Technological Adoption and Taxation: The Case of China's Golden Tax Reform*

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January 23, 2024

Abstract

This paper investigates the effect of Phase 2 of the Golden Tax Project on VAT in China. The reform introduced computer-generated invoices and electronic transaction linking. Using a *difference-in-differences* strategy, we show that the reform increased VAT by reducing exaggerated VAT deductions. The introduction of the new digital technology had large positive effects on Chinese fiscal capacity. VAT gains from the reform explain approximately 13.7% of VAT growth during 1998 to 2007.

*We thank Robert Moffitt and James Poterba for their helpful comments and the participants of NBER's 38th Annual Tax Policy and the Economy Conference for useful suggestions. We are grateful to Kaman Lyu, Carlo Medici, Ludovica Mosillo, Joris Mueller and Zhentao Jiang for excellent research assistance. All mistakes are our own.

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1 Introduction

Digital technologies have transformed society and the economy, and the public sector is no exception. Over the past two decades, numerous countries have adopted digital technology for public administration, reaching an estimated 400 initiatives by 2017 (Aker, 2017). Recent research highlights how these technologies can enhance state capacity, such as improving public service delivery (Muralidharan et al., 2016), bolstering regulatory enforcement (Saavedra, 2023), and fostering tax compliance (Jensen et al., 2022). The potential of digital technology to improve governance has unsurprisingly attracted the attention of policymakers, especially in low and middle-income countries (Amaglobeli et al., 2023).

In this paper, we study the impact of digital technology adoption on tax revenues in China, concentrating on a 2001-2002 reform known as Phase 2 of the Golden Tax Project. This reform digitized China's Value-Added Tax (VAT) system by creating a national database of linked transactions and improved compliance by requiring firms to use computer-generated and encrypted invoices. Digitization can affect VAT in several ways. It can enhance enforcement by facilitating cross-checks of self-reported information against third-party data. Digitization can also improve measurement of the tax base by creating electronic records of transactions and better tracking of taxable subjects. Additionally, these technologies can reduce administrative costs for firms, leading to improved compliance.

First, we describe the Golden Tax Project and China's VAT system. This background contextualizes the the reform of interest, which, starting in 2001, mandated computer-generated invoices nationwide and inaugurated a national database of linked transactions.

Next, we estimate the contribution of the reform to VAT revenues. Since the reform was nationwide, there is no pure control group. Motivated by interviews with tax officials, we compare VAT in sectors with a higher share of non-deductible inputs to sectors with a lower share of non-deductible inputs, before and after the reform. Firms with higher NDS had stronger incentives to falsify claims (i.e., there is little need to evade VAT if all sales can be offset by legitimately deductible inputs). Thus, higher NDS firms were more intensely treated by the reform. Our approach

is similar in spirit to a *difference-in-differences* strategy, except that the cross-sectional variation is a continuous measure.

Using a sector-level panel of large manufacturing firms for 1998-2007, we find that computerization significantly increased VAT in the five-year post-period. The increase in VAT was driven by a reduction of deductible inputs. These results are consistent with a pre-period firm evasion strategy of exaggerating inputs. Computerization had little effect on reported VAT gross,[1] which goes against the concern that the rise in VAT was driven by higher growth in the treated sectors.

Back-of-the-envelope calculations indicate that digitization accounted for 13.7% of China's VAT growth from 1998 to 2007 and represented 11.7% of China's total 2000 VAT revenue. These results are economically meaningful when one considers that nearly half of total tax revenues for China in the early 2000s came from VAT. In other words, the computerization of VAT constituted one of the largest sources of revenue growth for the Chinese government during this period.

Our estimates likely understate the true effect of computerization on tax revenues for two reasons. First, we do not have a perfect control group. In our sample, even the lowest NDS firms had some non-deductible inputs and were therefore partially treated. Second, computerization likely generated enforcement spillovers along transaction chains to low NDS firms.

These results show how a relatively straightforward technological improvement dramatically increased fiscal capacity and led to a new source of revenue for the Chinese government during its economic "miracle". Until now, most studies on China during this period have focused on the restructuring of the state-owned sector (e.g., Hsieh and Song, 2015) or the gains from the export industry (Khandelwal et al., 2013; Brandt et al., 2017; Kee and Tang, 2016; Han and Kung, 2015; Lu and Yu, 2015). We are the first to highlight the role of the VAT reform.

This study adds to the growing body of evidence on the importance of technology on state capacity. Much of this literature shows that technology can significantly improve state capacity, including via better public service delivery and regulatory enforcement. Muralidharan et al. (2016) find that a digital bio-metric system for implementing pension and public employment programs in

[1] VAT in China is levied on the difference between eligible sales, called "VAT gross", and deductible inputs, called "VAT deductions".

India provided faster, more reliable, and less corrupt public transfers. Saavedra (2023) show that a digital system for detecting illegal mining decreased regulatory violations. However, some papers suggest that these technologies come with trade-offs. For example, Muralidharan et al. (2023) find that digitizing public benefit payment decreased corruption, but many qualifying beneficiaries lost access to services.

Within this literature, we are most closely related to the subset of studies on digital technology and tax systems. Jensen et al. (2022) find that mapping and revenue management software increase property tax revenues in Ghana. Eissa and Zeitlin (2014) estimate a significant rise in VAT payments after the introduction of electronic billing machines in Rwanda. Similarly, Ali et al. (2015) find an increase in VAT when the Ethiopian Revenue and Customs Authority mandates firms to use electronic sales registry machines. Okunogbe and Pouliquen (2022) find that electronic tax filing does not substantially alter average tax payments but appears to enhance horizontal fairness among firms. Recent reviews of this literature are provided by Gupta et al. (2017), Pomeranz and Vila-Belda (2019), and Okunogbe and Santoro (2023). In a companion paper, we investigate the mechanisms of how the reform increased VAT and the effect of the reform on firm behavior (Fan et al., 2023) .

The paper is organized as follows. Section 2 provides an overview of China's tax environment and a history of VAT implementation and reform. Section 3 introduces our data. Section 4 estimates the aggregate increase in VAT revenues due to the reform. Finally, Section 5 concludes.

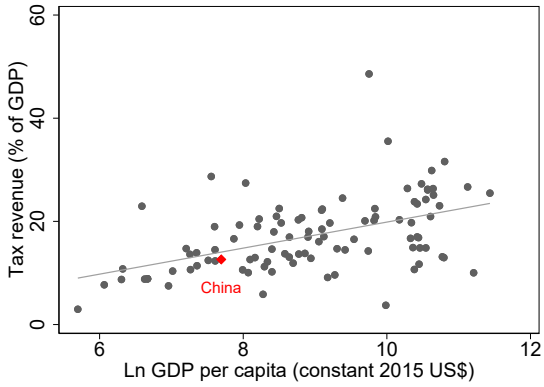
2 Background

In the late 1990s, China was a middle-income country with relatively low tax capacity. Figure 1 plots tax revenue as a share of GDP against the natural log of GDP per capita for 98 countries as reported by the World Bank Development Indicators. Subfigures (a) and (b) report data from 2000 and 2007, respectively. As in earlier studies (Besley and Persson, 2014), we find a positive relationship between tax capacity and income levels.

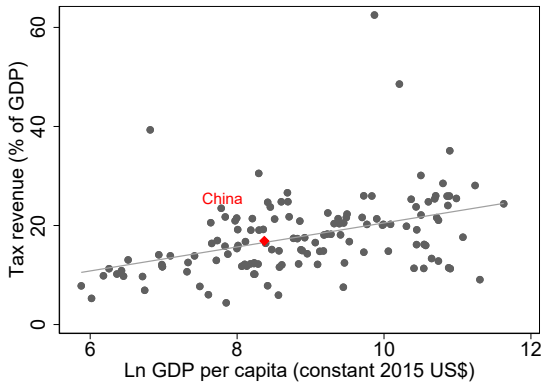
During this period, China's per capita income grew from $2,190 to $4,319 per capita (constant 2015 USD). In 2000, before the reform that we study, China's tax share stood at 12.6% and was below the regression line in Figure 1(a) – i.e., it collected less taxes than the average government with similar incomes. By 2007, the tax share had increased to 16.9% and China collected more taxes than the average government with similar incomes. This is consistent with the conventional wisdom that the reform studied in this paper was important for improving fiscal capacity.

Figure 1: Tax Revenue as a Share of GDP and Income Level

(a) 2000



(b) 2007



Notes: Data are from the World Bank World Development Indicators Database and the National Bureau of Statistics.

2.1 The Golden Tax Project

This paper studies Phase 2 of China's Golden Tax Project, which introduced electronic monitoring technologies to China's VAT system. To contextualize the reform, this section briefly describes all four phases of the project.

Pilot

When VAT was introduced nationwide in China in 1994, it faced widespread avoidance and evasion. These issues stemmed largely from the analog tax collection system. On a monthly basis, firms brought their records into local tax offices, which would compute their tax base and deductibles based on their sales and input receipts. To verify transactions, tax officials had to manu-

ally match receipts across firms, a cumbersome and sometimes infeasible task that left firms wide latitude to omit, misreport, or fabricate transactions (Cai and Cheng, 1997). Figure 2(a) provides an example of an analog invoice. It was relatively easy to falsify and exaggerate deductible inputs by adding or changing handwritten transaction values.

Top officials recognized the severe drawbacks of the analog system and, within months of its implementation, began to experiment with digitization. In March of 1994, the government piloted a digital VAT system for 50 cities, which they dubbed the "Golden Tax Project". The state-owned Great Wall Computer Group Company implemented the roll-out with support from the People's Bank of China, the National Development and Reform Commission, and the Aerospace Industry Corporation. The project had three main components: a cross-checking system, a invoice issuance system, and a cash register system (Xu and Jin, 1999).

A new centralized database was created as a cross-checking system. When firms filed their monthly invoices, official typists entered the transactions into the database. During audits, tax officials no longer needed verify the value of a transaction invoice by finding its corresponding invoice from another firm. Instead, officials could search for each invoice by its identification number and verify transaction value against the central database. This system substantially increased the risk of being caught while fabricating transaction values.

Additionally, for the largest transactions (with value over one million RMB), the pilot introduced computer-generated invoices. These invoices would automatically be entered into the central database with a unique identification code.

Finally, for some retail and small-scale enterprises, the pilot introduced digital cash registers. These registers created a permanent record of all sales, significantly increasing the state's ability to monitor business-to-consumer transactions, which were commonly under-reported. It is useful to note that large manufacturing firms, the subject of our subsequent analysis and which primarily sold to other businesses, were largely unaffected by these registers.

From August 1994 to February 1997, pilot cities processed 380 million special VAT invoices and audited over 66.19 million entries, identifying numerous cases of fraud (Cai and Cheng, 1997).

However, the system had several serious drawbacks. First, because there were just 50 pilot cities, all transactions with firms outside the pilot were susceptible to the same analog evasion strategies. Second, the computer system suffered from typos, as invoices were manually entered into the database. Due to these limitations, administrators discontinued the pilot by the end of 1996 (Zhang, 1998).

Phase 2 In 2001, the government started Phase 2 of the Golden Tax Project, the subject of this paper. An essential component of this reform was the national integration of invoice databases, which facilitated national cross-checking of transactions across regions and levels of government. The integrated system began operating on July 1, 2001.

Another key element of this reform was the phasing out of analog invoices. To facilitate this transition for firms, the state followed a schedule that gradually banned analog invoices for increasingly smaller transactions. In 2001, all transactions exceeding 100,000 RMB were digitized; in 2002, all transactions exceeding 10,000 RMB were digitized, and by January 1, 2003, all transactions had to take place via the system.

These invoices offered many advantages relative to their analog counterparts. At the time of a firm-to-firm transaction, a unique, encrypted code was created and printed on the invoice and simultaneously conveyed to a central database, along with other transaction information, like firm identity and transaction value. This change made it practically impossible to create entirely false invoices, as fake codes would not be present in the central database. Figure 2 displays an example of a receipt from the digital invoice system, including the unique code that tax officials used to find the transaction in the central tax database.

Figure 2: VAT Invoices

(a) Analog

(b) Digital

Notes: Photos from the State Administration of Taxation.

Audit statistics suggest that Phase 2 had a large impact on fraud rates. In January 2001, the tax office identified 11,952 suspected fraudulent VAT invoices. By December 2001, this number had decreased to 1,475. These figures implied that the share of fraudulent invoices declined from 0.22% to 0.02% in just one year (Liu and Lu, 2015).

Tax officials lauded the second phase of the project for its efficacy. The State Administration of Taxation (SAT) announced that the second phase of the Golden Tax Project was a "silver bullet against tax evasion and fraud" (Liu and Lu, 2015) and that evasion via fake invoices had been "effectively resolved" (Jin, 2002).

Phase 3 Our analysis ends before further reforms. We will briefly describe them here to shed light on the role of digitization in the economy today.

The tax authority began the third phase of the Golden Tax Project in 2013 using the slogan: "one platform, two-tier processing, three coverages, and four systems" (State Administration of Taxation, 2016). "One Platform" referred to creating a unified national tax service platform that would serve as a central hub for all tax-related services. "Two processes" referred to a two-stage data processing system that allocates responsibilities between the national and provincial tax authorities. "Three Covers" referred to making sure that the system covered all taxpayers, tax types, and tax-related services. "Four Systems" refereed to four systems supporting tax collection and

enforcement. Policymakers intended that Phase 3 would transition Chinese tax payments online by 2020. In contrast to earlier phases of the Golden Tax Project, Phase 3 applied to all forms of tax in China, not just the VAT.

Phase 4 The fourth phase of the Golden Tax Project began in 2022. It sought to expand China's digital tax infrastructure in three key ways. First, it would extend monitoring to "non-tax" activities of firms, including social security payments. Second, tax data would be shared with other government and commercial entities, including the People's Bank of China, to improve regulatory and policy implementation. Finally, it would embed more information about enterprises into the tax database, including information on firm registration, shareholders and management. Phase 4 was piloted in Guangdong, Shandong, Henan, Shanxi, Inner Mongolia and Chongqing. The government plans to implement it nationwide in 2024 (Zhang, 2021).

2.2 VAT

China implemented VAT for all goods in 1994 (Lin, 2009). Since then, VAT has emerged as the primary contributor to government revenue, constituting 37.7% and 39.8% of the total in 2000 and 2005, respectively. The Chinese State Administration for Taxation (SAT) collects the VAT.

As in other settings, VAT in China is levied on the difference between eligible sales, called "VAT gross", and deductible inputs, called "VAT deductions". The baseline statutory VAT rate was 17%. Different inputs are reimbursed at different rates, up to a full reimbursement of 17%. Table 1 displays the statutory remittance rate for various types of costs. Material inputs are generally fully deductible, while labor, fixed assets, and overhead are not. Some material inputs, such as agricultural products and those classified as "necessary," are partially deductible at rates between 7 to 13 percent. For large firms, expenditures on necessary goods were generally negligible.

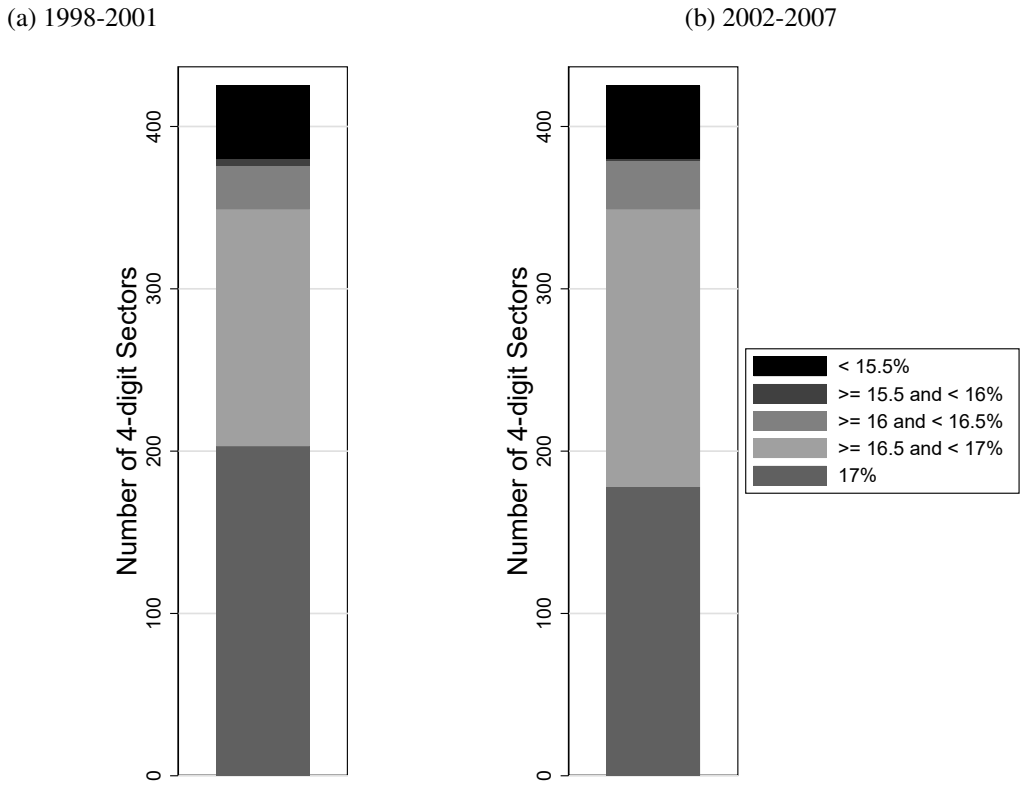
Table 1: Remittance Rates by Cost Type

Category	Rate	Category	Rate
Manufactured inputs	17	Waste materials	10
Repair inputs	17	Transportation	7
Retail inputs	17	Fixed asset purchases	0
Wholesale inputs	17	Capital depreciation	0
Agricultural products	13	Abnormal losses	0
Oil	13	Rent	0
Gas	13	Fringe benefits	0
Books	13	Interest on loans	0
Fertilizer	13	Overhead	0
Salt	13	Labor	0

Notes: Remittance rules come from the Provisional Regulations of the People's Republic of China on Value-Added Tax (State Council Order 134, published in December 1993).

Figure 3(a) presents a stacked bar chart for groups of statutory rates by four-digit Chinese Industrial Code sector for the pre-period years, 1998-2001. Figure 3(b) presents the same bar chart for the post-reform period of study, 2002-2007. These charts show that digitization was not accompanied by significant changes in statutory VAT rates.

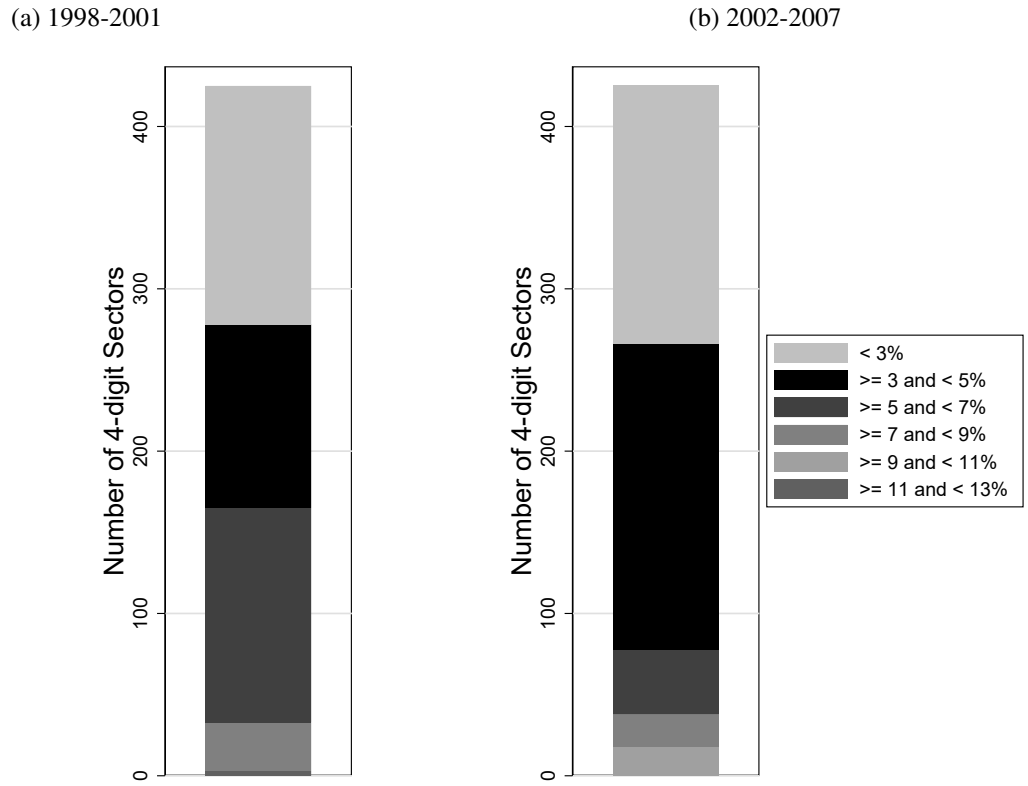
Figure 3: Statutory VAT Rates



Notes: Data from the State Administration of Taxation.

Special rules applied to imported inputs and exported goods. For deductible imports, the cost of the input as well as any associated tariffs were reimbursed at the standard rates presented in Table 1. Firms paid partial or no VAT on their exported output. Tax discounts for exports were implemented via a rebate system, and rebates varied by product and over time. In Figure 4, we compute the net VAT paid on exported products by subtracting the rebate rate from the statutory VAT rate. Figure 4(a) shows the distribution for the pre-period, 1998-2001. More than half of product exports were subject to VAT rates of 5% or below, and nearly all faced less than 9%. Figure 4(b) shows the corresponding distribution for the post period, 2002-2007. Over 80% of products were subject to rates below 5%.

Figure 4: VAT Rates Net of Export Rebates



Notes: Data from the State Administration of Taxation.

During this period, the main alternative form of enforcement was audits. Audits were conducted manually and had severe limitations: even when officials uncovered suspicious returns, they would sometimes not be able to prosecute due to a lack of proof. During the period of study, the number of tax officials remained steady, averaging $13,902$ central tax officials and $12,105$ local tax officials per province.

Tax officials claim that before computerization, the firms with a high level of non-deductible inputs as a share of sales (NDS) were more incentivized to evade and found it easier to evade VAT. Such firms had fewer legitimate deductibles with which to lower VAT obligations (as a share of sales). Officials also state that it was easier to exaggerate deductions than to understate sales because large or sudden changes in sales trigger audits. This mean that firms with high NDS, which had less real deductibles to report, had more scope for exaggeration.

3 Data

We use data from the *Annual Survey of Industrial Production* (ASIP), 1998-2007. These data cover large manufacturing firms and have been widely used by studies of Chinese firms. Our main sample is a panel of sectors covering 1998-2007 with annual revenues above 5 million RMB (603,865 USD). We aggregate firm-year data to sector-year data by averaging firm values. The data contain net VAT payment, gross VAT-eligible sales and VAT-eligible deductions for intermediate inputs. Thus, we can examine the mechanisms through which computerization improves enforcement and its effect on VAT payment. The VAT payment variable includes rebates, such as those awarded for exports.

The ASIP is conducted each year by the National Bureau of Statistics (NBS). NBS officials visit each firm and copy data from firm records to the survey. The data collected in ASIP cannot be used in any legal action against firms (such as tax violations). The production and balance sheet data (e.g., total output, intermediate inputs, labor inputs) are in a different module of the ASIP than VAT and are typically transcribed from a different firm account book than the one that includes VAT payments. These data have been accepted by a large number of existing studies, including those studying firm productivity (e.g., Hsieh and Klenow, 2009) and tax compliance (Cai and Liu, 2009; Li et al., 2021).

All of the values in the paper are reported in real terms.[2] Our sample excludes observations with the top and bottom 1% values of VAT and sales each year to remove outliers.[3] We use 4-digit Chinese Industry Classification sector definitions. The baseline sample fixes firm sectors to be the sector when the firm first appears in the sample.

Given our prior that firms were over-reporting VAT deductibles before computerization, one may be concerned that using the firm data in ASIP to calculate the non-deductible share (NDS) would introduce measurement error – i.e., confound real differences in NDS and evasion. To address this, we calculate sector-level NDS. We calculate pre-computerization sector-level NDS

[2]We use deflators provided by the Penn World Tables.

[3]The results are similar without dropping the outliers, but slightly less precise. They are available upon request.

with the *1997 Chinese Input-Output (I-O) Table* obtained from the China's National Bureau of Statistics (1999).[4] The data for the I-O table are collected in an independent process by a different group from the ASIP and are mainly used to tabulate national statistics and compute national GDP. The statistical office that collects the ASIP data and the one that constructs the I-O tables do not collaborate. The firm-level information used for constructing the I-O table is not shared with the tax department and it cannot be used as evidence of tax evasion (China's National Bureau of Statistics, 2009).

Our empirical strategy exploits time variation in the introduction of computerization and cross-sectional variation in NDS. The logic for the latter follows from the background discussion that firms with fewer real deductibles (as a share of sales) were able to exaggerate their reported deductibles more prior to the reform. Thus, these firms were therefore treated more intensely by the reform.

The cross-sectional measure of intensity, $\widetilde{NDS}_s$, is denoted as:

$$\widetilde{NDS}_s = \left(\frac{\widetilde{NonDeductible\ Inputs}}{Total\ Sales} \right)_s . \tag{1}$$

This term is the ratio of total non-deductible inputs to total output in sector s. To construct NDS by sector, we map each sector in the input-output tables into two groups, deductible or non-deductible, according to Chinese tax law. In practice, we consider inputs from agricultural, mining and manufacturing industries as materials, and thus deductible. We treat inputs from service industries, overhead, labor inputs, and value-added as non-deductible.[5] Table 2 reports a list of 4-digit Chinese Industrial Code sectors with the highest and lowest NDS values in the sample.

[4] In the 1997 Chinese I-O Table, there are 125 total listed inputs, 85 of which are VAT-deductible under Chinese tax law. The transaction-level data used to build the I-O table are not available to researchers.

[5] In a standard input-output table, the sum of all input values equals output value. Therefore, to obtain the final measure, we can equivalently sum the fractions of inputs from deductible industries to obtain a single fraction for each industry that represents the share of inputs deductible under Chinese VAT rules. This object can be characterized by the following equation, where D represents the set of deductible industries:

$$\widetilde{NDS}_s = 1 - \sum_{d \in D} Input\ fraction_{sd}. \tag{2}$$

Table 2: Sectors with Highest and Lowest NDS

Lowest Non-Deductible Share		Highest Non-Deductible Share	
(1)	(2)	(3)	(4)
Sector Name	Non-Deductible Share	Sector Name	Non-Deductible Share
Beet Sugar, Cane Sugar	0.24	Tobacco Leaf Re - Baking, Other Tobacco Processing, Cigarette Manufacturing	0.60
Frozen Aquatic Products Processing, Dry Processing Of Aquatic Products	0.25		
Electric Light Source Manufacturing, Lamp Holder, Lampholders Manufacturing	0.27	Caustic Soda Manufacturing, Inorganic Acid Manufacturing	0.56
		Industrial Ceramics, Other Ceramics	0.53
Wire And Cable Manufacturing, Postal Machinery And Equipment Manufacturing, Construction Machinery Manufacturing, Sewing Machine Manufacturing, Manufacture Of Special Equipment Not Included In Other Categories, Geological Special Equipment Manufacturing, Commercial, Catering, Service Machinery Manufacturing	0.30	Other Stationery Manufacturing, Notebook Manufacturing, Stationery Manufacturing, Lime	0.51
		Special Chemical Products Manufacturing, Manufacture Of Chemical Products In Forest Products, Explosives And Pyrotechnic Products Manufacturing, Chemical Reagents, Additives Manufacturing, Chinese Herbal Medicine And Chinese Medicine Processing, Biological Products, Chemical Drug Manufacturing, Manufacture Of Chemical Preparations	0.50
Petroleum Products	0.31		
Viscose Fiber Manufacturing, Acrylic Fiber Manufacturing, Nylon Fiber Manufacturing, Polyester Fiber Manufacturing, Chemical Fiber Pulp Manufacturing, Other Synthetic Fiber Manufacturing, Vinylon Fiber Manufacturing, Motorcycle Manufacturing, Manufacturing Of Inland Waterways, Diving Equipment Manufacturing, Manufacture Of Aids To Navigation, Motorcycle Parts And Accessories Manufacturing, Manufacture Of Marine Transport Ships, Luggage Manufacturing, Leather Leather Garment Manufacturing, Other Fur Products, Leather Shoes Manufacturing, Fur Tanning, Fur Clothing	0.33	Books, Newspapers And Periodicals, Packaging And Decoration Printing, Other Printing, Copying Of Recording Medium	0.49
		Crude Oil Processing, Bearing Manufacturing, Valve Manufacturing, Casting Manufacturing, Communication Terminal Equipment Manufacturing, Switching Equipment Manufacturing, Electronic Computer Manufacturing, Radar Special Equipment And Components, Other Electronic Equipment, Transmission Equipment Manufacturing, Radar Complete Machine Manufacturing, Other Communication Equipment Manufacturing, Radio And Television Equipment	0.48
Wool Spinning, Top Processing, Wool Knitting, Automotive Body Manufacturing, Special Vehicles And Modified Car Manufacturing, Small Car Manufacturing, Passenger Car Manufacturing, Heavy Truck Manufacturing, Micro - Car, Ink Manufacturing, Paint Manufacturing, Manufacture Of Organic Chemical Materials, Other Organic Chemical Products, Foam And Synthetic Leather, Synthetic Leather Manufacturing, Other Plastic Products, Manufacture Of Daily Plastic Sundry Goods, Plastic Shoe Manufacturing	0.34	Manufacturing, Asbestos Products, Other Refractory Products, Concrete Structural Component Manufacturing, Manufacture Of Waterproof Seal Building Materials, Building Stone Processing, Asbestos Cement Products, Brick And Tile Manufacturing, Manufacture Of Lightweight Building Materials, Cement Products, Other Brick, Lime And Light Construction Materials, Other Cement Products, Manufacture Of Other Basic Chemical Raw Materials	

Notes: Manufacturing sectors are defined by four-digit Chinese Industrial Codes. Non-deductible share is calculated from 1997 Chinese Input Output Tables. See the text for a detailed description.

The correlation coefficient between our main measure of pre-computerization NDS calculated from the I-O tables and the measure calculated from ASIP is 0.34 and statistically significant at the 1% level.

Summary statistics for firm and sector characteristics prior to the reform are reported in Table 3.

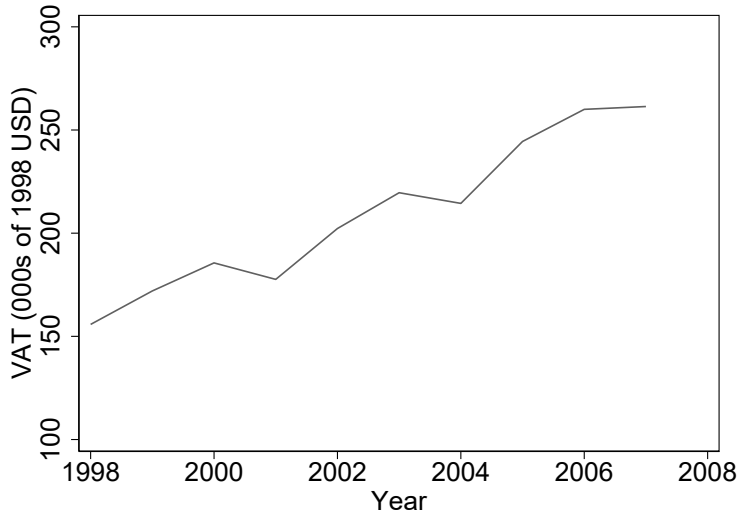
Table 3: Pre-Period Firm and Sector Characteristics

(1) Variable	(2) Mean	(3) SD	(4) Min	(5) Median	(6) Max
VAT Share	0.04	0.01	0.01	0.04	0.12
Export Share	0.17	0.18	0.00	0.10	0.73
HHI	0.00	0.01	0.00	0.00	0.34
Sales (000s USD)	4,860	1,880	1,829	4,272	19,811
State-Owned	0.38	0.48	0.00	0.00	1.00
Private	0.40	0.49	0.00	0.00	1.00
Foreign	0.22	0.42	0.00	0.00	1.00

Notes: Data are from the Annual Survey of Industrial Production. Summary statistics for the years 1998 to 2001. Sales are reported in thousands of 2005 USD. Export share equals total export value divided by total sales. VAT share equals total VAT payment divided by total sales. SOE, private, and foreign are indicators for firm ownership.

Figure 5 plots average VAT paid by firms in the sample over time. It shows that VAT increased rapidly from 155.8 thousand USD in 1998 to 261.4 thousand USD in 2007.[6] The increase is likely due to a combination of improved enforcement and China's economic growth. The empirical analysis in the next section will aim to disentangle the two forces and estimate the effect of improved enforcement.

Figure 5: VAT Payments over Time



Notes: Data are from the Annual Survey of Industrial Production.

[6] Values reported in 1998 USD.

In addition to VAT paid by firms, the ASIP also reports total VAT obligations, or gross VAT, and eligible deductions, or VAT deductibles. We will look at all of these variables as outcomes of the regression in the next section. The ASIP also reports total output, or sales. This will allow us to examine VAT as a share of sales in the next section.

4 Results

To estimate the effect of the reform on VAT, we use a panel of sectors and exploit two sources of variation: time variation from the 2001 introduction of computerization and cross-sector variation in the intensity of the treatment effect. The latter is motivated by the discussion in Section 2 that firms with higher NDS were more intensely treated by computerization. The baseline equation is:

$$VAT_{ist} = \alpha + \beta \widetilde{NDS}_s \times Post_t + \Gamma X_{ist} + \tau_t + \phi_s + \varepsilon_{ist}, \tag{3}$$

where VAT paid by firm i in sector s and year t, VAT_{ist}, is a function of: the interaction of a dummy which takes the value of one if it is 2002 or later, $Post_t$, and the measure of intensity at the sector level, $\widetilde{NDS}_s$; sector fixed effects, ϕ_i; and year fixed effects, τ_t. Sector fixed effects absorb long-run differences in VAT payment across industries and ensure that our results are not driven by changes in sector composition. Year fixed effects control for aggregate changes in China's economy over time, including rapid GDP growth, that could increase VAT payments for all firms in a given year.

We do not include uninteracted $\widetilde{NDS}_s$ and $Post_t$ as they would be absorbed by sector fixed effects and year fixed effects, respectively. We choose 2002 as the start of the post-reform period because hand-written invoices were banned at the end of 2001. Standard errors are clustered at the sector level. We weight the regressions with the number of firms in each sector and year. The coefficients and standard errors are identical to ones estimated from firm-year data.

X_{ist} is a vector of controls. We control for two measures of firm size to account for the possibility that tax policy varies by firm size (Bachas et al., 2019; Kleven et al., 2016). The first is the average pre-reform sales and the second is the pre-reform VAT. We control for the average value

of each variable over 1998-2001 to avoid endogeneity and their interactions with year fixed effects to allow the influences to be completely flexible over time.

The panel of sectors is aggregated from the full sample of firm-year data and allows for firm entry and exit. One might be concerned that firm exit is influenced by treatment, as firms may exit to avoid taxes. However, given that we study large manufacturing firms, we expect the impact of exit to be minimal.

We are interested in the estimate of β. If the reform increased compliance and VAT, then $\beta > 0$. Our identification strategy assumes parallel trends – i.e., absent the reform, the outcomes of interest across sectors with different NDS would have evolved along parallel trends (conditional on the controls).

Table 4 examines the effect of digitization on VAT. The sample means of the dependent variables are stated at the top of the table. Column (1) shows that the effect on gross VAT or VAT-eligible sales is negative, but statistically indistinguishable from zero. Column (2) shows that the reform reduces deductions. The estimate is statistically significant at the 1% level and is larger in magnitude than the estimated reduction in gross VAT in column (1). The reform, on average, reduced VAT deductions by $4,445 \times 1,000$ RMB (4.445 million RMB, or 584,000 USD) for a firm in a sector with no deductibles (i.e., the NDS is 100% of sales) relative to a firm in a sector where all sales are deductible (i.e., the NDS is 0% of sales). A back-of-the-envelope calculation shows that a firm with the sample mean NDS of 0.397 would have experienced a 37.0% ($4,445 \times 0.397/4774 = 0.3696$) decline in VAT deductions after computerization.

Column (3) shows that the reform increased VAT payment. The estimate is statistically significant at the 1% level. Note that we choose to examine level outcomes without logs because it is easier to conduct the back-of-the envelope calculations later in the paper. The estimates using log outcome variables are similar.

Column (4) examines VAT as a share of sales. The denominator is total firm revenues, which is reported in a different module of the firm survey. Since not all sales are VAT eligible, we use total sales in the denominator to normalize by firm size. If VAT payments increase because of a

change in enforcement, we may expect it to increase as a share of sales. If, instead, we are capturing spurious trends due to general macroeconomic growth, then total firm revenues would also increase and we would find no effect on VAT as a share of total sales. We find that the coefficient is positive and statistically significant at the 1% level. The reform caused firms to pay 2.03 percentage-points more VAT as a share of total sales.

In all four regressions, the year fixed effects increase over time. This pattern is consistent with the overall increase in VAT payments over this time displayed in Figure 5.

Table 4: The Effect of Digitization on VAT

	Dependent Variable			
	(1)	(2)	(3)	(4)
	VAT Gross (1,000 RMB)	VAT Deductions (1,000 RMB)	VAT (1,000 RMB)	VAT/Sales
Non-Deductible Share × Post-2002	-2,829*	-4,445***	1,634***	0.0203***
	(1,539)	(1,282)	(408.7)	(0.00386)
Observations	3,241	3,241	3,241	3,241
R-squared	0.618	0.671	0.404	0.901
Dependent Variable Mean	5989	4774	1538	0.0380

Notes: The sample is a sector-year panel covering 1998-2007. All regressions control for average pre-reform sales and average pre-reform VAT interacted with year fixed effects, sector fixed effects and year fixed effects. We note that sector fixed effects absorb uninteracted non-deductible share and year fixed effects absorb the uninteracted post-2002 indicator. All regressions use sector-year firm counts as analytic weights. Standard errors are clustered at the sector level. *** p<0.01, ** p<0.05, * p<0.1

The results show that the reform increased VAT paid by firms and that the increase is driven by a decline in deductions. This is consistent with conventional wisdom that the reform mainly impacted firms by removing their ability to falsify invoices for deductions. Another interpretation of these results is that the reform decreased the cost of reporting deductions for low NDS firms (Best et al., 2015). In that case, high NDS firms would file relatively fewer deductions. However, the reform had identical reporting rules across sectors, so it is unlikely that this channel drives the results.

We use a back-of-the-envelope calculation to interpret that magnitudes of the estimated effect

on VAT. We can do this in two ways. First, we multiply the full sample coefficient on VAT, $1,634$, by the difference in NDS between the mean and minimum of the full sample, or $(0.397–0.244) = 0.153$, which yields an average treatment effect of 250.0 thousand RMB. The average in-sample firm VAT bill increased from $3,590$ to $5,416$ thousand RMB from 1998 to 2007, an increase of $1,826$ thousand RMB. Our treatment effect represents 13.7% of the average growth in VAT over our sample.

Another way to benchmark the treatment effect is to compute the share of China's 2000 total VAT revenue it represents. To do so, we multiply the average full sample treatment effect by the average number of firms in the full sample per year, $711,643$ firms / 10 years $= 71,164$. We obtain $250.0 \times 71,164 = 17.79$ billion RMB. We then divide this value by China's total VAT revenue in 2000, 455.3 billion RMB, yielding 3.95%. However, this value should be scaled by the share of China's manufacturing sector included in our sample, which is 33.9%.[7] We find that our VAT treatment effect represents 11.65% of all VAT revenues in China in 2000.

These results suggest that the reform improved VAT enforcement in China. First, it decreased overall VAT deductibles, which is consistent with anecdotal evidence that digitization curtailed, or even eliminated, false deduction invoices. Second, it moderately decreased gross VAT. Because firms have an incentive to understate gross VAT obligations to evade taxes, the negative treatment effect suggests that firms may have downsized in response to the reform. Third, we find that firms' overall VAT payments increase because the decline in VAT deductions was larger than the decline in gross VAT. Finally, we find that the effective VAT rate increased as well, which goes against the alternative interpretation that output growth in intensely treated sectors increased VAT payments.

[7] We obtain this value by dividing the total manufacturing value-added in our full-ASIP cross-section, $1,487,844$ million RMB, by total value-added GDP from manufacturing in 2001, $4,385,430$ million RMB. We find that our sample covers 33.9% of manufacturing in China, as $4,385,430/1,487,844 = 0.339$.

5 Conclusion

As governments worldwide increasingly adopt information communication technologies for revenue collection, understanding the consequences of these technologies becomes crucial. It is especially important in the context of low and middle-income countries that hope to improve tax capacity. This paper explores the impact of digital technology on China's VAT system, with a focus on the national initiative known as Phase 2 of the Golden Tax Project. Using a difference-in-differences strategy, we estimate that digitization contributed at least 13.7% to China's VAT growth from 1998 to 2007 from manufacturing firms. The increase represented 11.7% of China's 2000 VAT revenues.

For comparison purposes, we consider recent evidence on technological improvements from other economies and for other forms of tax. Eissa and Zeitlin (2014) find that electronic billing machines increased VAT payments by an average of 8%. Ali et al. (2015) find that adopting an electronic tax system increased VAT payments by approximately 22%. Turning to other forms of taxation, Chen (2017) find that, after the elimination of the agricultural tax in China, the government heightened enforcement efforts for other taxes. Consequently, the total tax revenue, excluding agricultural taxes, experienced an average increase of 11.7%. Casaburi and Troiano (2016) find that an Italian program using satellite imagery to detect unreported property increased local tax revenues by 3% of the median value. Khan et al. (2019) find that performance-based transfers for tax inspectors increased annual tax revenue growth by more than 30%. The Chinese VAT gains we study are comparable to these other findings.

The results of this paper raise several questions for future research. The first is about how the VAT reform affected other taxes. On one hand, increased information from the VAT reform can improve the enforcement of other taxes such as the Corporate Income Tax. On the other hand, increasing VAT may induce firms to evade other taxes. The results also raise the question of how the increase in VAT affected firm behavior. Existing studies provide limited evidence on how firms adjust their economic or tax reporting behavior in response to taxes in the long-run. We address both of these questions in a companion paper, Fan et al. (2023).

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Appendix