Heese and Pacelli 2024).

However, much technology adoption is voluntary, and voluntary adoption determinants are not well understood. In this paper, we explore one particular theory of voluntary adoption—directed technological change—for its potential to explain business software adoption. In directed technological change models (e.g., Acemoglu 2002, 2010), input factor scarcity spurs innovations that reduce reliance on that given factor, leading to adoption and reduced reliance on that factor subsequently. The theory has its roots in Habbakkuk's hypothesis from the economic history literature (Habbakkuk 1962) and Hicks' (1932) theory of wages. The theory is used to explain, among other developments, countries' differential growth during the industrial revolution and the creation, initial adoption, and propagation of the spinning jenny, water frame, and carding machine in the eighteenth century. To illustrate using a software example that is the focus of this paper, when firms encounter labor scarcity, such as when regulation increases demand for accountants, the theory would predict that firms search for labor-saving tools, such as accounting software.

To test this, we examine accounting software adoption among private industrial firms (i.e., not audit firms) in the early 2000s. In our sample of firms newly adopting accounting software,

the median firm has 20 employees and is 15 years old. Focusing on private firm software adoption during this episode allows us to explore meaningful changes in technology use—the 2003 Current Population Survey reports that just 55% of employees used a computer at work, and only 40% connected to the internet or used email while on the job (U.S. Bureau of Economic Analysis 2003).

We identify private firms and software adoption based on task descriptions provided in a large set of resumes from the Revelio database. Our sample contains 57 million jobs from 33 million employees working at 2.4 million private firms. We develop a dictionary of terms indicating an employee's involvement with their employer's adoption (e.g., mentioning "install QuickBooks" or "accounting system implementation" on their resume during a specific employment spell), similar to Babina et al. (2024). We then aggregate our resume-based measures to the state-year level, and examine how adoption patterns (i.e., the number of firms first adopting accounting software that year) vary with labor market conditions.

Survey evidence and software reviews from our sample window indicate that private firms of the sort we study almost exclusively relied on labor for their accounting tasks. These firms typically dealt with financial statement preparation in one of two ways (AICPA 2004; Kawamoto 2004; Bertolucci 2005). First, employees—sometimes accounting managers, other times financial managers or owners—prepared financial statements, often using spreadsheets or paper records. Second, external accountants would prepare the financial statements, either because the firm did not have internal accounting help or because they preferred outsourcing accounting functions.[1] In both cases, the firm is exposed to shifts in prevailing wages in the accounting labor market. They can respond to these changes by adopting software, either through substituting for their internal accounting help (the first case), or as part of an "insourcing" effort (the second). Alternatively, as

[1] The AICPA (2004) survey reports financial statement preparation approaches by firm size. Forty percent of firms with under $5 million of revenue use someone internally, while 58% use an outside accountant. For firms with between $5 million and $25 million of revenue (>$25 million of revenue), the shares are 71% and 29% (83% and 14%), respectively.

U.S. private firms face no reporting or audit mandates, they could respond to tighter labor market conditions by reducing accounting output (e.g., by decreasing the frequency, length, or verification of financial reports).

Our initial tests examine software adoption as a function of wages for accountants and the number of accountants in a given state the previous year, state and year fixed effects, and GDP and unemployment controls. Our results provide initial support for the directed technological change hypothesis. Adoptions correlate with measures of accounting labor scarcity: adoption increases with accounting wages, and decreases with the number of accountants. Economically, a one-dollar increase in hourly wages is associated with a 1.5% increase in the number of firms adopting accounting software.

To more rigorously test the link between wages and software adoption, we employ a Bartik-style estimation that exploits the labor demand shock resulting from the passage of the Sarbanes-Oxley Act ("SOX"). By significantly enhancing reporting and audit standards for *public* firms, the regulation generated large spillovers to *private* firms not subject to the rule but relying upon the common, rather inelastic accountant labor pool.[2] The second piece of our empirical strategy utilizes pre-SOX differences in states' exposure to public company accounting labor markets, as measured by the ratio of the number of accountants to the number of public firms. Intuitively, holding constant the number of accountants in a state, those states with more public firms will experience a bigger post-SOX labor demand shock, leading to higher wages and a smaller pool of accountants available to private firms. A complementary interpretation is that states with fewer accountants per public firm have less "slack" to absorb the SOX demand shock. For brevity, throughout our paper we refer to such states as "shortage states."

[2] Supporting this, audit fee increases for non-accelerated filers not subject to SOX exceeded 40% (Ettredge, Sherwood, and Sun 2018), and private firms reduced their propensity to provide attested financial statements to their banks (Duguay, Minnis, and Sutherland 2020).

We validate our empirical approach in multiple ways. First, we document CPA firms and regulators discussing an accountant shortage and large audit firms aggressively seeking talent from unconventional sources following the SOX enactment (PCAOB 2005; Haskell & White 2006). Second, we develop a dataset of job transitions, and find elevated accountant switching from private firms or small audit firms to public firms or the Big-5 audit firms that typically audit them post-SOX. Notably, the switching increase is starkest in shortage states—those with the lowest ratio of accountants to public firms. Third, we find the greatest post-SOX accountant wage increases in these same states, in line with the theoretical construct of factor cost shocks incentivizing adoption in Acemoglu (2002, 2010).

Results from our Bartik-style estimation reinforce our initial findings: following SOX, software adoption increases more in shortage states. This finding is not sensitive to alternative approaches to measuring shortages or gleaning software adoption information from resumes. Moreover, placebo tests indicate that we are not merely picking up a common investment trend unrelated to the labor shortage construct: anti-virus software adoption does not vary with our accounting labor market measures in the post-SOX period.

Next, we examine the consequences of voluntary accounting software adoption, beginning with reallocation of accountant time. Naturally, these tests apply only to those firms initially relying on internal employees to prepare financial statements—the "first case" firms mentioned earlier. Intuitively, automation technology displaces labor from routine tasks (Acemoglu and Restrepo 2018), and those employees remaining with their firm may be assigned to other, less automatable tasks. Indeed, QuickBooks advertisements state "accounting software should be such that it automates your accounting process *so that you get time on your side for core business activities*" (emphasis added).[3]

[3] https://quickbooks.intuit.com/global/resources/accounting-and-bookkeeping/cloud-accounting-software/

Consistent with the first part of this claim, we find a greater decline in accountants employed in the post-SOX period in shortage states. To investigate the second part, we track accountants' operations and strategy tasks over time using position descriptions on their resumes. Some of the most common operations and strategy tasks we identify involve purchasing/procurement and strategic planning. Our instrumental variables analysis finds an increase in accountants' operations and strategy tasks.

Motivated by these findings, we then focus on reassignment to tasks related to management accounting practices. We once again rely on accountant resumes to identify individual involvement in management accounting practices (common ones include cash flow management, variance analysis, and cost accounting). Our instrumental variable tests find a significant reassignment to management accounting practices. Subsequent tests indicate that these results reflect firms picking up some new practices altogether, particularly those related to inventory management and demand planning, and not merely shuffling employees among existing practices.

Finally, we study the seasonality of accounting labor demand. Given the preponderance of December 31 fiscal year ends, accounting labor demand is highly seasonal. As a result, "busy season" is a defining characteristic of accounting work, and has been linked to attention and work quality issues that lead to audit failures (Sundgren and Svanstrom 2014; Maksymov et al. 2024). We find accounting software adoption is associated with less concentration in accounting job start dates and fewer January start dates, consistent with software adoption reducing the seasonality of private firm accounting labor demand.

Overall, our consequences tests indicate that accounting software adoption enables firms to redeploy those involved in the accounting function to operational tasks, fosters information environment improvements that render management accounting practices more feasible and worthwhile, and reduces the seasonality of accounting labor demand.

We make three contributions. First, our paper adds to the burgeoning literature studying technology adoption in firms (Bloom, Sadun, and Van Reenen 2012; Fedyk et al. 2022; Babina et al. 2024; Law and Shen 2024; Charoenwong et al. 2024; Kalyani et al. 2025). We add to this work by documenting one specific mechanism behind voluntary technology adoption, thus providing some helpful context for understanding the consequences of this adoption. Analyses of technology adoption consequences inevitably raise questions about why and when firms adopt in the first place. Our results indicate that labor market conditions are an important adoption driver. Additionally, we find that adoption enables firms to implement a number of new management practices. Smaller firms like those we study tend to be less sophisticated, and while there is evidence that such practices can improve productivity and profitability (Drexler, Fischer, and Schoar 2014; Bruhn, Karlan, and Schoar 2018), practice implementation has proven challenging to study in large samples (Bloom and Van Reenen 2007).

Second, our evidence adds to ongoing discussions of how technological changes are affecting professional labor markets (Kogan et al. 2023; Eloundou et al. 2024; Friedman et al. 2025). Acemoglu and Restrepo (2018) highlight how "white-collar workers in accounting… and some managerial occupations are seeing some of the tasks they used to perform being replaced by specialized software and artificial intelligence" (p. 4). Thus, our displacement and reinstatement evidence add to analyses of labor demand (Boke et al. 2024; Eloundou et al. 2024; Friedman et al. 2025).

Last, we provide large sample evidence on the role of software in private firms' financial statement *preparation* (i.e., distinct from verification or disclosure). The limited empirical work on preparation tends to condition on banking relationships rather than study preparation more generally (Allee and Yohn 2009; Cassar, Ittner, and Cavalluzzo 2015) or analyze the choice to follow accrual accounting (Lisowsky and Minnis 2020). An AICPA survey conducted in 2004

explored the extent to which preparation depends on internal versus external accounting labor (AICPA 2004). In the ensuing two decades, software has emerged as a leading preparation approach, and our analyses shed some light on how and why this transition occurred.

2. Theoretical Foundations

Technology adoption at firms has been traced to several motives, including compliance (Kim et al. 2023; Charoenwong et al. 2024; Heese and Pacelli 2024), strategic considerations (Liberti, Sturgess, and Sutherland 2022), and risk management (Kim 2024). The motive we focus on relates to factor market conditions for the firm's production inputs. Specifically, directed technological change models posit that technological innovation and adoption can often be traced to factor scarcity, labor in particular. As Acemoglu (2010) explains, "if a factor becomes more expensive, the demand for it should decrease, and we may expect some of this adjustment to take place by technology substituting for tasks previously performed by that factor" (p. 1039) (see also Hicks 1932).

Directed technological change models build upon the Habbukuk hypothesis in economic history (Habbukuk 1962). Habbukuk posited that labor scarcity was an important driver of the across-country differences in industrial development during the nineteenth century: "It seems obvious—it certainly seemed so to contemporaries—that that the dearness and inelasticity of American, compared to British, labour gave the American entrepreneur with a given capital a greater inducement that his British counterpart to replace labour by machines" (p. 17). The Habbakuk hypothesis has been used by Allen (2009) and Elvin (1972) to explain the link between wage levels and adoption of the spinning jenny, water frame, carding machine, and spinning wheel.

The directed technological change framework is useful for understanding firms' choice to adopt business software, including accounting software, in the early 2000s period we study.

Accounting processes around this time were labor-driven, with firms relying on accounting labor to help with financial statement compilation, verification, analysis, and reporting. As summarized in the introduction, this accounting labor reliance took two forms. First, firm accountants or managers prepared financial statements, often using spreadsheets or paper records. Second, external accountants would prepare statements for firms lacking internal accountants or preferring outsourcing.

The two cases share a common theme of exposure to the accounting labor market that could affect firms' willingness to consider alternative preparation approaches, including software adoption.[4] Notably, during this same period, the accounting labor market was subject to multiple forces that contributed to labor scarcity, including the passage of SOX as described in the next section, as well as the preponderance of December 31 fiscal year ends that results in "busy season" for accounting work. Compounding this, much accounting work is performed by Certified Public Accountants (CPAs), who face significant licensing requirements that inhibit the responsiveness of the labor supply to demand shocks.[5] Even the unlicensed staff accountants working for audit firms or public companies take classes and undergo training spanning multiple years, given the specialized nature of accounting work, adding another source of accounting labor supply inelasticity.

Turning to the consequences of technology adoption, Acemoglu and Autor (2011) and Acemoglu and Restrepo (2018) show how novel technologies—which expand the degree to which capital (e.g., information technology investments) can substitute for labor—affect the *tasks* performed by professionals. On the one hand, technology can displace tasks. For example, basic

[4] Offshoring was far less common in the early 2000s than today, and we expect offshoring to be used exceedingly rarely for the small private firms dominating our sample.

[5] For example, the Uniform Accounting Act "reserves the issuance of reports in standard form on audited, reviewed and compiled financial statements and other attest information to licensees who have demonstrated qualifications to perform attest and compilation services" (UAA 2018).

accounting tasks such as consolidation, report generation, or invoicing can be automated by software. On the other hand, technology can also create or enable new higher-productivity tasks, which Acemoglu and Restrepo label as a reinstatement effect. For example, the automation of basic accounting tasks enables time-constrained managers to turn their attention to more operations- and strategy-oriented tasks which are difficult to automate, such as production planning or operations management.

3. Setting, Sarbanes-Oxley Act, and Data

a. Setting

We study accounting software adoption at U.S. private firms. Private firms maintain relatively unsophisticated accounting systems—most do not undergo audits, and many do not even use GAAP (Allee and Yohn 2009; Lisowsky and Minnis 2020). In the early 2000s era of our sample, reliance on internal and external accounting labor for compilation and assurance services was common. For example, a 2004 AICPA survey of private firms indicates that over 80% of participants prepare financial statements, and that preparation is most commonly handled by internal financial managers, followed by outside accountants (AICPA 2004). This reliance was ripe for disruption, as computers became widely adopted and business software was increasingly capable of taking over tasks that employees typically handled.

One particularly noteworthy development around this time was the growth in QuickBooks accounting software, produced by Intuit. Intuit was started in 1983 by Scott Cook and Tom Proulx as a personal finance software company (HMS 2023). By the late 1980s, their product Quicken was among the best-selling tools in the personal finance software category, and they began entering the commercial market with QuickPay, a payroll processing tool. In 1992, Intuit launched QuickBooks, an accounting software application aimed at small business owners with little or no formal accounting knowledge.

Subsequent versions of the software included expanded functionality, double-entry bookkeeping, full audit trail capabilities, and industry-specific licenses. During our sample period, QuickBooks became widely adopted by small and medium sized businesses, and to a modest extent, professional accountants and consultants. A 2005 Businessweek article estimated that QuickBooks had a 74% market share of the retail (i.e., SME) market, and three million customers (Lacy and Greene 2005). Its SimpleSmart edition was popular with business owners lacking expertise in accounting, and priced competitively at $99. "Premier" and "Enterprise" editions priced at $499 and $3,500, respectively (Lacy and Greene 2005). One business owner stated that the software saved her 10 hours per week, explaining "I needed something I could just let do the work for me." QuickBooks' success attracted competitors to the accounting software market, and we include these vendors in our adoption analysis described in the next section.

While adopting accounting software can help firms reduce their preparation time and effort, there are costs that factor into the decision beyond the price of a software license. Adopting first requires having a personal computer, and, depending on the particular software product, an internet connection. The direct costs of these requirements may be modest. However, the indirect costs can be significant. In the early 2000s period preceding the regulatory change we study, adopting accounting software required a "leap of faith" for many business owners lacking training or experience in business software applications.[6] This is particularly true for the private firms that QuickBooks and other vendors were targeting. As we discuss later, the typical firm in our sample is small (under 50 employees), led by an owner without a university degree, and disproportionately involve construction and related services. Moreover, it seems natural that in these years of emerging software growth, some business owners would remain leery of sharing sensitive financial

[6] To illustrate, in 2003 only 63% of U.S. households reported having a computer, and the figure is only 39% for individuals with just a high school education or lower (BLS 2010).

information, particularly if they perceived a risk of their information being hacked, lost, shared on the web, or reported to the Internal Revenue Service. Overall, although accounting software licenses per se were not particularly expensive, there existed meaningful financial, educational, and psychological barriers to adoption.

b. Sarbanes-Oxley Act

In 2002, U.S. Congress passed the Sarbanes-Oxley Act in the wake of multiple major accounting scandals. Section 404 of SOX requires a public firm's management and auditors to report on the adequacy of the internal controls over financial reporting (Iliev 2010; Ge, Koester, and McVay 2017). Accelerated filers were required to comply with these internal control reporting provisions beginning in fiscal years ending on or after November 15, 2004. This represented one of the most consequential changes in securities regulation in the past half century, and resulted in a significant demand shock for accounting labor particularly to help with developing, documenting, and testing controls and meeting new disclosure requirements. The demand shock applied to both audit firms and the client companies whose financial statements they audit.

These developments are relevant to the private firms in our sample because the market for CPA services and accountants more broadly is a common one: private firms and public companies regularly access a similar pool of CPAs and accountants. So, when new securities regulation introduces a substantial accounting labor demand shock for public firms, accounting labor becomes scarcer for private firms and other nonpublic entities. The responsiveness of the labor supply to these demand shocks is shaped in part by licensing restrictions: CPAs comprise much of

the accounting labor pool, and due to licensing restrictions (Barrios 2022; Sutherland, Uckert, and Vetter 2024), their supply is rather inelastic (Cascino, Tamayo, and Vetter 2021).[7]

Therefore, accounting labor demand shocks can propagate across different segments of the market. Regulator, employer, and media accounts from the SOX-era support this assumption. A PCAOB commentary on SOX implementation challenges explains:

> The first year of internal control reporting was enormously challenging for all involved. Section 404 of the Sarbanes-Oxley Act prompted the biggest change in the auditor's work in 70 years… *There was a shortage of personnel; especially experienced people. We know that the major firms were scrambling for personnel*. (PCAOB 2005; emphasis added).

Haskell & White, a mid-sized accounting firm serving both private and public companies from pre-revenue to $500 million, authored a 2006 report titled "Accountant Deficit" stating[8]:

> Accountants are in such high demand in Southern California that Haskell & White LLP has offered to pay its employees $20,000 if they refer an experienced accountant to the firm and the candidate is hired.
>
> Demand for accountants really took off after the passage of Sarbanes-Oxley legislation in 2002, which put new burdens on the accounting done by public companies. Public companies are hiring additional in-house auditors to ensure the accuracy of their financial statements following the high-profile scandals at Enron Corp., Adelphia Communications Inc. and Worldcom Inc. With audits now taking up as much as 60 percent more time to complete, and at higher costs, accounting firms say they are being squeezed as never before. Not only do clients have more complex work for auditors but firms also have fewer experienced accountants to do the work. (Haskell & White 2006).

In terms of academic evidence, Duguay, Minnis, and Sutherland (2020) find that private firms' propensity to provide an attested financial statement to their bank declined by 6.3% following the passage of SOX. Ettredge, Sherwood, and Sun (2018) find that non-accelerated filers *not subject to the Act* experienced audit fee increases exceeding 40%. Those subject to the Act

[7] Nevertheless, we study accounting wages and employment for the accounting occupation generically, because the directed technology adoption hypothesis applies to both licensed CPAs and other accountants, and we cannot separate the two types of workers in our data.

[8] See also the Wall Street Journal commentary titled "Accountant Shortage Solved: Pay them More" https://www.wsj.com/articles/SB111655896101439011

experienced increases exceeding 80%. Collectively, such findings illustrate the inelasticity of the accounting labor supply, and the resulting exposure of private firms to major securities reforms targeted at public firms.

c. Data

We identify accounting software adoption using the employee resume dataset from Revelio Labs. Revelio is a workforce intelligence company that collects unstructured employment records from professional networking websites and other sources, structures the records, and sells them to consulting firms, investors, academics and governments. As part of their data structuring, they extract, clean, and tabulate each employee's job title, start and end date, employer, qualifications, and tasks as the employee describes in their position description. According to Revelio's website,[9] their resume dataset contains "hundreds of millions of publicly available employment records." Given our focus on private firms and our use of Sarbanes-Oxley as an exogenous shock to these firms, we eliminate public firm employers and accounting firms from the sample, but note that this choice does not affect our inferences.

The "description" field and employment dates are key to our adoption identification. Specifically, we rely on employees describing key work activities during each employment spell to identify whether and when their firm adopted accounting technology. We developed a data dictionary of adoption terms based on our research of the accounting software market. Given QuickBooks' dominant share of this market, "QuickBooks" is the most commonly triggered term (over 60% of identified adoptions); however, there are other brands (e.g., "Peachtree" or "Sage 50") and terms ("accounting software" or "financial reporting package") that we rely upon (our criteria are not case sensitive). We employ a broad, generic measure because incorporating

[9] https://www.reveliolabs.com/

different software editions or comparing brands introduces complexity and does little to inform our main analyses. We exclude accounting software that is part of broader ERP software (e.g., "NetSuite") as well as software names that may also refer to other concepts (e.g., "Sunrise" or "Tally"). The full keyword list is presented in Appendix B, and Figure 1 details how frequently individual keywords appear.

We estimate when the firm adopted accounting software using two steps. First, we classify firms as using accounting software in a given year if they have an employee whose job description for that year includes our dictionary terms. Second, we identify the earliest of these years under the classification scheme as the adoption year. Our approach to using resumes from professional networking websites to detect technology adoption is standard in the literature (e.g., Fedyk et al. 2022; Babina et al. 2024). Figure 2 provides example resumes that are representative of the type we identify as demonstrating accounting software use.

The increasingly popular approach of using resume data to infer technology adoption comes with tradeoffs. One on hand, the approach helps researchers develop measures of technology adoption that is otherwise rather difficult to infer from, for example, public filings or company websites. Moreover, the approach allows for analysis of private firms that lack such filings and websites but are important drivers of economic activity (Bernard and Sutherland 2025). On the other hand, individuals in today's labor force may have incentives to overstate their technological skills and experience, such as by embellishing their exposure to artificial intelligence. Strategic behavior of this sort is less relevant to our study, as the motives for embellishing involvement in software adoption *two decades ago* are less clear.[10] Nevertheless, the

[10] Related, LinkedIn (an important data source for Revelio) launched in 2003 and only obtained a sizable user base over the following decade. Thus, many of the software adoption references we study were historical rather than contemporaneous experiences by individuals seeking work.

limitations of the resume-based approach inform our shift-share design, which compares adoption across states during a given year.

For accounting wage and employment data, we access the Occupational Employment and Wage Statistics table from the Bureau of Labor Statistics (BLS). We identify individuals working in accounting based on the occupation code (13-2011; "accountants and auditors"). The BLS is also the source for our macroeconomic control variables. We obtain data on state-year proportion of firms from the Statistics of U.S. Businesses (SUSB). We access Dun & Bradstreet to estimate the number of employees for each company in our Revelio dataset (e.g., Black and Strahan 2002; Barnatchez, Crane, and Decker 2017).

d. Summary statistics

Table 1 presents summary statistics for the state-year level variables used in our main tests.[11] Our sample spans 1999-2008. The median (average) state-year has 41 (87) instances of accounting software adoption. In terms of our accounting labor variables, the median (average) hourly wage is $24.68 ($24.92) and there are 11,360 (19,375) accountants (Standard Occupational Classification: 13-2011). To assess accounting labor scarcity, we scale the number of accounting workers by the number of Compustat firms in the state-year. The median (mean) of this scaled variable is 239 (327). Half of our observations are from the post-SOX period beginning in 2004.

4. Research Design and Results

a. Accounting software adoption

[11] We use state-level measurement because Revelio's more granular geographic variables (e.g., MSA) are unstandardized.

Our initial tests model accounting software adoption using the following Poisson specification (Cohn, Liu, and Wardlaw 2022) for the count variables and OLS for the ratio variables:

$$y_{s,t+1} = AcctWage_{s,t} + AccEmp_{s,t} + GDP_{s,t} + Unemp_{s,t} + \alpha_s + \alpha_t + \varepsilon_{s,t}. \quad (1)$$

The unit of observation is state-year, where *s* indexes states and *t* indexes years. The sample spans 1999-2008, such that there are five pre-SOX years and five post-SOX years. The dependent variable is $AcctSW_{s,t+1}$, the number of firms adopting accounting software the following year. We measure the dependent variable in year t+1 to avoid issues related to reverse causality. *AcctWage* and *AccEmp* are the average hourly accountant wage and log ratio of the number of accounting workers to the number of Compustat firms in the state-year (scaling accounts for state size differences). We control for log GDP and the unemployment rate in the state-year. We also control for state fixed effects (α_s) to account for time-invariant state-level firm composition and labor market characteristics, and year fixed effects (α_t) to account for the overall state of the economy and its effect on accounting software adoption. We cluster standard errors by state.

As an initial step, we include the accounting wage and employment variables separately. Table 2 presents the results. Column 1 shows that accounting wages in a given year predict accounting software adoption in the following year. Column 2 studies accounting employment, and finds that having more accounting workers per Compustat firm in the state-year is negatively associated with software adoption in the following year. Column 3 includes both the wage and employment variables in the same regression, and our findings are similar: accounting software adoption follows periods of high accounting wages and fewer accounting workers in the state-year. Economically, the 0.015 $AcctWage_t$ coefficient implies that a one-dollar increase in accounting hourly wages is associated with a 1.5% increase in the number of firms adopting accounting

software.[12] The -0.091 coefficient on *AcctEmp* implies that a one standard deviation increase in the pooled sample (within-state) accounting employment is associated with 5.7% (2.9%) less adoption. The median (average) firm that newly adopts accounting software in our sample period has 20 (74) employees, are 15 (26) years old, and disproportionately comes from the engineering and construction, information technology services, and healthcare and wellness services industries.

b. Bartik

Our next analyses employ a Bartik-style estimation (e.g., Bartik 1991; Breuer 2022) to examine the drivers of accounting software adoption, using the following Poisson estimation for the count variables and OLS for the ratio variables:

$$y_{s,t} = Shortage_{s,pre} \times SOX_t + GDP_{s,t} + Unemp_{s,t} + \alpha_s + \alpha_t + \varepsilon_{s,t}. \quad (2)$$

The unit of observation is state-year, where *s* indexes states and *t* indexes years. The sample spans 1999-2008. As before, the dependent variable is *AcctSW*, the number of firms adopting accounting software that year. *Shortage* is an indicator variable equal to one for states in the lowest tercile for the average ratio of accountants to Compustat (i.e., public) firms, *measured in the pre-SOX period* (1999-2003) (i.e., before the regulatory change to avoid mechanical issues, hence the *pre* subscript). *SOX* is an indicator variable equal to one starting in 2004, the first year of compliance with Section 404 provisions for accelerated filers. Similar to Equation (1), we control for log *GDP* and the unemployment rate in the state, as well as state fixed effects (α_s) to account for time-invariant state-level firm composition and labor market characteristics, and year fixed effects (α_t) to account for the overall state of the economy and its effect on accounting software adoption. We cluster standard errors by state.

[12] A one standard deviation increase in the pooled sample (within-state) accounting hourly wages is associated with a 7.0% (5.4%) increase in the number of firms adopting accounting software.

Intuitively, our estimation compares how states with more versus less exposure to the SOX shock differ in their post-SOX accounting software adoption patterns. To illustrate, consider two states, A and B. Both states have 1,000 accountants, but state A has one public firm while state B has five public firms. Our analysis compares software adoption rates in the two states during the post-SOX period, while controlling for state and year fixed effects and GDP and unemployment. Under a directed technology adoption hypothesis, state B should have higher post-SOX accountant wage increases than state A, because state B faces a greater SOX-induced shortage.[13]

We validate the assumptions underlying our empirical approach in multiple ways. First, Section 3.b discusses institutional and academic evidence of an accountant shortage following SOX (PCAOB 2005; Ettredge et al. 2018; Duguay et al. 2020). Second, we use Equation (2) to study job transitions between private firms and smaller (i.e., not Big-5) accounting firms to public firms and the Big-5 accounting firms that typically audit them. If the labor market for accountants is shared as the Section 3.b evidence suggests, then we should see elevated transition rates, particularly in states with more public firms. Table 3 presents evidence consistent with this prediction: column 1 shows a positive coefficient for *SOX*, indicating more job switches to public firms and Big-5 accounting firms, and column 2 shows a greater increase in shortage states. Figure 3, Panel A presents an event-time version of the column 2 regression results, and finds that the switching increase is concentrated in the post-SOX period.

Third, we examine accountant wages. We find that in the post-SOX period, accounting wages increase generally (column 3), and more so in shortage states (column 4), thus supporting our assumption that SOX generated a meaningful shift in the cost of accounting labor to private

[13] A potential concern is that SOX might not create a shortage for states with a low accountants-to-public-firm ratio if, before SOX, a large majority of accountants already worked for private firms or at non-Big 5 audit firms, thus allowing the state to absorb the extra demand from public firms. However, we find that high *Shortage* states have lower percentage of accountants working for private firms or non-Big 5 audit firms (71%), compared to low *Shortage* states (89%).

firms. Once again, we validate our inference in event-time plots in Figure 3, Panel B and find little indication that our findings stem from pre-SOX wage trends. Economically, states in the top scarcity tercile experience a $1.11 greater increase in accounting wages compared to states in the bottom tercile, and this difference represents 37% of the within-state standard deviation in accounting wages.

Table 4 then presents our results of modelling software adoption using Equation (2). Column 1 finds that in the post-SOX period, there is more accounting software adoption in shortage states, reinforcing our Table 2 inference that labor scarcity drives technology adoption. Column 2 examines a complementary specification based on indicator variables for terciles of *Shortage*, and finds the greatest adoption for the most labor-constrained states.

We then conduct several analyses to strengthen our inferences. First, Figure 3, Panel C presents an event-time version of column 2. In the pre-SOX period (i.e., before 2003), there is no statistical software adoption difference across high and low *Shortage* states. Then in 2004, states with a greater shortage during the pre-period see a jump in adoption, consistent with SOX inducing a major shift toward software- from labor-based accounting work. This evidence supports a causal interpretation of our Table 4 results, as opposed to an interpretation based on pre-existing trends or concurrent events uncorrelated with accounting labor shortages.

Second, Table 5 assesses the sensitivity of our results to alternative specifications. Panel A examines a *Shortage* measure with a denominator based on the total market capitalization of public firms in the state. This allows the shortage effect to vary with firm size. We continue to find more switching, greater wage increases, and more software adoption in shortage states.

Another concern is that changes in the number or size distribution of private firms in the state could confound our estimation. Panel B adds controls for the number of private firms (column 1), and the size distribution of private firms (HHI in column 2 and number of firms with fewer

than 100 employees in column 3). We continue to find a significantly positive coefficient on *Shortage*×*SOX*. Panel C then scales our adoption count measure by the number of private firms in the state-year, and re-estimates equation (2). Our inferences are similar: labor shortages are associated with more software adoption in the post-SOX period.

Another concern is that measurement error related to our attempt to identify software adoption using resumes somehow biases the results in our favor. We therefore repeat our tests using an adoption variable based only on resumes including references to "QuickBooks," which unambiguously captures accounting software use. Panel D shows that our results are similar.

Then, we address a broader concern that our results are simply picking up a technology adoption trend that has little to do with accounting labor market conditions or demand for accounting software. For example, our early 2000s sample period coincided with widespread growth in the number of firms adding computers, software, and websites; this adoption may be difficult to model and could correlate with our labor market variables of interest. Therefore, we conduct a placebo test where the dependent variable measures anti-virus software adoption (as identified from employee resumes) rather than accounting software adoption. Under a trend explanation, we should find greater post-SOX adoption for shortage states. However, Panel E reports an insignificant coefficient on *Shortage* x *SOX*.

Overall, our evidence in this section is most consistent with accounting software adoption following from labor scarcity induced by the enactment of the Sarbanes-Oxley Act.

5. Accounting Software Adoption Consequences

In our next set of tests, we investigate how accounting software adoption affects the reassignment of employees involved in the accounting function to new tasks, the implementation of management accounting practices, and the seasonality of accounting labor demand.

a. Task reassignment: Operations and strategy

As a first step, we examine the change in the number of accountants in the state-year, scaled by the total number of private firms according to Revelio. Table 6, Panel A shows that, using both Equation (2) and our instrumental variables framework, there is a greater private firm accountant decline in the post-SOX period in shortage states. This evidence, combined with our earlier results linking labor scarcity to software adoption, points to displacement of accountants and motivates our next analyses of new tasks accountants may take on ("reassignment"). Further motivating these reassignment analyses is the QuickBooks advertisement shown in Figure 4, Panel A claiming that their software frees up accountants to work on "core business activities."

To explore task reassignment empirically, we examine the non-accounting tasks listed on accountants' resumes, as recorded by Revelio. Specifically, we examine the same sample of private firms we use to identify accounting software adoption in our main tests, and see whether the proportion of accountants with new tasks related to operations and strategy changes. To do so, we create a dictionary of operations and strategy keywords that are included in the following three Revelio skill groups: 1) budget management / reporting / reporting & analysis; 2) operations management / inventory management / logistics; and 3) strategic planning / team leadership / negotiation. To identify accountant task uptake, our measure then counts the number of accountants in the state-year with job descriptions containing at least one of these keywords, and scale by the number of private firm accountants in the state-year. Appendix B presents the full list of keywords in these Revelio skill groups; the most common examples in our sample include "inventory," "purchasing," "strategic planning," and "logistics."

Table 6, Panel B models task uptake using Equation (2). Column 1 finds more operations and strategy tasks among accountants in the post-SOX period in shortage states. In terms of economic magnitude, compared to the lowest scarcity tercile the highest scarcity tercile has a 0.64

percentage point greater increase in the proportion of accountants with operations and strategy tasks, which corresponds to 1.4 times the within-fixed effects standard deviation. This pattern aligns with our Table 4 results showing that such states see significantly more accounting software adoption.

To more directly trace task reallocation to accounting software adoption, column 2 uses an instrumental variables approach. Specifically, we predict *AcctSW* using OLS regressions based on our Equation (2).[14] Then, we regress our task measure on the predicted value of the number of accounting software adopting firms. Our inference is the same as in the reduced form estimation: there is a reallocation towards operations and strategy tasks, and it is happening through accounting software adoption. We also repeat our tests on a more focused set of operations and strategy keywords, as the "off-the-shelf" Revelio set is broad and contains several terms not directly related to our construct of interest. Columns 3 and 4 show a similar pattern to our original results: more task uptake, and this is happening through accounting software adoption.

b. Task reassignment: Management accounting practices

Next, we use our resume-based approach to identify and study reassignment of accountants to management accounting practices, which are plausibly relevant to displaced accountants. We develop a keyword dictionary referencing common management accounting practices including cash flow management, variance analysis, and cost accounting (Appendix B contains the full set of keywords). Our measure counts the number of accountants in the state-year whose job descriptions contain at least one of these keywords. Then, we scale this measure by the number of accountants in private firms in the state-year according to Revelio, and multiply by 100 to express it in percentage terms.

[14] The first-stage F-statistic exceeds 10 and the p-value is <0.01 in our instrumental variables estimations.

We then use this percentage measure to explore whether accounting software adoption leads to accountants being reassigned to other tasks, in this case management accounting practices. Table 7 presents the results, using Equation (2) (odd columns) and our instrumental variables approach (even columns). Columns 1 and 2 find greater reassignment to management accounting practices post-SOX in shortage states. Economically, column 1 shows that the highest shortage tercile states experience about a 0.36 percentage point greater expansion in management accounting practices than the lowest shortage tercile states, corresponding to 1.24 times the within-fixed effects standard deviation. The instrumental variables analysis in column 2 links this expansion to accounting software adoption.

These results provide support for the hypothesis that accounting software adoption facilitates the implementation of management accounting practices. However, such a result could also derive from the task reallocation documented in Table 6 (i.e., accountants having freed up time), the more structured system of recording and analyzing financial information, or both. To help narrow down the channel, we repeat our tests on a firm sample where there was *no* increase in the operations and strategy tasks of accountants from the pre-SOX period (1999-2003) to the post-SOX period (2004-2008). For this subsample, the task reallocation channel is less likely to be at play. Columns 3-4 find that our coefficients remain significant, suggesting that reallocation alone is unlikely to be producing the increased implementation in management accounting practices. We revisit this later in this subsection.

Table 8 explores which types of management accounting practices accountants are taking on. We assign our management accounting practice keywords into three categories based on the nature of the practice: profitability analysis, inventory/demand planning, and cash flow/risk management (see Appendix B for the full set of keywords for each category). We then model practice take-up for each of the three categories using Equation (2). At this stage we view these

analyses as exploratory and descriptive—we do not have an ex-ante hypothesis for which practice types see the greatest take-up.

Column 1 shows that profitability-related management accounting practices increase more in shortage states after SOX, amounting to a 0.35 percentage point greater expansion in the highest shortage states versus the lowest, which corresponds to about 2.0 times the within-state standard deviation. We observe a statistically significant increase in inventory/demand planning practices as well. By contrast, we do not find a significant increase in cash flow/risk management practices (column 3). Our inferences across these columns are qualitatively similar under the IV approach used earlier (not tabulated for brevity). Thus, it appears that the link between software adoption and accountants' take-up of management accounting practices is driven by profitability analysis and inventory/demand planning.

Our tests thus far in this subsection focus on reassignment of accountants to management accounting practice tasks. A separate question is whether these practices are *new to the firm altogether*. In other words, following accounting software adoption, are accountants merely reassigned to practices that firms are already engaging in, or does adoption help the firm pick up new practices? Indeed, adopting new management accounting practices is more feasible and desirable when the firm has 1) a more structured system of recording and analyzing financial information, and 2) accountants with freed up time as a result of the software adoption (as our prior results show). Management accounting practice tools in many software programs lend support to this possibility: Figure 4 Panels B and C show budgeting, forecasting, and inventory management modules within popular accounting software programs. Additionally, many accounting software programs embed linkages to banking, credit card, payroll, tax, and shipping vendors, enabling new decision and control capabilities even for firms that previously had an external accountant compile their financial statements (Kawamoto 2004). The results in Table 7,

Columns 3 and 4 lend further support to extensive margin expansion of management accounting practices.

Analyses summarized in Figure 5 explore this question. Specifically, we model the number of new firm adopters of each management accounting practice listed in Appendix B using Equation (2). We then present the *Shortage*×*SOX* interaction coefficients, ranking them from largest to smallest, and highlighting those that are statistically significant. No change in new adopters would indicate that our Table 6 and 8 results merely capture reassignment of accountants to existing practices, whereas significantly positive interaction coefficients suggest that firms are picking up the practice for the first time.

We find significant interactions for a number of practices, including supply chain optimization, enterprise risk management, supply management, demand planning, variance analysis, and inventory management. Thus, accounting software adoption appears to facilitate firm-level adoption of a modest number of management accounting practices related to inventory and demand planning.

c. Labor demand seasonality

Our final tests examine the seasonality of accounting labor demand. Intuitively, accounting labor demand is highly seasonal given the large share of firms with December 31st fiscal year ends. Additionally, tax filing deadlines are concentrated several months after: C-corporation (S-corporation) returns are due on or before the 15th day of the fourth (third) month after the tax year's end, which is typically December 31st. Then, software adoption can reduce seasonality by reducing the role for accountants in the production of accounting outputs.

We examine labor demand seasonality in a state-year using two measures. The first measure is the percentage of accountants beginning their jobs in the month of January. The second

is the Herfindahl-Hirschman index (HHI) of the distribution of accountant job start months during the year ($AcctMonth^{HHI}$).

Table 9 presents the results of modeling these two variables using Equation (2) (odd columns) and our instrumental variables approach (even columns). Column 1 shows that post-SOX, the state-level January share declines significantly more in shortage states. In terms of economic magnitudes, the highest tercile shortage states experience a 2.3 percentage point greater reduction in January share than the lowest.

Figure 3, Panel D plots an event-time version of this result, and shows that the January share decline occurs only after the enactment of SOX. Column 2 arrives at a similar inference using our instrumental variables framework. Columns 3 and 4 repeat these tests using the HHI-based measure, and again arrive at similar inferences.

6. Conclusion

Recent technological advances have provided firms with new reporting and managerial tools, which have transformed the mix of labor and capital employed in operations and the nature of work for managers. These developments have raised questions from both researchers and practitioners around the drivers of technology adoption. Our paper examines how labor market conditions drive voluntary adoption of accounting software, drawing on theories of directed technological change. These theories suggest that firms respond to input factor scarcity by adopting labor-saving technologies, thereby reducing reliance on the constrained resource.

Our analysis reveals that accounting software adoption positively responds to accounting labor market scarcity—firms are more likely to adopt in environments with rising accounting wages or limited accounting labor supply. To confirm this finding, we employ a Bartik-style estimation approach, using SOX as a labor demand shock that amplified scarcity in certain regions.

Consistent with the theory, states facing greater shortages exhibit higher adoption rates, highlighting the role of labor market constraints in shaping technology adoption patterns.

We also explore the displacement and reinstatement consequences of software adoption. Adoption leads to a reduction in accountants employed at private firms, consistent with displacement, but also to accountants taking on operations and strategy tasks, consistent with reinstatement. Accountants also add management accounting practice tasks, and in some cases, help their firms implement these practices for the first time. Finally, we show that software adoption reduces the seasonality of accountant hiring.

At this stage, we are unable to draw strong conclusions about whether firms are better off having adopted accounting software. We can, however, offer two interpretations rooted in related work. On one hand, adopting firms' first-best preparation choice may well have been labor-based, and only when faced with labor shortages do they resort to software adoption. Then, the gains from task reassignment and management accounting practice implementation merely serve to subsidize the greater adoption costs that the firm would have preferred avoiding (e.g., Charoenwong et al. 2024). On the other hand, managers at private firms often lack sophistication around basic accounting choices (e.g., Gassen and Muhn 2024). They may not fully grasp the gains from adopting accounting software, especially during the early 2000s era we study when such tools were rather new. Directed technological change models point to a related, more dynamic possibility, whereby there is an interaction between new firm adoption and vendors' investments in new features and customer experience improvements. Future research with firm-level profitability data can explore these possibilities.

Overall, our findings suggest that labor scarcity not only accelerates technology adoption, but also leads to the reassignment of accounting labor within firms and the implementation of management accounting practices.

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Appendix A: Variable Descriptions

Variable	Definition	Source
AcctSW	The number of accounting software adopting firms in the state-year. Accounting software adoption is measured as the first mention of accounting software keywords in resume descriptions. Refer to Appendix B for keywords.	Revelio
$AcctSW^{QB}$	The number of accounting software adopting firms in the state-year. Accounting software adoption is measured as the first mention of 'quickbooks' in resume descriptions. Refer to Appendix B for keywords.	Revelio
AcctWage	The mean wage of accountants (BLS occupation code 13-2011) in the state-year.	U.S. Bureau of Labor Statistics (BLS)
AcctEmp	The total number of accountants (BLS occupation code 13-2011) scaled by the total number of Compustat firms in the state-year, log transformed.	BLS & Compustat
SOX	An indicator variable for years beginning in 2004.	Public
Shortage	Three minus the tercile ranking of mean *AcctEmp* from 1999 to 2003 for each state-year. High *Shortage* corresponds to low *AcctEmp*.	BLS & Compustat
$Shortage_{mid}$	The middle tercile ranking of mean *AcctEmp* from 1999 to 2003 for each state-year.	BLS & Compustat
$Shortage_{high}$	The lowest tercile ranking of mean *AcctEmp* from 1999 to 2003 for each state-year.	BLS & Compustat
TotalFirms	The total number of firms in the state-year according to the Revelio resume dataset.	Revelio
GDP	GDP in the state-year, log transformed.	BLS
Unemp	The unemployment rate in the state-year	BLS
PrivateFirms	The number of private firms calculated as the total number of firms based on SUSB subtracted by the total number of public firms based on Compustat in each state-year	SUSB & Compustat
FirmSizeHHI	The Herfindahl-Hirschman index measuring concentration of firms across employee-size categories. The size categories are firms with fewer than 20, 20–99, 100–499, and 500 or more employees.	SUSB

Firms^{small}	The number of firms with less than 100 employees based on SUSB in each state-year.	SUSB
AntiVirus	The number of antivirus software adopters in the state-year. Antivirus software adoption is measured as the first mention of either 'antivirus' or 'anti-virus' in resume descriptions.	Revelio
AcctPerFirm	The number of accountants (role_k50= "Accountant") employed at private firms in the sample scaled by the number of private firms in the sample.	
OtherTasks (*OtherTasks*^{core})	The number of accountants (role_k50= "Accountant") with job descriptions including operating or strategy keywords (streamlined keywords) scaled by the total number of accountants employed by private firms in the state-year, expressed as a percentage. Refer to Appendix B for keywords.	Revelio
MgAcct (*MgAcct*^{NoTask})	The number of accountants (role_k50= "Accountant") with job descriptions including management accounting practice keywords (excluding firms that experienced an increase in *OtherTasks*^{core} from the pre-SOX period to the post-SOX period) scaled by the total number of accountants employed by private firms in the state-year, expressed as a percentage. Refer to Appendix B for keywords.	Revelio
AcctMonth^{HHI}	The Herfindahl-Hirschman index of the monthly distribution of accountant job start dates, expressed as a percentage.	Revelio
AcctMonth^{Jan}	The percentage of accountants who begin their jobs in January.	Revelio

Appendix B: Keywords

Variable	Keywords
AcctSW	QuickBooks, accounting software, Peachtree, accounting program, financial reporting package, accounting application, accounting package, accounting platform, accounting solution, financial reporting software, ledger software, Sage 50, financial reporting tool, financial reporting application, ledger application, accounting tool, record keeping software, financial reporting platform, FreshBooks, AccountEdge, ledger package, record keeping platform, record keeping program, ledger program, financial reporting solution, ledger platform, financial reporting program, record keeping application, ledger solution, bookkeeping software
$AcctSW^{QB}$	QuickBooks
AntiVirus	antivirus, anti-virus
OtherTasks	KPI reports, order management, complaint management, budget forecasts, purchasing negotiation, invoice processing, reporting & analysis, reporting, supervising, budget monitoring, capital budgeting, schedules, stock control, capacity planning, budget process, supervision, budget management, business operations, purchasing processes, staff management, operating budgets, supplier negotiation, purchase orders, cross-functional team building, department budgeting, purchase management, staff supervision, supervisory experience, cross-functional coordination, Contract management, LTL, logistics management, logistics, warehousing, EDI, global sourcing, demand planning, WMS, warehouse operations, distribution center operations, warehouse management, truckload, transportation, international logistics, steel, spend analysis, supply chain optimization, supply chain management, supplier quality, inventory management, supplier evaluation, inventory control, supplier development, inventory analysis, inventory, supply management, international shipping, customs regulations, shipping, import, IBM iSeries, production planning, forklift operator, strategic sourcing, reverse logistics, building materials, supply chain, freight forwarding, cement, freight, container, purchasing, DOT regulations, air freight, procurement, AS400 system, billing systems, operations management, dispatching, transportation management, ocean, JD Edwards, 3PL, e-procurement, export, trucking, collections, materials management,

	materials, MRP, product marketing, mobile internet, innovation, strategic negotiations, mobile, customer insight, product development, commercialization, start-ups, international project management, strategy, market research, consumer insight, mobile communications, business strategy, negotiation, global business development, product lifecycle management, brand equity, segmentation, international business, strategic consulting, competitive intelligence, strategic planning, internet of things, team leadership, virtual teams, consumer electronics, messaging, business planning, mobile applications, contract negotiation, mobile devices, benchmarking, mobile technology, entrepreneurship, organizational change, cloud applications, product launch, global marketing, product management, agriculture, product strategy, innovation management, small business, competitive analysis, strategic alliances, international marketing, strategic leadership, budgets, strategic partnerships, international trade, strategic thinking, consulting, strategy development, management consulting, technical leadership, thought leadership, market intelligence, advertising research, agribusiness, balanced scorecard, business modeling, consumer behavior, market development, technology management
OtherTasks^{core}	order management, complaint management, purchasing negotiation, stock control, capacity planning, business operations, purchasing processes, staff management, supplier negotiation, purchase orders, purchase management, contract management, logistics management, logistics, warehousing, global sourcing, warehouse operations, distribution center operations, warehouse management, truckload, transportation, international logistics, supply chain optimization, supply chain management, supplier quality, inventory management, supplier evaluation, inventory control, supplier development, inventory analysis, inventory, supply management, international shipping, customs regulations, shipping, import, production planning, strategic sourcing, reverse logistics, building materials, supply chain, freight forwarding, freight, container, purchasing, air freight, procurement, operations management, dispatching, transportation management, e-procurement, export, trucking, materials management, product marketing, innovation, strategic negotiations, customer insight, product development, commercialization, international project management, strategy, market research, consumer insight, business strategy,

	global business development, product lifecycle management, brand equity, segmentation, international business, strategic consulting, competitive intelligence, strategic planning, business planning, entrepreneurship, contract negotiation, product launch, global marketing, product management, product strategy, innovation management, competitive analysis, strategic alliances, international marketing, strategic leadership, strategic partnerships, international trade, strategic thinking, consulting, strategy development, management consulting, market intelligence, advertising research, business modeling, consumer behavior, market development
MgAcct	cash flow forecasting, managerial finance, cost accounting, variance analysis, management accounting, financial forecasting, enterprise risk management, risk, cash flow, financial management, working capital management, contract management, supply chain optimization, supply chain management, inventory management, inventory analysis, production planning, strategic sourcing, demand forecasting, supply chain, operations management, KPI reports, budget forecasts, budget monitoring, capital budgeting, budget process, budget management, operating budgets, department budgeting, demand planning, spend analysis, demand forecasting, benchmarking, balanced scorecard
$MgAcct^{profitability}$	cost accounting, variance analysis, management accounting, KPI reports, budget forecasts, budget monitoring, capital budgeting, budget process, budget management, operating budgets, department budgeting, spend analysis, benchmarking, balanced scorecard
$MgAcct^{cashflow}$	cash flow forecasting, managerial finance, financial forecasting, enterprise risk management, risk, cash flow, financial management, working capital management
$MgAcct^{inventory}$	contract management, supply chain optimization, supply chain management, inventory management, inventory analysis, production planning, strategic sourcing, demand forecasting, supply chain, operations management, demand planning, demand forecasting

Figure 1: Measuring Accounting Software Adoption
This figure presents the keywords we use to identify accounting software adoption. Count is the number of resume descriptions containing each keyword in our sample.

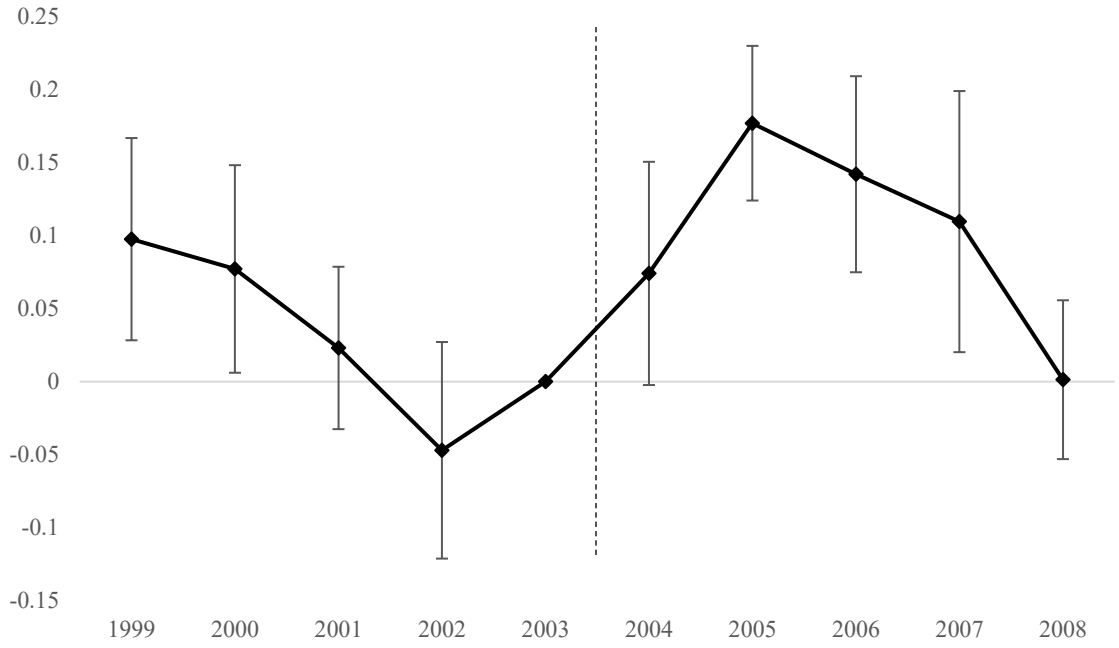
Keywords	Count
quickbooks	91,064
accounting software	28,698
peachtree	11,253
accounting program	3,366
financial reporting package	2,744
accounting application	1,978
accounting package	1,355
accounting solution	980
accounting platform	787
sage 50	587
financial reporting tool	500
financial reporting software	359
ledger software	341
accounting tool	312
financial reporting application	279
ledger application	201
financial reporting solution	103
record keeping software	95
freshbooks	80
financial reporting platform	75
record keeping program	74
accountedge	70
ledger package	68
financial reporting program	58
ledger platform	47
ledger program	46
record keeping platform	46
ledger solution	28
record keeping application	28
book keeping software	16

Figure 2: Example Resumes
This figure presents examples of resumes that we identify as indicating the use of accounting software at the firm. To preserve anonymity, we have redacted the employer and firm names.

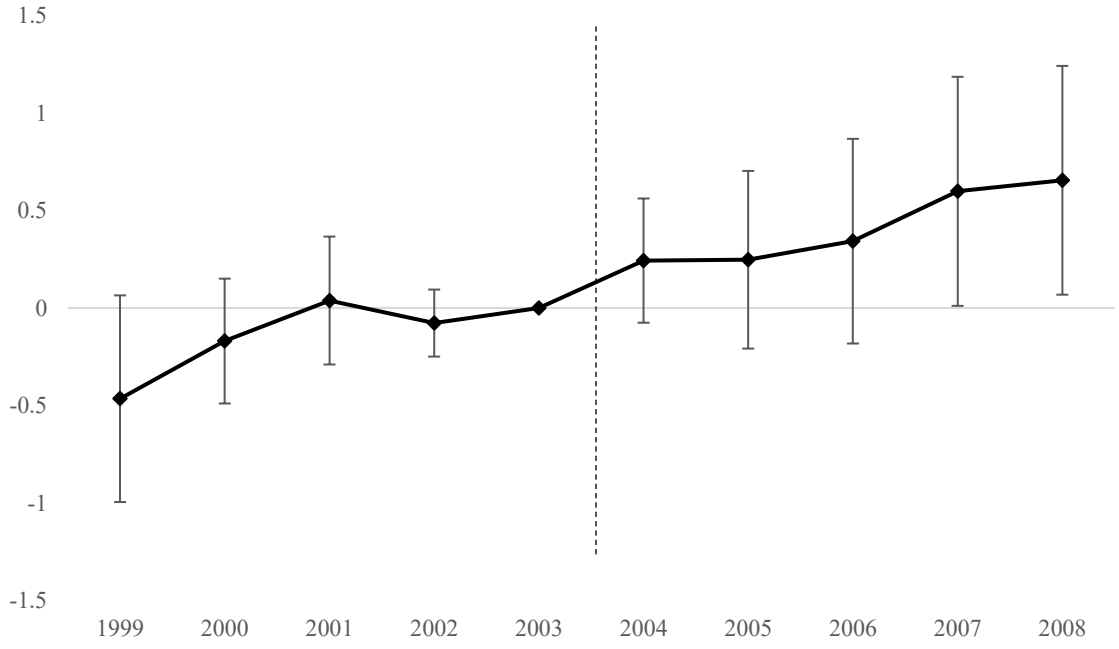


Figure 3: Event Time Plots
This figure plots the coefficients and 90% confidence intervals from an event time version of Equation (2). Each panel title notes the dependent variable. The holdout year is 2003.

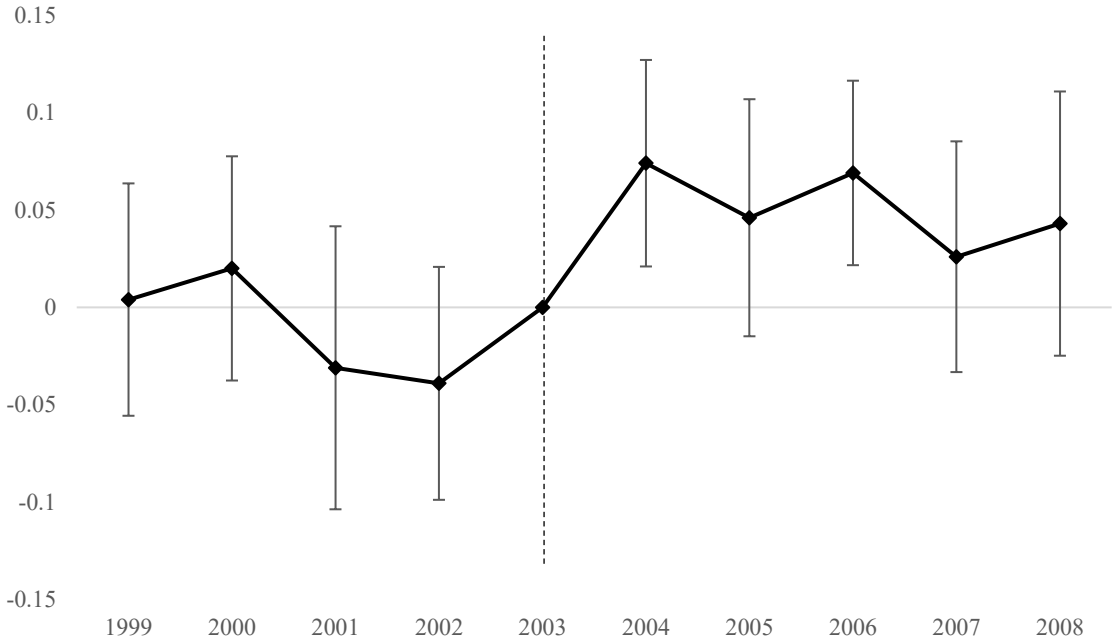
Panel A. Accountant Job Switches to Public Firms or Big 5 Audit Firms (AcctSwitch)



Panel B. Accountant Wages (AcctWage)



Panel C. Accounting Software Adoption (*AcctSW*)



Panel D. Seasonality in Accountant Hiring ($AcctMonth^{Jan}$)

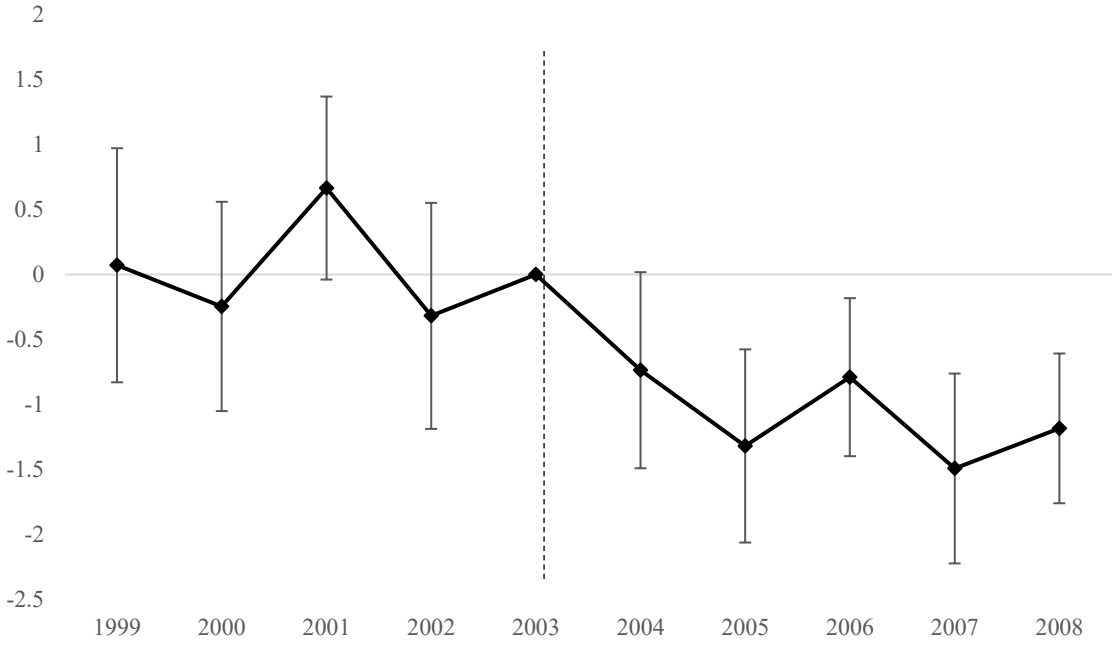
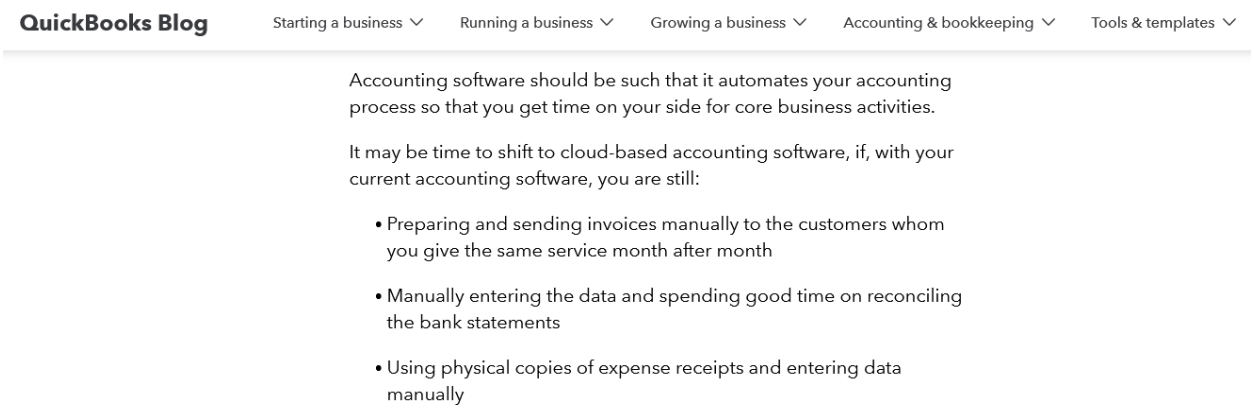


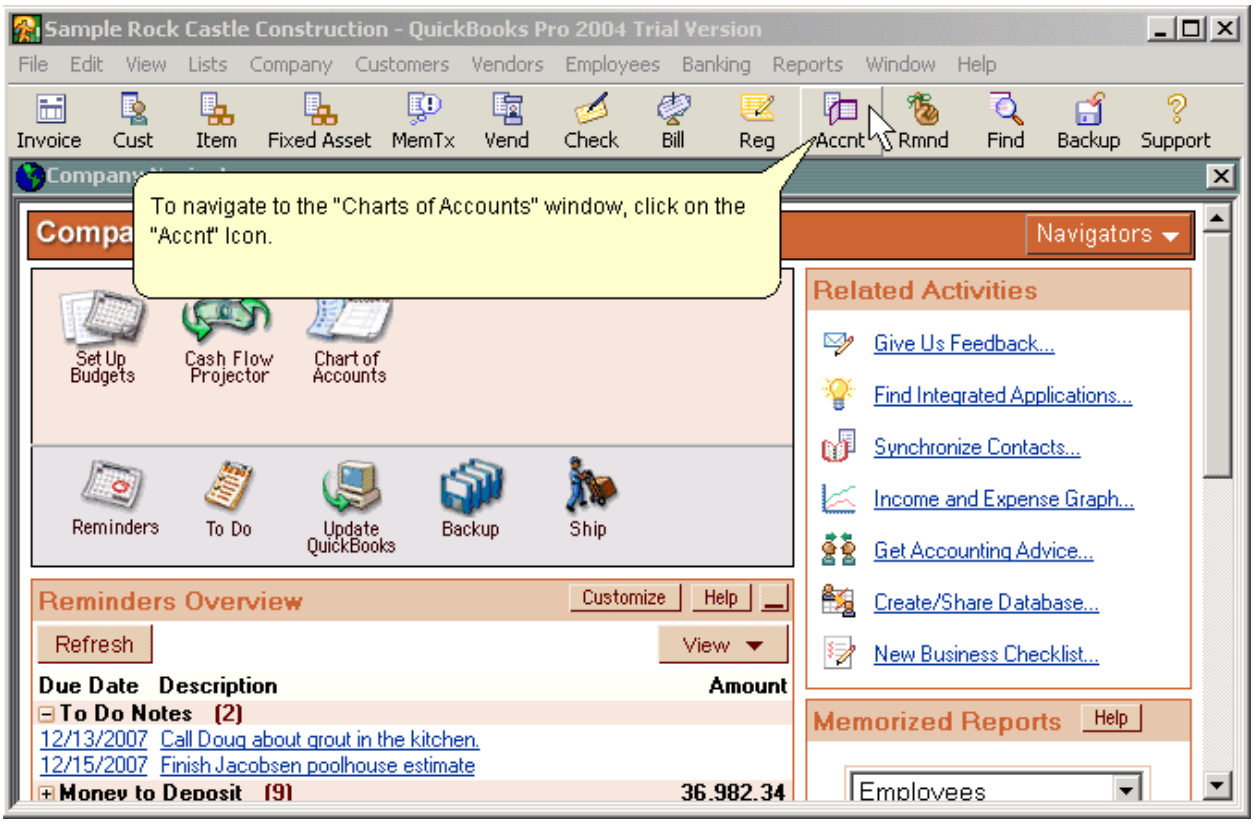
Figure 4: Accounting Software Advertisements
This figure compiles software advertisements and software screenshots describing program features and adoption benefits. Sources are provided under the advertisements.

Panel A. Automation and Time Reallocation



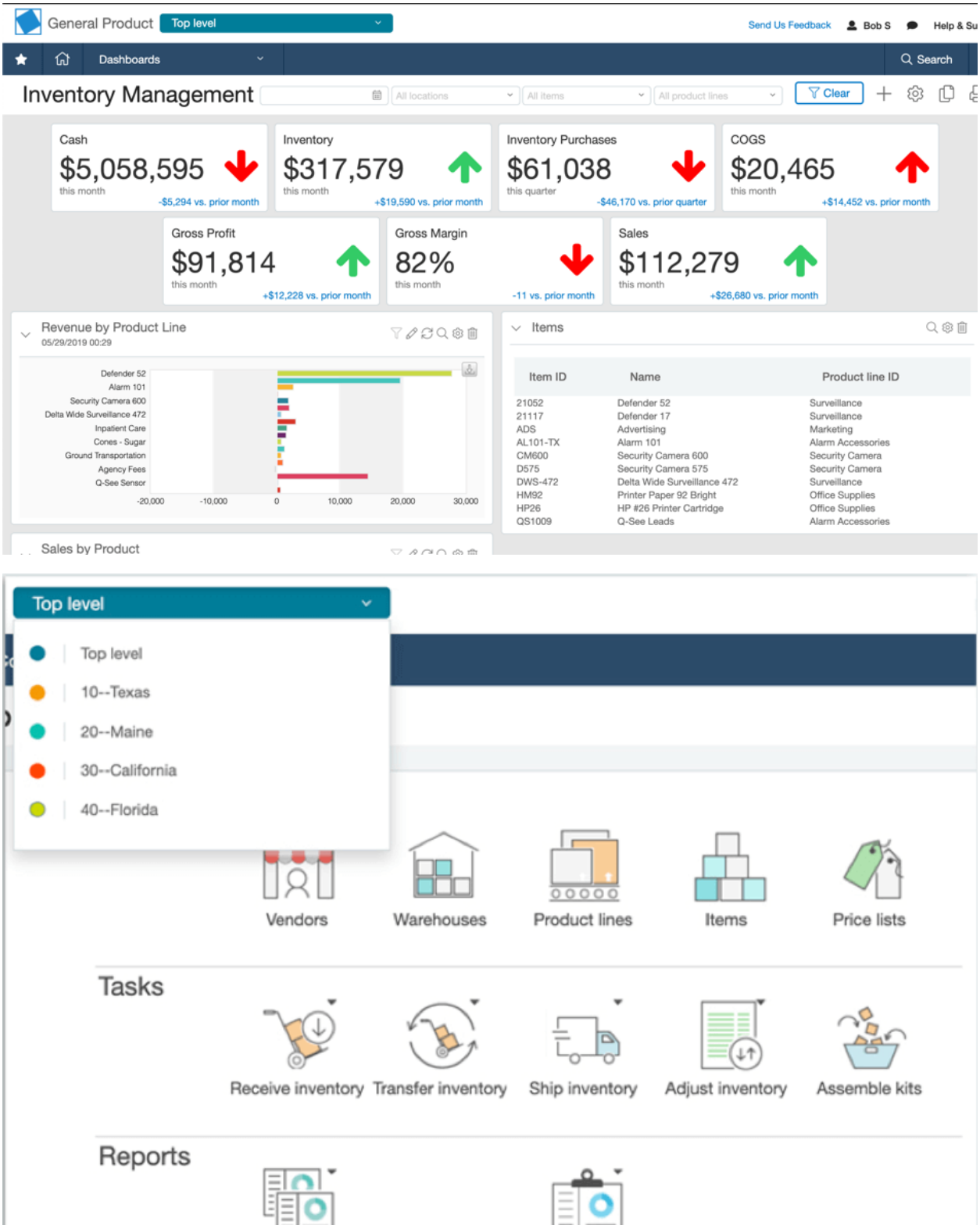
Source: https://quickbooks.intuit.com/global/resources/accounting-and-bookkeeping/cloud-accounting-software/

Panel B. Budgeting and Cash Flow Projection Tools



Source: https://www.conficio.com/plan-b/examples/quickbooks/create_account/credit_card/flat_excerpt.html

Panel C. Inventory Management Tools



Source: https://www.sage.com/en-ca/sage-business-cloud/intacct/additional-financial-management-modules/cloud-inventory-management-system/

Figure 5: Firm-Level Management Accounting Adoption
This figure plots *Shortage*×*SOX* coefficients for an analysis of individual management accounting practices using Equation (2). The dependent variable is the number of new adopters of the given management accounting practice, measured at the firm level. The management accounting practices are listed in Appendix B. We sort practices on their *Shortage*×*SOX* coefficients from largest to smallest, and practices whose *Shortage*×*SOX* coefficients are statistically significant at 10% level are shaded black.

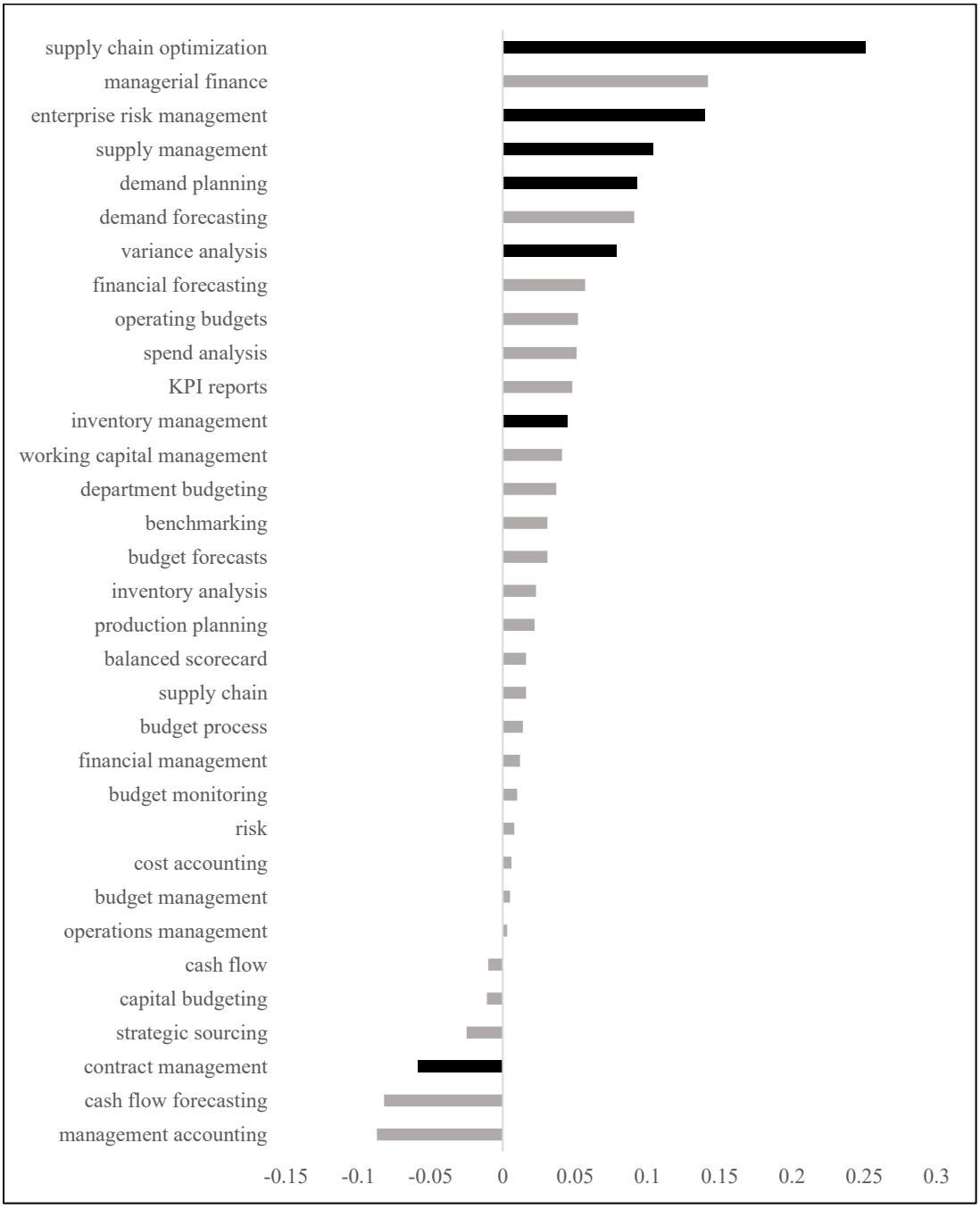


Table 1: Summary Statistics

This table provides summary statistics for the variables used in our analyses. The sample spans 1999-2008 for 50 states in the U.S. Variables logged transformed in the regressions are reported both in raw and logged values. Refer to Appendix A for variable descriptions.

Variable	N	Mean	SD	Q1	Median	Q3
Main Variables						
AcctSW	500	86.61	130.11	14	41	106
$AcctSW^{QB}$	500	51.49	89.61	7	22	59
AcctWage	500	24.92	3.86	22	25	27
$AcctEmp_{unscaled}$	500	19,375	22,502	4,435	11,360	23,585
AcctEmp	500	5.55	0.61	5.16	5.48	5.89
Other Variables						
GDP_{raw}	500	302,245	355,879	71,422	186,061	386,939
GDP	500	12.09	1.05	11.18	12.13	12.87
Unemp	500	4.75	1.14	3.90	4.70	5.50
AntiVirus	500	28	36	6	15	37
Consequences						
OtherTasks	500	22.09	2.83	19.97	22.67	24.39
$OtherTasks^{core}$	500	9.11	1.22	8.26	9.24	10.07
MgAcct	500	7.28	1.45	6.14	7.37	8.46
$MgAcct^{NoTask}$	500	4.97	0.88	4.33	5.03	5.55
$MgAcct^{profitability}$	500	4.87	1.14	3.97	4.88	5.75
$MgAcct^{cashflow}$	500	2.30	0.47	1.93	2.41	2.69
$MgAcct^{inventory}$	500	0.83	0.22	0.69	0.86	0.98
$AcctEmp_{private}$	500	13,455	17,203	2,452	6,878	17,582
$AcctMonth^{Jan}$	500	30.56	5.38	25.91	29.98	34.79
$AcctMonth^{HHI}$	500	14.27	2.66	12.01	13.68	16.18

Table 2: Software Adoption and Labor Scarcity

This table studies software adoption using Equation (1). The unit of observation is state-year. *AcctSW* is the number of new software adopters. *AcctWage* is the mean accountant wage. *AcctEmp* is the number of total accountants scaled by the number of Compustat firms, log transformed. *GDP* is the log GDP. *Unemp* is the unemployment rate. Standard errors are clustered at the state level. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)
	$AcctSW_{t+1}$	$AcctSW_{t+1}$	$AcctSW_{t+1}$
$AcctWage_t$	0.014**		0.015**
	(2.13)		(2.19)
$AcctEmp_t$		-0.084*	-0.091*
		(-1.67)	(-1.73)
GDP_t	0.497**	0.417	0.546**
	(2.15)	(1.56)	(2.51)
$Unemp_t$	-0.032**	-0.032**	-0.029**
	(-2.32)	(-2.01)	(-2.15)
Observations	500	500	500
FE	State, Year	State, Year	State, Year
Cluster	State	State	State
Adjusted R-squared	0.950	0.950	0.950

Table 3: Accountant Switches and Wages

This table studies accountant job switches and wages using Equation (2). The unit of observation is state-year. *AcctSwitch* is the number of accountants who switch from private firms or non-Big 5 audit firms to public firms or Big 5 audit firms, scaled by the total number of accountants in the state-year. *AcctWage* is the mean accountant wage. *SOX* is an indicator equal to one starting in 2004. *Shortage* is three minus the tercile ranking of mean *AcctEmp* in the pre-SOX period for each state. *GDP* is the log transformed GDP. *Unemp* is the unemployment rate. Standard errors are clustered at the state level. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

	(1) *AcctSwitch*	(2) *AcctSwitch*	(3) *AcctWage*	(4) *AcctWage*
SOX	0.003***		1.556***	
	(9.07)		(4.43)	
Shortage×*SOX*		0.001**		0.554***
		(2.64)		(3.02)
GDP	-0.008***	-0.007**	19.803***	-0.008***
	(-3.91)	(-2.40)	(9.79)	(-3.91)
Unemp	-0.001***	-0.000*	0.916***	-0.001***
	(-10.03)	(-1.94)	(8.70)	(-10.03)
Observations	500	500	500	500
FE	State	State, Year	State	State, Year
Cluster	State	State	State	State
Adjusted R-squared	0.760	0.801	0.771	0.934

Table 4: Software Adoption and Accounting Labor Scarcity—SOX

This table studies software adoption using Equation (2). The unit of observation is state-year. *AcctSW* is the number of new software adopters. *SOX* is an indicator equal to one starting in 2004. *Shortage* is three minus the tercile ranking of mean *AcctEmp* in the pre-SOX period for each state. $Shortage_{high(mid)}$ is an indicator variable equal to one for states with the highest (middle) tercile of *Shortage,* and zero otherwise. *GDP* is the log transformed GDP. *Unemp* is the unemployment rate. Standard errors are clustered at the state level. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

	(1)	(2)
	AcctSW	*AcctSW*
Shortage×*SOX*	0.059***	
	(2.92)	
$Shortage_{mid}$×*SOX*		-0.000
		(-0.01)
$Shortage_{high}$×*SOX*		0.086*
		(1.84)
GDP	0.926***	0.922***
	(2.90)	(2.99)
Unemp	-0.011	-0.013
	(-0.79)	(-0.92)
Observations	500	500
FE	State, Year	State, Year
Cluster	State	State
Adjusted R-squared	0.947	0.947

Table 5: Robustness

This table studies software adoption using variations of Equations (1) and (2). The unit of observation is state-year. In Panel A, *Shortage* is replaced with $Shortage^{mcap}$, where the denominator is based on the total market capitalization of Compustat firms instead of firm count. Panel B adds controls for the number and characteristics of private firms. *PrivateFirms* is the number of private firms. *FirmSizeHHI* is the Herfindahl-Hirschman index of firms across employee-size categories. $Firms^{small}$ is the number of firms with fewer than 100 employees. In this panel, we exclude the *GDP* control to avoid multicollinearity. In Panel C, the dependent variable is $AcctSW^{ratio}$, the number of new software adopters divided by the number of firms, expressed as a percentage. In Panel D, the dependent variable is $AcctSW^{QB}$, the number of QuickBooks adopters. In Panel E, the dependent variable is *AntiVirus,* the number of antivirus software adopters. *Shortage* is three minus the tercile ranking of mean *AcctEmp* in the pre-SOX period for each state. *SOX* is an indicator equal to one starting in 2004. *AcctSwitch* is the number of accountants who switch from private firms or non-Big 5 audit firms to public firms or Big 5 audit firms, scaled by the total number of accountants in the state-year. *AcctWage* is the mean accountant wage. *AcctEmp* is the number of total accountants scaled by the number of Compustat firms, log transformed. Standard errors are clustered at the state level. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

Panel A. Market Capitalization-based *Shortage*

	(1) *AcctSwitch*	(2) *AcctWage*	(3) *AcctSW*
$Shortage^{mcap} \times SOX$	0.073***	0.403*	0.031**
	(2.79)	(1.96)	(2.16)
Controls	Yes	Yes	Yes
Observations	500	500	500
FE	State, Year	State, Year	State, Year
Cluster	State	State	State
Adjusted R-squared	0.804	0.932	0.947

Panel B. Controlling for the Number of Private Firms

	(1) *AcctSW*	(2) *AcctSW*	*AcctSW*
Shortage×*SOX*	0.048**	0.042**	0.047**
	(2.50)	(2.18)	(2.45)
PrivateFirms	1.218***	1.082***	
	(4.91)	(4.08)	
FirmSizeHHI		2.344	
		(1.26)	
$Firms^{small}$			1.199**
			(4.95)
Controls	Yes	Yes	Yes

Observations	500	500	500
FE	State, Year	State, Year	State, Year
Cluster	State	State	State
Adjusted R-squared	0.948	0.948	0.948

Panel C. Scaled Adoption

	(1) $AcctSW^{ratio}_{t+1}$	(2) $AcctSW^{ratio}_{t}$
$AcctWage_t$	0.0022*	
	(1.84)	
$AcctEmp_t$	-0.002	
	(-0.30)	
$Shortage_t \times SOX_t$		0.017***
		(4.94)
Controls	Yes	Yes
Observations	500	500
FE	State, Year	State, Year
Cluster	State	State
Adjusted R-squared	0.800	0.822

Panel D. QuickBooks-based Adoption Measure

	(1) $AcctSW^{QB}_{t+1}$	(2) $AcctSW^{QB}_{t}$
$AcctWage_t$	0.019**	
	(1.98)	
$AcctEmp_t$	-0.122*	
	(-1.91)	
$Shortage_t \times SOX_t$		0.071**
		(2.50)
Controls	Yes	Yes
Observations	500	500
FE	State, Year	State, Year
Cluster	State	State
Adjusted R-squared	0.936	0.931

Panel E. Placebo Tests

	(1) $AntiVirus_{t+1}$	(2) $AntiVirus_t$
$AcctWage_t$	-0.009	
	(-0.93)	
$AcctEmp_t$	0.046	
	(0.72)	

$Shortage_t \times SOX_t$		-0.003
		(-0.12)
Controls	Yes	Yes
Observations	500	500
FE	State, Year	State, Year
Cluster	State	State
Adjusted R-squared	0.857	0.858

Table 6: Software Adoption and Accountant Tasks

This table studies accountants working on operations or strategy tasks. The unit of observation is state-year. In Panel A, the dependent variable is *AcctPerFirm*, the number of accountants employed at private firms in the sample scaled by the number of private firms in the sample, expressed as a percentage. In Panel B, the dependent variable is *OtherTask,* the number of accountants employed by private firms with job descriptions including operations or strategy keywords according to Revelio scaled by the number of accountants at private firms in the sample, expressed as a percentage. $OtherTask^{core}$ is an alternative measure based on a more focused set of keywords. Appendix B contains the keyword lists. *Shortage* is three minus the tercile ranking of mean *AcctEmp* in the pre-SOX period for each state. *SOX* is an indicator equal to one starting in 2004. $\widehat{AcctSW}$ is the predicted value of *AcctSW* from the first-stage OLS regression using Equation (2). Columns 1 and 3 (2 and 4) present results based on Equation (2) (instrumental variables analyses). Control variables include *GDP* and *Unemp*. For models using predicted values, we report first-stage F-statistics and their corresponding p-values. Standard errors are clustered at the state level. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

Panel A. Number of Accountants Employed by Private Firms

	(1) *AcctPerFirm*	(2) *AcctPerFirm*
Shortage×*SOX*	-0.215**	
	(-2.17)	
$\widehat{AcctSW}$		-0.414**
		(-2.17)
Controls	Yes	Yes
Observations	500	500
FE	State, Year	State, Year
Cluster	State	State
Adjusted R-squared	0.996	0.996
First-stage F-statistic		11.46
		(0.00)

Panel B. Accountants with Other Tasks

	(1) *OtherTask*	(2) *OtherTask*	(3) $OtherTask^{core}$	(4) $OtherTask^{core}$
Shortage×*SOX*	0.319***		0.151**	
	(2.96)		(2.00)	
$\widehat{AcctSW}$		0.613***		0.291**
		(2.96)		(2.00)
Controls	Yes	Yes	Yes	Yes
Observations	500	500	500	500
FE	State, Year	State, Year	State, Year	State, Year
Cluster	State	State	State	State
Adjusted R-squared	0.971	0.971	0.924	0.924
First-stage F-statistic		11.46		11.46
		(0.00)		(0.00)

Table 7: Software Adoption and Management Accounting Practices

This table studies accountant involvement in management accounting practices. The unit of observation is state-year. The dependent variable is *MgAcct,* the number of accountants with job descriptions including management accounting practice keywords scaled by the number of accountants at private firms in the sample, expressed as a percentage. $MgAcct^{notask}$ is *MgAcct* measured after excluding firms with an increase in $OtherTask^{core}$ from 1999-2003 to 2004-2008. Appendix B contains the keyword lists. *Shortage* is three minus the tercile ranking of mean *AcctEmp* in the pre-SOX period for each state. *SOX* is an indicator equal to one starting in 2004. $\widehat{AcctSW}$ is the predicted value of *AcctSW* from the first-stage OLS regression using Equation (2). Columns 1 and 3 (2 and 4) in present results based on Equation (2) (instrumental variables analyses). Control variables include *GDP* and *Unemp*. For models using predicted values, we report first-stage F-statistics and their corresponding p-values. Standard errors are clustered at the state level. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

	(1) *MgAcct*	(2) *MgAcct*	(3) $MgAcct^{notask}$	(4) $MgAcct^{notask}$
Shortage×*SOX*	0.181***		0.075*	
	(3.07)		(1.77)	
$\widehat{AcctSW}$		0.349***		0.145*
		(3.07)		(1.77)
Controls	Yes	Yes	Yes	Yes
Observations	500	500	500	500
FE	State, Year	State, Year	State, Year	State, Year
Cluster	State	State	State	State
Adjusted R-squared	0.957	0.957	0.915	0.915
F-statistic		11.46		11.46
		(0.00)		(0.00)

Table 8: Software Adoption and Management Accounting Practices by Type
This table studies accountant involvement in management accounting practices. The unit of observation is state-year. The dependent variable is $MgAcct^{cashflow}$ ($MgAcct^{profitability}$; $MgAcct^{inventory}$), the number of accountants with job descriptions including cash flow / risk management (profitability analysis; inventory / demand planning) keywords scaled by the number of accountants at private firms in the sample, expressed as a percentage. Appendix B contains the keyword lists. *Shortage* is three minus the tercile ranking of mean *AcctEmp* in the pre-SOX period for each state. *SOX* is an indicator equal to one starting in 2004. Control variables include *GDP* and *Unemp*. Standard errors are clustered at the state level. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

	(1) $MgAcct^{cashflow}$	(2) $MgAcct^{profitability}$	(3) $MgAcct^{inventory}$
Shortage×*SOX*	0.175***	0.059*	0.024
	(3.25)	(1.75)	(0.96)
Controls	Yes	Yes	Yes
Observations	500	500	500
FE	State, Year	State, Year	State, Year
Cluster	State	State	State
Adjusted R-squared	0.951	0.842	0.769

Table 9: Software Adoption and Hiring Seasonality

This table studies hiring seasonality. $AcctMonth^{Jan}$ is the percentage of accountants who begin their jobs in January. The unit of observation is state-year. $AcctMonth^{HHI}$ is the Herfindahl-Hirschman index of the monthly distribution of accountant job start dates, expressed as a percentage. *Shortage* is three minus the tercile ranking of mean *AcctEmp* in the pre-SOX period for each state. *SOX* is an indicator equal to one starting in 2004. $\widehat{AcctSW}$ is the predicted value of *AcctSW* from the first-stage OLS regression using Equation (2). Columns 1 and 3 (2 and 4) in both panels present results based on Equation (2) (instrumental variables analyses). Control variables include *GDP* and *Unemp*. For models using predicted values, we report first-stage F-statistics and their corresponding p-values. Standard errors are clustered at the state level. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

	(1) $AcctMonth^{Jan}$	(2) $AcctMonth^{Jan}$	(3) $AcctMonth^{HHI}$	(4) $AcctMonth^{HHI}$
Shortage×*SOX*	-1.141***		-0.813***	
	(-4.90)		(-7.15)	
$\widehat{AcctSW}$		-2.194***		-1.565***
		(-4.84)		(-7.15)
Controls	Yes	Yes	Yes	Yes
Observations	500	500	500	500
FE	State, Year	State, Year	State, Year	State, Year
Cluster	State	State	State	State
Adjusted R-squared	0.917	0.917	0.909	0.909
F-statistic		11.46		11.46
		(0.00)		(0.00)