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Consumption Tax Reform and the Real Economy: Evidence from India's Adoption of a Value-Added Tax*

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Abstract

We study the impact of a consumption tax reform on firm capital and productivity by examining India's replacement of the sales tax with a value-added tax (VAT). Unlike the sales tax, the VAT allowed firms to offset their tax liability with VAT paid on capital inputs, effectively reducing the tax-related cost of capital. Exploiting the staggered adoption of the tax reform across Indian states, we show that VAT adoption increased firm capital by 3%. The effects are driven by financially-constrained firms – an important source of heterogeneity in a developing country context. We also document a corresponding improvement in the productivity of financially-constrained firms. Our findings thus suggest that beyond revenue generation, consumption tax reforms can have the additional effect of stimulating investment and productivity in resource-constrained environments.

Key words: Value-added taxes; financial constraints; consumption tax reform; capital misallocation

JEL classification number: H32

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Policymakers have long debated whether tax incentives can stimulate economic growth by spurring capital investment. A large literature in tax policy and public finance in turn focuses on whether tax reforms affect firm behavior (Hassett and Hubbard 2002). Empirical evidence on this topic offers mixed results. For example, Zwick and Mahon (2017) and Ohrn (2018) find that corporate tax cuts lead to increased firm investment, while Yagan (2015) and Desai and Goolsbee (2004) find that the 2003 U.S. dividend tax cut — one of the biggest cuts in American history — had almost no impact on firm investment.

This paper contributes to the ongoing debate by identifying the effects of a consumption tax reform on firm capital in a major developing economy.[1] Our context is India's replacement of state-level sales taxes with a federally-harmonized value-added tax (VAT) for manufactured commodities. The key distinction between these two revenue systems is that unlike a sales tax, the VAT is levied only on the incremental value-addition at each stage of the production process. Limiting the consumption tax base to incremental value-addition is implemented through an input tax credit (ITC), which permitted firms to offset their final VAT liability with the tax paid during the purchase of inputs – reducing the tax-related cost of capital.[2]

Given that the ITC was applicable to the purchase of plants, machinery, and equipment, our paper empirically identifies whether this reduction in the effective cost of capital under the VAT regime affected firms' capital stock and productive efficiency. For causal identification, we exploit the differential timing of VAT adoption across Indian states in a difference-in-differences (DiD) framework.[3] Using firm-level data from a large financial database covering over 6,000 registered manufacturing firms, we show that a state's VAT adoption increased firm capital by 3 percent. Our preferred specification includes firm and industry-by-year fixed effects, restricting the comparison of outcomes to firms within the same industry group and year. We provide evidence to strengthen the validity of our causal estimates by verifying that state characteristics – such as GDP growth, size of the manufacturing sector, and numerous state fiscal

[1] Low tax compliance in developing countries adds complexity to the choice and design of tax-based incentives to stimulate firm investment (Kopczuk and Slemrod 2006; Pomeranz 2015).

[2] The ITC permitted firms to deduct taxes paid on the purchase of capital inputs, equipment, and machinery, but not any taxes paid on labor.

[3] The first state adopted the VAT in 2003, and the remaining states phased into the VAT regime over the rest of the decade, with the last state adopting in 2008.

characteristics – do not predict the timing of states' adoption of the VAT. These, alongside tests for differential pre-trends in outcomes, mitigate concerns of states selecting into the tax reform in a manner that confounds our estimates of causal effects.

To further bolster confidence in our estimation strategy, we also conduct several placebo tests. As manufactured commodities formed the base for both the sales tax and the VAT, we confirm that VAT implementation had no detectable effect on the capital of non-manufacturing firms. Using data from a nationally representative survey of registered manufacturing establishments, we also rule out any increase in the price of machinery and capital equipments in response to VAT adoption by states. This alleviates the concern that an increase in the demand for capital could have negated the reduction in the tax-related cost of capital due to the ITC (Goolsbee 1998).

In addition to identifying the average effects of replacing the sales tax with the VAT, a key goal of our paper is also to explore whether any investment response to tax reform was driven by financially-constrained firms. The presence of financial constraints forces firms to rely on relatively "costly" external funds to finance their capital expenditures and existing research suggests that the capital stock of such firms would be most likely to respond to reductions in the cost of capital (Criscuolo et al. 2019). This forms our motivation to examine the distributional impact of the consumption tax reform across financially constrained firms.[4]

To empirically test for heterogeneity along this dimension, we use the size-asset (SA) index developed by Hadlock and Pierce (2010) to measure the severity of financial constraints faced by firms over the five-year period prior to states' adoption of the VAT (between 1998 and 2002). We find that the positive impact of the VAT on capital was concentrated among firms falling in the top tercile of the pre-VAT SA index distribution – i.e., firms most likely to be financially constrained, who exhibited a 6 percent increase in capital. Moreover, we also show that the VAT-induced increase in firm capital is enhanced for firms operating in industries with a relatively higher dependence on external finance, where financial constraints are most likely to bind.

[4]Understanding the role of financial constraints is also of particular importance in developing economies, as financial constraints have been shown to explain productivity losses through capital misallocation.

Extending the measures of total factor productivity developed by Hsieh and Klenow (2009), we next show that while exposure to the VAT had little impact on average firms' productivity, it had a positive effect on the productivity of financially constrained firms. Conditional on states' adoption of the VAT, moving from a firm at the 25^{th} percentile of the SA index to the 75^{th} percentile resulted in an additional 1 percent increase in firm productivity. This suggests that the VAT-induced capital expansion enabled financially constrained firms to operate at more efficient levels. We next estimate the aggregate impact of VAT adoption at the state-industry level: while the VAT had a null effect on aggregate capital for the average state-industry combination, it increased capital in industries with a high fraction of financially constrained firms. The findings are similar for aggregated average industry productivity.

Finally, we apply the decomposition proposed by Olley and Pakes (1996) to determine whether the increase in aggregate productivity among select state-industry groups is driven through an overall reallocation of resources towards firms with higher productivity. In applying this approach, we identify whether VAT adoption by states impacted the covariance between firms' productivity and their share of industry output; a positive effect implying that a larger share of industry output is being accounted for by more productive firms. The results, however, show that VAT adoption had little impact on the covariance between average productivity and firms' output share, even in state-industry cells with a high fraction of financially constrained firms. The increase in aggregate productivity thereby stems from an increase in the productivity of individual firms, as opposed to an overall improvement in the allocation of resources in the economy. Collectively, these results suggest that while the elimination of distortionary consumption taxes reduced capital costs, it did not lead to an improvement in capital allocation. It is possible that VAT adoption did not disproportionately increase the capital costs of financially *unconstrained* firms, thereby restricting it's aggregate impact on capital allocation.

This study contributes in a few key ways to the literature at the intersection of tax policy, public finance, and development economics. We add to a large and growing literature on the impact of tax incentives on firm investments. Several studies show that tax-based incentives positively affect investment (Cummins et al. 1994, 1996; House and Shapiro 2008; Zwick and Mahon 2017; Ohrn 2018). Others, however, find that the 2003 dividend tax cut had no impact on firm investment (Desai and Goolsbee 2004; Yagan 2015). Perhaps most closely related to our work is a recent study by Chen et al. (2020) on the impact of China's 2009 VAT reform, which similarly lowered the tax cost of investment. We differ from that paper by focusing only on domestic firms, and leveraging unique temporal *and* spatial variation in VAT administration. Consistent with Chen et al. (2020), we also document a positive effect of the VAT on investment.

Our paper also highlights the distributional effects of tax-based incentives on firm investment by showing that the elimination of consumption tax distortions increases the capital of financially-constrained firms. This finding is consistent with recent work by Dharmapala et al. (2011), who find that a tax holiday on the foreign earnings of U.S. multinational corporations had limited effects on domestic investments; affected firms, which were well-governed (and not-financially constrained) instead passed on the tax benefits to their shareholders.

Relatedly, our paper contributes to the broader literature on how taxation affects corporate decision-making.[5] Our approach parallels recent papers that exploit state-level differences in taxes in the U.S. to examine the choice of firm location (Giroud and Rauh 2019) and corporate debt (Heider and Ljungqvist 2015). Barring a few exceptions (Cai and Harrison 2011; Liu and Lu 2015; Agrawal and Zimmerman 2019), prior work has mostly focused on developed economies. Our paper finds that even in a developing economy like India with imperfect tax compliance, the VAT-based incentive had a positive impact on firm investment and productivity.

Our main finding also relates to work on how tax-based fiscal stimulus affects economic activity. Berger et al. (2020) show that a temporary homebuyer tax-credit between 2008 and 2010 in the U.S. is successful in stimulating housing markets. D'Acunto et al. (2020) show that the pre-announcement of higher future value-added taxes in Germany stimulated household consumption by raising households' inflation expectations. Existing studies of emerging economies suggest more modest effects, though. Cai and Harrison (2011) and Liu and Lu

[5] See Graham (2015) for a review.

(2015) show that the VAT reduction in China, aimed specifically at increasing firm fixed investments, had a relatively limited effect on investment but increased exports. We show instead that switching from a sales tax to a VAT can stimulate investment (especially among relatively smaller and younger financially constrained firms), and document the positive spillovers emanating from the elimination of consumption tax distortions on firm performance.

Finally, our paper also has tax policy implications. VAT systems have become a key source of revenue for over 160 economies in the past two decades (Keen and Lockwood 2010). Our findings depart from prior work that has argued that the VAT can be regressive as they often hit the poorest households hardest [and similarly, that small businesses are adversely hit due to increased compliance costs (Gale et al. 2016)]. Our findings instead suggest that switching to a destination-based VAT may instead aid financially-constrained firms, contrary to concerns regarding the adverse distributive effects of VAT. (Thomas et al. 2020).

The remainder of the paper is organized as follows. Section I provides a background on India's VAT and a framework demonstrating how the replacement of the sales tax with the VAT may affect firm capital. Section II describes our data and Section III lays out our empirical strategy. Section IV presents our key findings. Section IV.C presents several robustness and placebo tests in support of our empirical findings.

I Background and Conceptual Framework

To motivate our empirical analysis, we start by documenting the institutional details surrounding India's transition to a VAT. We then discuss how this new tax structure incentivized firms to invest in capital.

I.A Adoption of the VAT

Value-added taxes were introduced in India in 1986 as a part of import tariff reforms. With the onset of economic liberalization in 1991, both the federal, and state governments started to consider replacing the system of state-specific sales taxes with a VAT to improve efficiency in revenue collection and to transition to an uniform set of consumption taxes.[6] As India's federal structure designated consumption tax administration to state governments, a committee of state finance ministers was set up in 1999 to design a common VAT framework for all states.

After five years of deliberation regarding a structure for VAT administration, including base and rates, a majority of states agreed to replace their state-specific sales taxes with an uniform destination-based VAT. Manufactured commodities formed the VAT base and two common rates – 4 percent and 12.5 percent – were applied, with the majority of commodities being assigned to the lower rate (VAT White Paper 2005).[7] Based on local factors, states were accorded the flexibility to exempt a set of 10 commodities from the VAT base. As the new VAT rates were lower than the prevailing sales tax rates for a number of commodities, the federal government agreed to partially compensate states for any revenue losses in the first three years after VAT adoption.[8]

The VAT was adopted by states individually across nearly a decade. The state of Haryana was the first to adopt the VAT in 2003, and other states transitioned in subsequent years.[9] The staggered nature of VAT adoption thus created natural treatment and comparison groups, conditional on the timing of VAT adoption being orthogonal to our firm outcomes of interest. Importantly, the timing of VAT adoption does not appear to be correlated with trends in economic outcomes. Tables A1 and A2 in the Online Appendix provide evidence that states' timing of VAT adoption was not predicted by prior growth in state domestic product, revenues, and expenditures.[10]

[6]Previously, each state independently had its own sales tax structure, with myriad commodity-specific tax rates (Agrawal and Zimmerman 2019).

[7]Services were taxed separately under the Service Tax, administered by the federal government, with revenues annually distributed to the states.

[8]Sales taxes comprised over 50% of state revenues and the federal government committed to 100 percent compensation for revenue losses in the first year, 75 percent in the second year, and 50 percent in the third year. Both the state and federal governments expected that an expansion of the tax base, tax simplification due to fewer rates, and improved efficiency in tax administration would compensate for the revenue losses arising from any reduction in statutory rates (VAT White Paper 2005).

[9]In 2005, another 16 states switched from the sales tax to the VAT, while in 2006, six more adopted the VAT. In 2007, the southern state of Tamil Nadu adopted the VAT, while in 2008, the last state, Uttar Pradesh in northern India, adopted the VAT.

[10]In each specification in Tables A1 and A2 (Online Appendix), we regress an indicator variable equaling 1 if the state has adopted the VAT in a given year on state and year fixed effects, and three annual lags of the state-level macroeconomic characteristic of interest. The final column in each table includes all the covariates. Across both tables, only the logged per capita state expenditures (lag 1) is a significant predictor (5% level of significance or

According to India's official tax policy description, the VAT White Paper (2005), there were two motivations for switching to the VAT: the first was to eliminate the cascading effect of sales taxes levied at every point along the production chain; the second was to harmonize consumption tax rates on identical commodities across states, eliminating "unhealthy" tax competition between states. The VAT base was limited to incremental value-addition at each stage using the input tax credit (ITC), which permitted manufacturers to receive a credit for any VAT paid on inputs purchased during the production process. The net VAT remitted to the state government by any firm would equal the VAT levied on the firm's sales, less any VAT paid on capital inputs (including machinery and equipment). The committee expressed hope that the restriction of the consumption tax base to incremental value addition would lead to an overall reduction in manufacturing prices through the elimination of double taxation embedded in the sales tax (VAT White Paper 2005).[11]

I.B Conceptual Motivation: VAT, Input Tax Credits, & Firm Investment

The key distinction between the sales tax and the VAT is that the latter permits firms to apply the ITC and offset their final tax liability by the amount of tax paid while purchasing inputs. Thus, if there are no additional transaction costs or processing delays associated with the receipt of the ITC, we would expect firms to adjust their marginal costs by accounting for the ITC. Formally, consider a profit-maximizing firm that chooses capital k and labour l to produce commodity y, priced at p. The firm is a price-taker, and each unit of capital is priced at r, while labor is priced at w. Capital inputs are taxed at the rate τ, which is also the tax rate on the firm's output.[12] The firm produces y using a standard production function, $f(k,l)$ with diminishing returns in both inputs. The firm's profit maximization problem is:

$$\pi(k,l) = (1-\tau)pf(k,l) - wk - r(1+\alpha\tau)k, \tag{1}$$

better) of a state adopting the VAT. To this effect, in all of our main specifications, we control for a linear trend in per capita state government expenditures.

[11] It is worth noting however, that while the replacement of the sales taxes with the VAT eliminated a major source of double taxation, the presence of the central sales tax on inter-state trade meant that the cascading impact of consumption taxes was not eliminated in its entirety (Agrawal and Zimmerman 2019).

[12] The assumption that the firm's capital inputs and final output is taxed at the same rate can easily be relaxed.

where α in equation (1) represents the ITC component associated with the VAT. Under the sales tax, $\alpha = 1$ and there is no off-setting of taxes paid during the purchase of firm capital. Alternatively, under the VAT, if the ITC works seamlessly and firms receive an immediate credit for taxes paid on capital, $\alpha = 0$. If transaction costs or processing delays diminish the value of the ITC, $\alpha \in (0, 1)$. The replacement of the sales tax with the VAT can intuitively be considered as a reduction in α from 1, towards 0.

Assuming that the firm faces a borrowing constraint and λ represents the shadow price of inputs, the first order conditions for profit-maximization are:

$$f_k(k^*, l^*) = \frac{r}{p} * \frac{(1 + \alpha\tau)(1 + \lambda)}{1 - \tau} \tag{2}$$

and

$$f_l(k^*, l^*) = \frac{w}{p} * \frac{1 + \lambda}{1 - \tau}. \tag{3}$$

In equations (2) and (3), f_k and f_l are the partial derivatives of the production function with respect to capital and labor, while k^* and l^* denote optimal capital and labor, respectively.

From equation (2), we can gauge the impact of both the tax distortion, and financial constraints, on firm capital. In the absence of the tax distortions and financial constraints, the firm's optimal capital would be when the firm's marginal revenue product of capital (MRPK) equals the ratio between its marginal cost of capital and the marginal revenue from an additional unit of output. However, the presence of tax distortions (on both output and cost of capital) introduces a wedge, increasing the firm's MRPK, and pushing it away from the optimal MRPK. Moreover, if the firm is financially constrained and the borrowing constraint binds ($\lambda > 0$), it further exacerbates the wedge introduced by the sales tax. If the replacement of the sales tax with a VAT involves no change in the prevailing consumption tax rate, but only a reduction in α ($\alpha = 1$ under the sales tax), it is straightforward to show from equation (2) that the optimal capital response would be:

$$\frac{dk^*}{d\alpha} = \frac{r(1 + \lambda)\tau}{p(1 - \tau)f_{kk}}. \tag{4}$$

As $f_{kk} < 0$, $\frac{dk^*}{d\alpha} < 0$, implying that a *reduction* in α should *increase* the optimal capital of the firm, even in the absence of any change in the prevailing tax rates.[13] This expression provides us with our first hypothesis of interest:

Hypothesis 1: Replacement of the sales tax with the VAT should result in an increase in firm capital.

Additionally, as $\lambda > 0$ for firms facing a binding borrowing constraint, the optimal capital response to a change in α would be higher courtesy the $(1 + \lambda)$ term in the numerator of (4). This brings us to the second hypothesis of interest:

Hypothesis 2: The increase in capital stock in response to the replacement of the sales tax with the VAT should be higher for financially constrained firms..

The remainder of the paper identifies the above two hypotheses using a firm-level panel.

II Data and Summary Statistics

II.A Data

Our main data source is Prowess, an extensive database on registered Indian firms maintained by the Centre for Monitoring the Indian Economy (Lilienfeld-Toal et al. 2012; Vig 2013). Prowess provides us with a firm-level panel for the 1998-2012 period. Covering both listed and unlisted firms, the Prowess database includes information on firm assets, liabilities, borrowings, income, expenses, and employee compensation. We focus on manufacturing firms for our analysis. However, we also use data on firms in the services sector (automatically exempted from the VAT), as well as select manufacturing sectors exempted from the VAT as

[13] Agrawal and Zimmerman (2019) in their comparison of sales tax and VAT rates show that the average statutory rate declined by approximately 1 percentage point in the aftermath of VAT adoption. Allowing the tax rate to also change would cause the optimal capital response to be:

$$\frac{\partial k^*}{\partial \alpha} = \frac{1}{f_{kk}}\left[\frac{(\alpha r(1+\lambda) + pf_l)(\tau r(1+\lambda))}{p^2 f_{lk}(1-\tau^2)} + \frac{f_l}{1-\tau}\right] < 0. \quad (5)$$

placebo groups to corroborate our main findings.[14] This provides us with a sample of around 6,000 firms. We use information on the location of firm headquarters to assign firms to states.[15]

Our main outcome is a firm's capital stock, which we measure using the value of plant and machinery. We use net plant and machinery to account for depreciation over time, although the results are unchanged when we use gross values or capital stock scaled by firm assets. Two other key outcomes of interest to gauge firm performance are revenue productivity (total factor productivity measured in terms of firm revenues), and the marginal revenue product of capital (MRPK). We detail how these are estimated in Online Appendix A2.A.

We focus on identifying how reducing consumption tax distortions through a VAT affect financially-constrained firms that rely on "costly" external finance. To identify such firms, we exploit firm balance sheet information and measure the intensity of financial constraints using the size-asset (SA) index developed by Hadlock and Pierce (2010). The SA index expresses the severity of financial constraints faced by a firm as a function of its size and age. Size is measured using firm assets, while age is measured as the duration (in years) a firm is publicly listed. As both firm assets and the decision to be publicly listed can change in response to states' adoption of the VAT, we first compute the SA index for our sample of firms for each year between 1998 and 2002, when no state had adopted the VAT. Next, we obtain the five-year firm-specific mean of the annual SA index to arrive at a single parameter measuring the severity of financial constraints faced by a firm in the pre-VAT period. Additional details on the SA index and its correlations with individual firm characteristics predictive of a firm being financially constrained are shown in Online Appendix A2.B. In particular, we show that firms with a higher score on the SA index are also more likely to be smaller in size, have lower capital stock, tangible assets, and fewer banking relationships in the pre-VAT period.

Additional data sources include commodity-level manufacturing prices from the Annual

[14]Within the manufacturing sector, textile, sugar, and tobacco manufacturers are exempt from the VAT, along with select sub-sectors in the food manufacturing industry, such as the preparation of animal feeds, milk processing, etc. Services continued to be taxed under the Service Tax levied by the federal government.

[15]Given that the VAT is levied at the point of sales, an implicit assumption is that a firm's headquarters and operations are located in the same state. In Section 5.1, we demonstrate that results are unchanged if we exclude firms headquartered in two of India's largest metropolises – for which this assumption is most likely to be violated. Further discussion below.

Survey of Industries – a representative survey of registered Indian manufacturing firms – which we use to confirm that the cost of capital does not increase in response to VAT adoption. We also obtain state-level covariates from the Handbook of Statistics of Indian States (hosted by the Reserve Bank of India) to control for factors such as state revenues, expenditures, share of manufacturing output, bank branch density, and population.

II.B Descriptive Characteristics

Table 1 presents summary statistics for our sample of manufacturing firms in the Prowess data. This includes firms operating in sectors not exempted from the VAT between 2000 and 2008. The mean capital stock is 176 million Indian rupees (INR) (measured in 1993 values). Mean net fixed assets are INR 238 million. The distribution is pulled rightwards by large firms — the median capital stock (net fixed assets) being INR 20 (35) million. The average annual growth in capital stock during this period is 4 percent, while the corresponding growth in firm sales and employee compensation is 13 and 11 percent respectively. The average firm profitability during this period is 4 percent of firms' incomes, with almost 80 percent of the firms recording positive profits (prior to interest payments and taxes). While 35 percent of the firms have been publicly listed at some time during this period, only 11 percent have an external credit rating. Almost 40 percent of the firms are headquartered in one of the two major metropolises, Delhi and Mumbai, with the average firm being 20 years old.

In Figure 2, we plot the average change in capital stock and revenue productivity across the pre and post-VAT periods as a function of firms' pre-VAT score on the SA index. For each firm, we first collapse the outcomes of interest into pre and post-VAT averages and compute the within-firm difference in capital stock (revenue productivity) across the two periods. The horizontal axis is divided into 50 equally-spaced bins measuring the severity of financial constraints faced by firms in the pre-VAT period. Within each bin, we plot the unconditional mean of the within-firm difference in post and pre-VAT outcomes.

The results are consistent with our predictions in Section I.B. Panel A in Figure 2 depicts a positive correlation between the severity of financial constraints and the change in capital stock across the two periods. Thus, while most firms witnessed an increase in capital stock in the post-VAT period, this is concentrated amongst firms facing a higher severity of financial constraints in the pre-VAT period, particularly for firms with SA index scores in the range $[-2, 0)$. A similar effect is also observed for firms' revenue TFP (right panel, Figure 2). We now present the empirical strategy to rigorously test this descriptive result using a DiD design.

III Empirical Strategy

We now discuss our strategy to identify the causal impact of replacing the sales tax with a VAT on firm capital.

III.A VAT Adoption and Capital Stock

The key objective of our paper is to measure the impact of VAT adoption on firms' capital stock – in other words, to identify the effect of a decline in α as outlined in equation (4). This will provide reduced-form evidence that India's VAT regime incentivized firms to increase investment in response to a reduction in the effective cost of capital. We test this hypothesis using a DiD design, exploiting the differential timing of VAT adoption across states using the following specification:

$$\ln(Y_{ist}) = \alpha_i + \delta_{jt} + \beta VAT_{st} + \phi \mathbf{X}_{ist} + \epsilon_{ist}. \tag{6}$$

In equation (6), the unit of observation is the firm. Y is the outcome of interest for firm i, headquartered in state s, and observed in year t. Our primary outcome of interest is capital stock, measured using net plant and machinery, but we later expand our analysis to identify the effects of VAT adoption on firm productivity and other related outcomes. α and δ are firm and industry-by-year fixed effects (three-digit industry level). $\mathbf{X}$ denotes firm- and state-specific covariates. Standard errors are clustered by state for inference.

The independent variable of interest is a state-level treatment indicator, *VAT*, and β identifies the average treatment effect, conditional on the fixed effects and state-specific covariates. The inclusion of industry-by-year fixed effects implies that we are comparing firms within the same three-digit industry and year, with the cross-sectional variation stemming from the differential timing of firms' exposure to the VAT.

Our identifying assumption for a causal interpretation of β is that firm outcomes would have been comparable in the absence of states' adoption of the VAT. While the parallel trends assumption cannot be formally tested, we provide several pieces of evidence supporting the credibility our identification strategy. In Figures A3 and A4 in the Online Appendix, we plot the trends in key firm outcomes in the pre-VAT period across three groups of states. The groups are based on whether states adopted the VAT in a) 2003 or 2005; b) 2006; or c) 2007 or 2008. Across both figures, no differential trends are apparent in the pre-VAT period for any of the 14 firm outcomes. We also estimate the impact on capital using an event-study framework:

$$\ln(Y_{ist}) = \alpha_i + \delta_t + \sum_{k=-4}^{4} \beta_k VAT_{st+k} + \epsilon_{ist}. \tag{7}$$

Equation (7) separately identifies the treatment effect for each year in the four-year window before and after the introduction of the VAT.[16] The year prior to VAT introduction – $k = -1$ – serves as the base year. The annual VAT effect for the remaining years are estimated relative to this base year. Failing to reject the null hypothesis of $\beta_k = 0, \ \forall \ k \in \{-2, -3, -4\}$, would support the assumption of no differential pre-VAT trends.

III.B Heterogeneous Effects by Firm Financial Constraints

We also test whether the treatment effect outlined in Subsection III.A is stronger for financially constrained firms (Hypothesis 2, based on equation (4)). To do so, we explore the heterogeneous effect of the VAT across the severity of financial constraints that firms faced in the pre-VAT period. Specifically, we estimate the following equation:

$$\ln(Y_{ijst}) = \alpha_i + \delta_{jt} + \beta_1 VAT_{st} + \beta_2 VAT_{st} * SA_i + \phi \mathbf{X}_{ist} + \epsilon_{ist}. \tag{8}$$

Here, SA denotes the severity of financial constraints faced by firms based on their pre-treatment score on the SA index. β_1 now estimates the average VAT effect on firm outcomes for firms

[16] Due to the differential timing of VAT adoption across states, the number of pre- and post-VAT years varies across states. To this effect, we limit our sample to four pre- and post-VAT years for this specification.

whose pre-VAT SA index score is 0. As the support of the SA index lies between -4 and 0, and a higher score reflects a strengthening of financial constraints, β_1 can be interpreted as estimating the VAT's impact on the most financially constrained firms. β_2 estimates the differential treatment effect on firm capital as the severity of financial constraints increase.

As the SA index is a function of firm size and age, we also follow Criscuolo et al. (2019) to directly test for treatment heterogeneity across relatively small and young firms. Young firms in particular have been shown to be a good proxy for cash constraints (Cabral and Mata 2003; Angelini and Generale 2008), along both the intensive and the extensive margin (Kerr and Nanda 2009). As the Prowess has limited data on the number of employees, we rely instead on employee compensation as a measure of firm size. Additionally, we also test for differential treatment effects across firm characteristics, which have been identified (e.g., Campello et al. 2010 and Lin and Paravisini 2013) to be predictive of financial constraints: whether a firm is unlisted, lacks a credit rating, has few banking relationships, and has low tangibility. Listed firms, by virtue of their ability to access capital markets, are often considered to be financially unconstrained (Zia 2008), while the lack of a credit rating and limited banking relationships can also affect firms' ability to obtain credit from external sources (Giroud and Mueller 2015). As firms can pledge their land and building as collateral, and Almeida and Campello (2007) show that capital expenditures in firms with high tangibility are less sensitive to cash flows, we also identify heterogeneity across firms with a relatively low level of tangible assets (value of land and building), and by extension, more likely to be financially constrained.

Finally, we draw from Rajan and Zingales (1998), who show that inherent technological factors make select industries more dependent on external financing for their capital expenditures. This dependence on external finance imply that financial constraints are also more likely to bind in such industries (Larrain and Stumpner 2017). Using Compustat data for publicly listed U.S. firms between 1980 and 1990, Rajan and Zingales (1998) compute industry-level dependence on external finance.[17] We map the industry-level (three-digit industry) measures calculated by Rajan and Zingales (1998) to firms' industrial classifications in the Prowess database

[17] Rajan and Zingales (1998) restrict themselves to U.S. firms under the assumption that the U.S. serves as the first best case where financial frictions are relatively small, particularly for listed firms.

and identify whether firms' response to the VAT were amplified in industries which – for arguably exogenous reasons – are more likely to be dependent on external finance.

IV Results

We now discuss our empirical findings, beginning with the VAT's impact on firm capital. Next, we document heterogeneous effects across financially-constrained firms. We conclude by estimating the aggregate impact of VAT adoption on capital and productivity.

IV.A Impact of the VAT on Firm Capital

IV.A.1 Main Findings

We now examine the average treatment effect – VAT adoption by states – on firm capital. Table 2 presents our baseline results, estimated using equation (6). The regression for column (1) includes firm and year fixed effects and shows that firms' exposure to the VAT increased capital by almost 3 percent. Column (2) replaces the year fixed effects with three-digit industry-year fixed effects, restricting the comparison of firm outcomes to firms in the same broad industry and year. The identifying variation stems from the differential timing of VAT adoption across states and the point estimates remain unchanged in magnitude and precision to the inclusion of industry-year fixed effects. The specifications in columns (3) and (4) include a quadratic in firm age and time-varying state-level covariates, with little impact on the coefficient. Our preferred specification is column (4), which controls for firm age and state-level covariates, along with firm and industry-year fixed effects. The results show that VAT adoption increased firm capital by 3 percent [INR 6 million (in 1993 INR) relative to the pre-VAT mean].

Column (5) includes lagged firm-level controls for profitability, cash-flow and tangibility – all of which can impact current capital stock.[18] The absence of data for select variables reduces the sample size significantly in column (5). Nonetheless, the coefficient is only slightly atten-

[18] Profitability is measured using return on assets while tangibility is measured using land and buildings as a share of total assets. The specification controls for two lags of firm-specific controls, in addition to the quadratic in firm age. As firm-level variables such as profitability, cash-flow, sales and employee compensation can all be affected by the VAT, we choose to directly identify the treatment's impact on these variables, as opposed to treating them as covariates.

uated and remains significant at the 5% level. Column (6) replaces the quadratic in firm age with firm-age fixed effects and the results are unaffected by this alteration. In summary, the results in Table 2 provide support for our prediction in (4): firm capital increased in response to replacing the sales tax with the VAT (reduction in α from 1 towards 0). Section IV.C discusses additional robustness checks of the baseline estimates.

A causal interpretation of the coefficients in Table 2 is subject to the standard DiD assumption: capital would have evolved similarly across firms in the *absence* of VAT adoption. While the counterfactual cannot be directly tested, Figure A3 in the Online Appendix shows the absence of any systematic differential pre-VAT trends in capital (and other firm outcomes) across early and late VAT adopting states.

We next use the event study specification in equation (7) to identify whether the increase in capital coincided with states' timing of VAT adoption, or alternatively, if there existed a pre-trend in our outcome of interest. The horizontal axis in Figure 3 denotes the time (in relative years) from the adoption year. The coefficients are benchmarked to the year prior to VAT adoption (denoted by -1). Panel A of Figure 3 documents a sharp increase in capital in the year of VAT adoption and there is no discernible pre-VAT trend. In the absence of any other state-level changes coinciding with VAT adoption, we attribute the positive impact on firm capital to states' replacement of the sales tax with the VAT. Importantly, the lack of any sharp decline in firm capital in either of the pre-VAT years alleviates concerns that firms may have delayed capital expansions in anticipation of the VAT.

IV.A.2 Understanding the Channels

Our conceptual framework suggests that the VAT should increase investment by allowing firms to deduct any VAT paid during the purchase of capital – the disallowance of which under the sales tax system manifested as a distortion to the cost of capital. Allowing firms to deduct taxes paid on the purchase of plant, machinery, and equipment is equivalent to an investment incentive, which would be expected to increase firm capital.

Goolsbee (1998) however cautions that general equilibrium effects can dampen the impact of investment incentives on firm capital through increased aggregate demand that would instead *increase* the cost of capital. We consider this to be unlikely in our context, as the ITC component of the VAT also eliminates the prevalent double-taxation of commodities under the sales tax, which was expected to reduce manufacturing prices (VAT White Paper 2005).[19] We illustrate this in the Online Appendix (Section A1) using a stylized example and show that in the absence of any significant increase in firm mark-ups and statutory tax rates, the replacement of the sales tax with the VAT would be expected to *reduce* manufacturing prices.

We also confirm this empirically in Appendix Table A3 using commodity-level price data from a nationally representative survey on manufacturing establishments. The results bear out that the replacement of sales taxes with the VAT, if anything reduced the price of manufactured commodities – including machinery and capital equipment (column 5, Table A3). This alleviates the concern that allowing firms to deduct taxes paid on purchases of fixed capital through the ITC might not translate into a reduction in the cost of capital due to an overall increase in the demand for capital equipments.

IV.B Effect of the VAT on Financially Constrained Firms

Having established a positive causal impact of the VAT on firm capital, we next identify whether financially constrained firms drive the treatment effect, using equation (8) to examine treatment heterogeneity across ex-ante firm financial constraints. We gauge firm-level financial constraints using the SA index (Hadlock and Pierce 2010), which measures the intensity of financial constraints as a function of firm size and age. We use data from the pre-VAT period between 1998 and 2002 to construct the SA index, ensuring that the financial constraints measure is unaffected by VAT adoption.

In column (1) of Table 3, we find a positive and significant coefficient on the interaction term ($VAT \times SA$), confirming that the capital response to VAT is increasing in the ex-ante intensity

[19] Recall, that unlike the VAT, the sales tax disallowed any off-setting of taxes paid on the purchase of either fixed capital, or other capital inputs used in the manufacturing process. Consequently, the base upon which the sales tax is levied for any manufactured commodity also included the value of sales taxes paid during the purchase of all capital inputs used to manufacture that commodity, leading to double taxation.

of firm financial constraints. The *VAT* coefficient indicates a 22 percent increase in capital for the most constrained firms ($SA = 0$) post VAT adoption. Corresponding to the average firm's pre-VAT SA index of -2.52, the mean increase in firm capital is in excess of 2 percent (0.22 - (0.078*2.52)), equivalent to INR 5 million. The interaction term suggests that conditional on states' adoption of the VAT, moving from the 25th percentile to the 75th percentile of the SA index resulted in an additional 6 percent increase in firm capital.[20]

The SA index is based on a firm's assets and years since listing on the stock exchange. Almost two-thirds of the firms in our sample are unlisted, and this could mechanically push the distribution of the SA index rightwards toward 0 (see Online Appendix A2.B). Column (2) in this regard shows that our results are unchanged if we directly use the firm's age to construct the SA index.

We next test for non-linearities by identifying treatment heterogeneity in the top two terciles of the pre-VAT SA index distribution. SA^{T2} (SA^{T3}) is a dummy equaling 1 if the firm falls in the second (top) tercile of the SA index. The uninteracted *VAT* term now estimates the VAT's impact on the least financially constrained firms in the bottom tercile of the SA index. Consistent with the descriptive evidence in Figure 2, we see in column (3) of Table 3 that the treatment effects are concentrated amongst the most financially constrained firms, lying in the top 2 terciles of the pre-VAT SA index. While the $VAT \times SA^{T2}$ interaction is significant at the 10% level (p-value 0.055), the $VAT \times SA^{T3}$ interaction is significant at the 1% level (p-value 0.008). With the sum of the two coefficients being significant at the 5% level, column (3) confirms that the most financially constrained firms in the top tercile of the SA index exhibited a 6 percent increase in capital in response to the VAT.

In Panel B of Figure 3, we extend the distributed lag specification in equation (7) to examine the annual treatment effect on capital for financially constrained firms (above median score on the SA index).[21] We expect no differential change in capital for financially constrained firms in the pre-VAT period, but a positive coefficient in the years following VAT adoption. Panel B of

[20] The 25th percentile of the pre-VAT SA distribution is -2.96, while the 75th percentile is -2.23. The increase in capital post-VAT for a firm at the 75th percentile relative to the 25th percentile of the pre-VAT SA index equals 0.73*0.078 = 0.057.

[21] Specifically, we estimate:

Figure 3 shows that the interaction of the year dummy with the financial constraints indicator yields a small positive and statistically insignificant coefficient prior to states' adoption of the VAT, and switches to being positive and significant after VAT adoption. The absence of any differential pre-treatment trends for financially constrained firms further validates our empirical design.

Our findings are robust to alternate measures of financial constraints based on firm characteristics. We follow Criscuolo et al. (2019) and use proxies for financial constraints based on firm size and age. As Prowess has limited data on employees, we use the firm's employee compensation as a proxy for firm size and define the dummy *Low Salaries* to equal 1 if the firm's pre-VAT (between 1998 and 2002) average annual compensation is lower than the median pre-VAT compensation across all firms. Column (4) shows that while the *VAT* indicator remains positive, the $VAT \times LowComp$ interaction is negative, albeit not significant. As Criscuolo et al. (2019) caution that firm size is an imperfect measure of financial constraints, we follow their recommendation to identify VAT heterogeneity across small firms that are also young.

Column (5) shows the VAT heterogeneity across young firms. The dummy *Young* is set to 1 if the firm is incorporated after 1996 – the year from which our sample begins.[22] The capital response to VAT is almost entirely driven by young firms, who exhibited a net 29 percent increase in capital post-VAT. The results in column (6) show that the response to the VAT is almost entirely driven by firms that are both young and relatively small in size. The coefficient of interest, $VAT \times \; Low\; Salaries \times Young$, is positive and significant at the 5% level, indicating that small young firms exhibited a 26 percent increase in capital post-VAT. The $VAT \times \; Low\; Salaries$ coefficient in column (5) remains negative, suggesting that small-sized older firms had a lower response to the VAT, consistent with Criscuolo et al. (2019). In terms of magnitudes, the sum of the four coefficients in column (5) suggest that the net treatment effect for small young firms

$$\ln(Y_{ist}) = \alpha_i + \delta_t + \sum_{k=-4}^{4} \beta_{1k} VAT_{st+k} + \sum_{k=-4}^{4} \beta_{2k} SA_i \times VAT_{st+k} + \epsilon_{ist}, \tag{9}$$

where *VAT* and *k* are defined as per equation (7), and *SA* is a dummy equaling 1 if the firm's score on the SA index exceeded the pre-VAT median (-2.60). β_{2k} measures the differential change in capital for financially constrained firms, and *k* the years after (or prior to) states' adoption of the VAT. The coefficients are estimated relative to the year before states adopted the VAT, which continues to serve as the reference year.

[22] This implies that the "oldest" of the young firms would be 11 years old in 2008, the last year of our sample.

was a 36 percent increase in capital (p-value $< .001$), equivalent to INR 8 million.[23]

The results in columns (1) to (4) of Table A4 in the Online Appendix show robustness to alternate firm-level indicators of financial constraints, namely being unrated, unlisted, having low tangibility, and few banking relationships.[24] Consistent with our discussion in Subsection III.B, the coefficients on the respective interaction terms are positive and significant in all instances except column (1), confirming that VAT had a larger impact on financially constrained firms.[25]

Column 5 of Table A4 in the Online Appendix shows the differential effects of the VAT across industries' dependence on external finance based on the Rajan and Zingales (1998) measure. The results show that the interaction between the *VAT* indicator and industries' dependence on external finance yields a positive coefficient when financial constraints bind in industries with a relatively higher dependence on external finance, although the coefficient is significant only at the 15 percent level. In terms of magnitudes, the results suggest that moving from a firm operating in an industry at the 25th percentile of the Rajan and Zingales (1998) score to the 75th percentile produced a 1.5 percent ((0.47-0.14)*0.047 = 0.015) increase in capital, in response to the VAT.

IV.C Robustness Checks

Having identified the VAT's positive impact on firm capital, driven primarily by financially constrained firms, we now show the robustness of our main results to alternate specifications and sampling choices. First, we note that our results do not appear to be driven by sample selection. Figure 4 shows that our results are not driven by firms operating in any single state, alleviating concerns about unobserved concurrent state policies that increase manufacturing firms' capital stock. Here, we re-estimate Equation 6, dropping one state at a time and plot-

[23]This is relative to the pre-VAT mean capital of INR 23 million for firms that are both young and small in size.

[24]For credit ratings and public listing, we consider a firm to be unrated (unlisted) if it has never received a credit rating (never been publicly listed) in the pre-VAT period (prior to 2003). For tangibility (banking relationships), we classify firms as having low tangibility (few bank relations) if their average tangible assets as a fraction of total assets (average bank relations) is less than the median firm's tangible assets as a share of total assets (bank relations) in the 1998-2002 period. Tangible assets capture firms' value of land and buildings.

[25]In column (1) of Table A4, the interaction term of interest – $VAT \times Unrated$ – is positive but not significant. The sum of the VAT indicator and the interaction term however is significant at the 1% level, implying that unrated firms displayed a 4 percent increase in capital post-VAT.

ting each coefficient (vertical lines representing 90 percent confidence intervals). The figure indicates that no single state materially affects the magnitude or precision of our main results.

We also find that our method of statistical inference is robust. Columns (1) and (2) of Table 4 demonstrate that inference is unaffected by our choice of clustering. While our preferred level of clustering is the state – the level at which our treatment varies, we find that the results are robust to alternate levels of clustering at the level of the firm, and two-way clustering by state and year.

Next, we show that possible mismatches between a firm's headquarters and location of operations are not driving our results. Recall that we discern firms' exposure to the VAT based on the location of a firm's headquarters. This leads to the concern that since the sales tax and the VAT are collected at the point of sales, we might misclassify a firm's exposure to the VAT if its operations are located in a state different from its headquarters. This misclassification is most likely to be accentuated for firms headquartered in major metropolitan centers and we re-estimate our baseline specification in column (3) of Table 4, after excluding firms located in the metropolises of Delhi and Mumbai. Although we lose almost a third of our original sample, the coefficient remains similar in magnitude to those in Table 2 and significant at the 5% level.

Finally, we show the results from two placebo tests in columns (4) and (5) of Table 4. In Section I, we noted that the sales tax and the VAT applied to manufacturing firms and select industries were exempted from the VAT. If the decline in capital costs due to the ITC drives the capital increase and only VAT paying firms could claim the ITC, we would not expect the VAT to affect firm capital in VAT-exempted sectors. We restrict the sample to manufacturing industries exempted from the VAT across all states (tobacco, sugar, textiles, and select food manufacturing industries) and show the results in column (4). Similarly, column (5) only includes firms in non-manufacturing industries which were exempted from the VAT. In both instances, the estimated VAT effect is negative, albeit not significant. The coefficient for non-manufacturing firms in particular is attenuated towards 0, implying a null effect. These two placebo tests mitigate concerns that the positive impact of VAT adoption on capital is driven by alternate state-level interventions affecting firm capital, whose timing also coincides with that of VAT adoption.

Our last placebo test is a permutation test where we randomly assign the timing of VAT adoption (between 2000 and 2010) to treated states and re-estimate the coefficient of interest from equation 6. We repeat this process 100 times and plot the empirical CDF of the *VAT* coefficient in Figure 5. The vertical line denotes the coefficient in column (4) of Table 2. We see that only 5 out of 100 coefficients from the permutation-based placebo test exceed the coefficient from our baseline specification.[26] This exercise confirms that the state-specific differential timing of VAT adoption indeed drives the VAT effect on capital. For the positive effect on capital to be generated through any other confounding factor, this factor would also have to be exactly correlated with the state-specific timing of VAT adoption.

Additional robustness checks in the Online Appendix show that our results are neither driven by the likely serial correlation in our outcome of interest, nor are they sensitive to alternate choices of the dependent variable. Table A7 follows the recommendation of Bertrand et al. (2004) and collapses the residualized dependent variable into pre and post-VAT averages, and estimates the treatment effect based on 2 observations for each firm.[27] The treatment continues to have a positive and significant impact on firm capital for financially constrained firms, even after collapsing the data and reducing the serial correlation in the dependent variable, assuaging concerns that our baseline results are generated through a Type-II error due to the strong correlation of capital stock over time. In Table A5, we show that our results are unchanged, regardless of whether we measure capital as gross plant and machinery, gross or net fixed assets (land, buildings, plant, and machinery), or if we scale capital by total firm assets.

[26]The upper bound of the 95% confidence interval of the coefficients obtained from the permutation test exceeds the lower bound of the 95% confidence interval in column (4) of Table 2 seven out of a 100 times, which is very close to what would be expected to occur through pure chance.

[27]To residualize the dependent variable, we first regress firm capital (revenue productivity) on firm and industry-year fixed effects, along with state-level time-varying covariates. The residuals from this specification are subsequently averaged across the pre- and post-VAT periods.

V Effects of the VAT on Other Firm Outcomes

V.A Effect on Firm Productivity

The previous sections documented that the positive impact of the VAT on firm capital were driven by financially constrained firms, while Figure A1 in the Online Appendix showed that financially constrained firms in the pre-VAT period on average had lower capital, lower productivity, and higher MRPK. If the lower productivity and higher MRPK are an upshot of these firms' inability to obtain the optimal level of capital, we would expect an expansion in capital to also increase (reduce) firm productivity (MRPK).

This hypothesis is examined in Table 5. Column (1) identifies little impact on overall firm productivity. As productivity is measured using revenue productivity based on firm sales, it is possible that the negative treatment effect on manufacturing prices (discussed in Subsection IV.A.2) limits the increase in revenue TFP by depressing the value of firm sales, biasing us against detecting an effect. In column (2) we examine treatment heterogeneity across financially constrained firms and find that the interaction term is positive and significant at the 5% level, with the most financially constrained firm witnessing a 4 percent increase in revenue TFP. A firm with the mean pre-VAT score on the SA index experienced a 0.1 percent increase in productivity.[28] Conditional on states' adoption of the VAT, moving from the 25^{th} to 75^{th} percentile of the SA index resulted in an additional 1 percent (0.016*0.73 = 0.012) increase in firm productivity.

Consistent with the results on firm productivity, the results in columns (3) and (4) show that while the VAT had little impact on the average firm's MRPK, moving from a firm at the 25^{th} percentile of the SA index to the 75^{th} percentile reduced MRPK by an additional 3 percent (-0.039*0.73 = - 0.028). The results in Table 5 support the explanation that VAT adoption not only affected firm capital but also improved their operating efficiency. The results are consistent with prior studies positing that financial constraints depress firm efficiency by restricting their

[28]Recall that the uninteracted *VAT* coefficient estimates the impact of VAT adoption on firm productivity for firms whose score on the SA index is 0. As the average score on the SA index is -2.52, the net treatment effect on firm productivity for the average firm is 0.041 + (-2.52*0.016). Since (13) measures revenue productivity as the residual from a regression of log sales, the coefficient estimates are interpreted as percentage changes.

ability to obtain the capital for optimal operations (Rajan and Zingales 1998; Hsieh and Klenow 2009; Bloom et al. 2010; Midrigan and Xu 2014; Larrain and Stumpner 2017).

V.B Other Firm Outcomes

We also examine the impact of VAT adoption on other firm outcomes that might respond to changes in firm capital. To conserve space, the results are presented in Table A6 of the Appendix. For each outcome of interest, we identify the average treatment effect for the full sample and also examine treatment heterogeneity by the ex-ante intensity of financial constraints. Panel A shows that the VAT had a positive impact on sales and the use of raw materials for financially constrained firms, (columns (2) and (6)), but did not affect employee compensation (column (4)). Thus, conditional on VAT adoption, moving from the 25th percentile of the SA index to the 75th percentile increased sales (raw materials) by an additional 7 percent (6 percent).

VAT adoption by states, however, had no discernible impact on firm profitability, return on assets or cash flows (Panel B). While the point estimates for return on assets (columns (3) and (4)) are positive, the coefficients are too noisy to draw any conclusion. Significantly, VAT adoption did not affect cash flows (columns (5) and (6)), ruling out the competing mechanism that the ITC provision of the VAT increased cash flows, which in turn affected the capital of financially constrained firms, whose investments are likely to be more sensitive to cash flows. Taken together with the decline in manufacturing prices documented in Appendix Table A3, this finding suggests that the VAT increased firm capital by eliminating the distortionary aspect of the sales tax and reducing the cost of capital.

VI Treatment Effect on Aggregate Industry Outcomes

In this section, we identify the aggregate VAT impact on industry capital and productivity.

VI.A Treatment Effects on Industry Capital and Productivity

In Subsection IV.B, we show that VAT adoption increased firms' capital, primarily among financially constrained firms, which also aided their productivity. We now aggregate our outcomes to the state-industry level (3-digit) to examine whether the treatment effects identified at the firm-level translated into aggregate increases in industry capital and productivity. For capital, this implies a summation of capital across firms. We use the unweighted mean revenue TFP across all firms in each state-industry-year cell to assess productivity at the state-industry level. To identify whether the VAT resulted in an aggregate improvement in capital allocation, we adopt the approach of Larrain and Stumpner (2017) and estimate the VAT's impact on the dispersion of MRPK within each state-industry-year cell. If the VAT improves capital allocation across firms, we would expect the dispersion in within-industry MRPK (measured using within industry standard deviation) to decline. The specification to identify the aggregate treatment effect is:

$$Y_{sjt} = \alpha_{sj} + \delta_t + \beta_1 VAT_{st} + \beta_2 Share\,Cons._{sj} * VAT_{st} + \epsilon_{sjt}. \tag{10}$$

The unit of observation is state-industry (3-digit), where α_{sj} denotes state-industry fixed effects and absorbs time-invariant factors explaining differences in the outcome at the state-industry level. As financially constrained firms drive the VAT effect, we interact the treatment indicator with the fraction of firms in each state-industry pair deemed to be financially constrained (*Share Cons.*). A firm is considered to be financially constrained if its pre-VAT score on the SA index exceeded the median pre-VAT score across all firms. The sample is restricted to manufacturing firms operating in industries not exempt from the VAT. Standard errors are clustered by state.

The results in column (1) of Table 6 indicate a null effect of VAT adoption on aggregate capital for the average state-industry combination. The results in column (2) test for treatment heterogeneity across the fraction of financially constrained firms in each state-industry group. The interaction term ($VAT \times Share\,Cons.$) is positive, statistically significant and large in magnitude: moving from a state-industry group where 29 percent of the firms are financially constrained (25^{th} percentile), to one where 67 percent of firms are financially constrained (75^{th} percentile) causes an additional 13 percent increase in aggregate capital.

Consistent with the results in columns (1) and (2), the results in columns (3) and (4) show that VAT adoption had a positive impact on aggregate revenue productivity only in state-industry groups with a relatively high concentration of financially constrained firms. However, there is no corresponding reduction in the dispersion of firms' marginal product of capital, providing limited evidence in favour of an aggregate improvement in capital allocation within industries.

VI.B Decomposition of VAT Effect on Industry Productivity

Financial constraints can dampen aggregate productivity through a misallocation of resources away from the most productive firms (Hsieh and Klenow 2009). Above, we show that VAT adoption led to an increase in average productivity within industries with a high concentration of financially constrained firms. We now extend the decomposition of Olley and Pakes (1996) to evaluate whether the increase in average productivity was also accompanied by an aggregate reallocation of resources towards firms with higher productivity. While the absence of any impact on the within-industry dispersion of MRPK indicates that the VAT did not improve capital allocation, we formally analyse this using the productivity decomposition of Olley and Pakes (1996):

$$a_{jst} = \overline{a_{jst}} + \sum_{i=1}^{n_{jst}} \Delta s_{ijst} \Delta a_{ijst}. \qquad (11)$$

The first term in equation (11) is industry j's unweighted revenue productivity – our outcome of interest in Table 6. The second term captures the covariance between individual firms' revenue productivity and their share of industry output. Δa (Δs) is the deviation of firm i's revenue productivity (share of industry output) from the unweighted mean industry productivity (share of output) while n is the number of firms in each state-industry-year cell. Effectively, equation (11) decomposes the increase in aggregate industry productivity into a) increase in individual firms' productivity ($\bar{a}$), and b) higher covariance between productivity and firms' share of industry output ($\Delta s \Delta a$). An increase in $\Delta s \Delta a$ would support the explanation that productive firms are expanding in size and accounting for a greater share of industry output.

We identify whether the VAT shifted output towards firms with higher productivity by regressing $\Delta s \Delta a$ on the VAT indicator using equation (10). The results in Table 7, however, provide little support to the hypothesis that the VAT facilitated a reallocation of resources towards more productive firms, even within industries with a high concentration of financially constrained firms. The coefficient in column (1) for *VAT*, identifying the average treatment effect across all state-industry observations, is negative and imprecisely estimated. Testing for treatment heterogeneity across the fraction of financially constrained firms in each state-industry, the interaction term is positive but not statistically significant.

The results in columns (3) and (4) show the impact of the VAT on a – weighted industry-level productivity computed in equation (11). While the VAT has no detectable impact in the aggregate (column (3)), the interaction between the VAT indicator and the fraction of financially constrained firms is positive and significant (p-value: 0.056), suggesting that weighted industry productivity increased in response to the VAT in financially constrained state-industry groups. However, the productivity increase is driven by an increase in the average productivity of financially constrained firms and unaccompanied by an expansion in the output share for these firms. The results in Table 7 are consistent with those in Table 6, where we find limited evidence in support of an aggregate reduction in capital misallocation, even in industries with a relatively large share of financially constrained firms.

VII Conclusion

We examine the impact of a tax-based incentive on capital and productivity of financially constrained firms in India. We exploit a unique natural experiment in India that replaced the pre-existing sales taxes with the VAT as the primary consumption tax at the state level. Using the differential timing in VAT adoption across states for causal identification, we show VAT adoption led to a 3 percent increase in firm capital. The capital increase is concentrated amongst financially constrained firms. The increase in capital also increases the revenue productivity of financially constrained firms, suggesting that these firms take advantage of the reduced capital costs and shift to a more efficient production processes. Our findings provide insight on the positive spillovers emanating from eliminating consumption tax distortions on capital productivity and show that additional reforms are needed to address the misallocation of resources.

We also provide a useful data point in the context of the COVID-19 pandemic. As economies recover from the COVID-19 pandemic, governments will need to implement additional fiscal stimulus measures and there may be limits to using conventional fiscal policies as government fiscal debts have been severely hit. Tax-based incentives can provide a possible solution. Our paper shows that even in a developing market where compliance is an issue, VAT-based taxes can incentivize the right kind of firms to invest, leading to an improvement in the productivity of the economy, as a whole.

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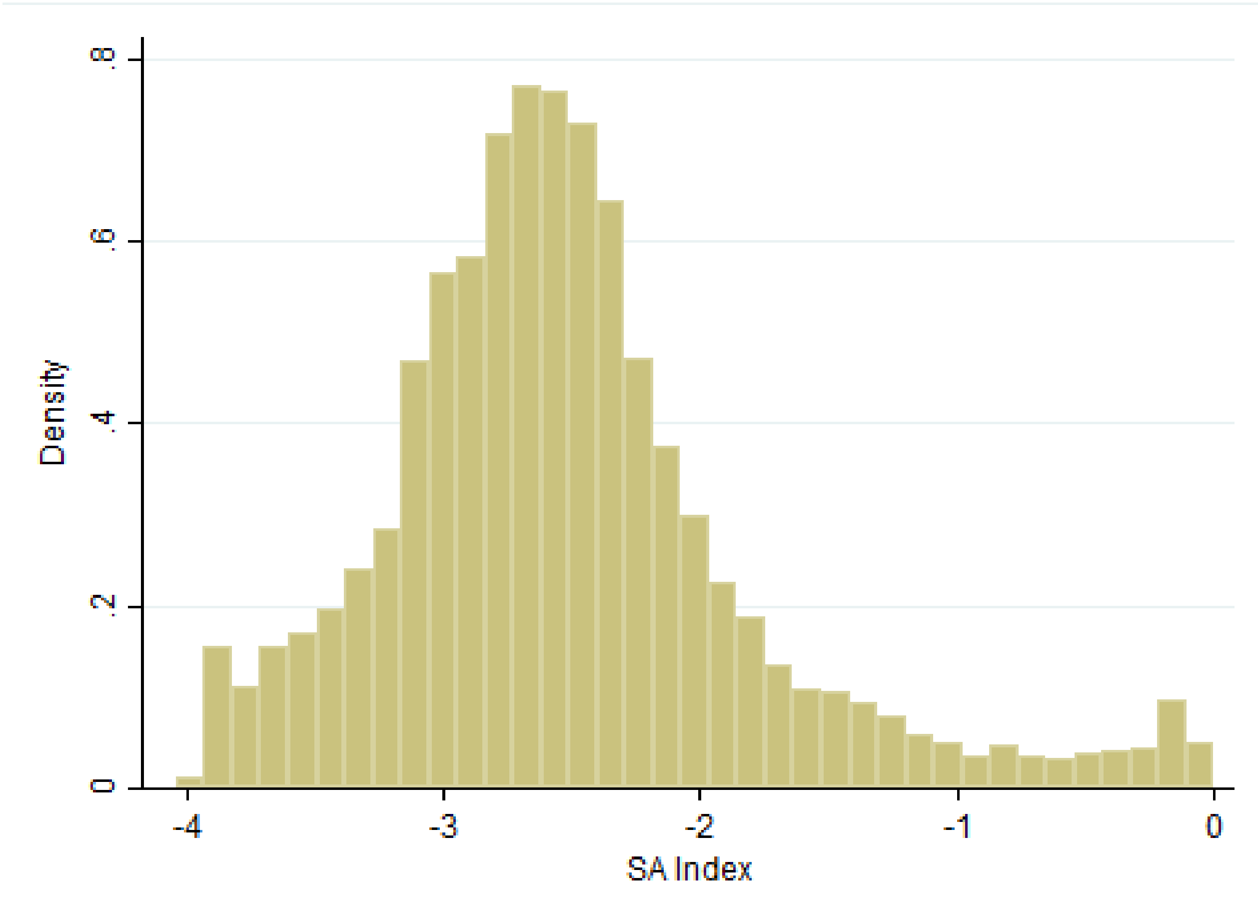
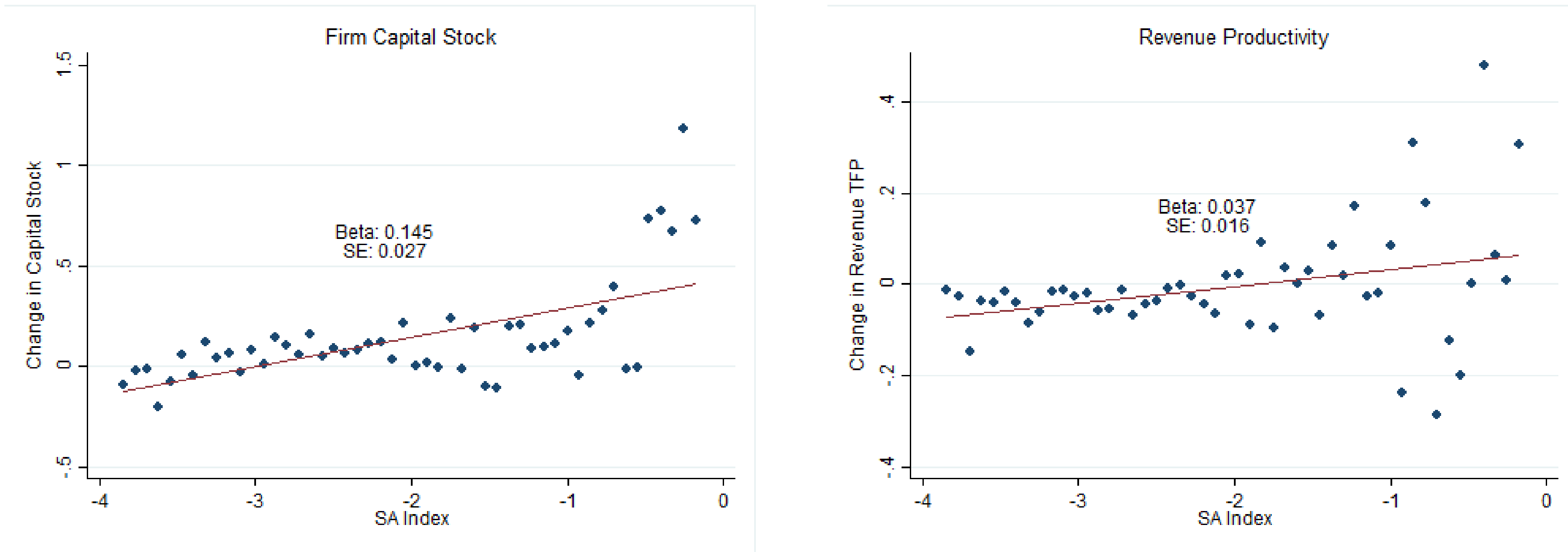
FIGURE 1
Pre-VAT Distribution of Firm Financial Constraints



Notes: This figure shows the distribution of firms' average score on the size-asset (SA) index (Hadlock and Pierce 2010) in the pre-VAT period between 1998 and 2002. Higher scores on the index indicate the increasing severity of financial constraints.

FIGURE 2
Post-VAT Change in Firm Capital and Productivity by Intensity of Financial Constraints

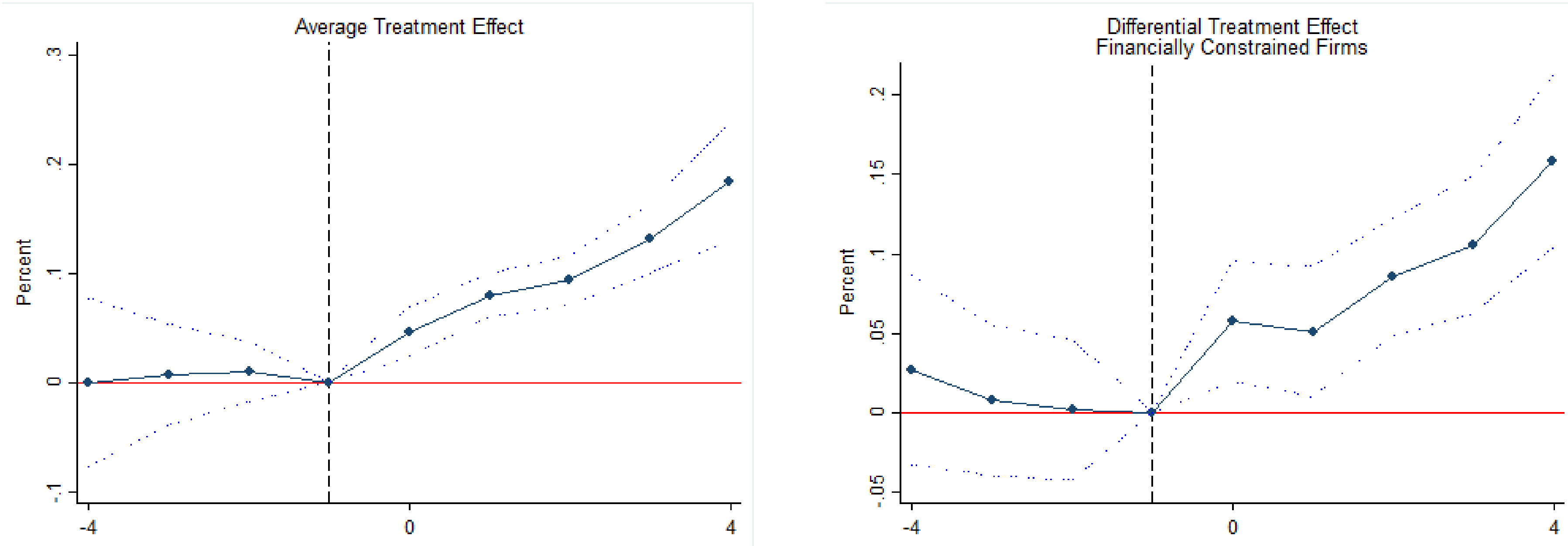


Panel A

Panel B

Notes: Panels A and B show the average change in firm capital stock and productivity, before and after states' adoption of VAT, binned across the ex-ante intensity of firm financial constraints. The x-axis represents the SA index (Hadlock and Pierce 2010) of ex-ante financial constraints, divided into 50 equally-spaced bins. Each point represents the average unconditional difference in the outcome of interest for firms whose ex ante score on the SA index falls in the corresponding bin. The difference is computed as the log difference in average capital stock (productivity) between the post- and pre-VAT period. Capital stock is measured using firms' stock of net plant and machinery.

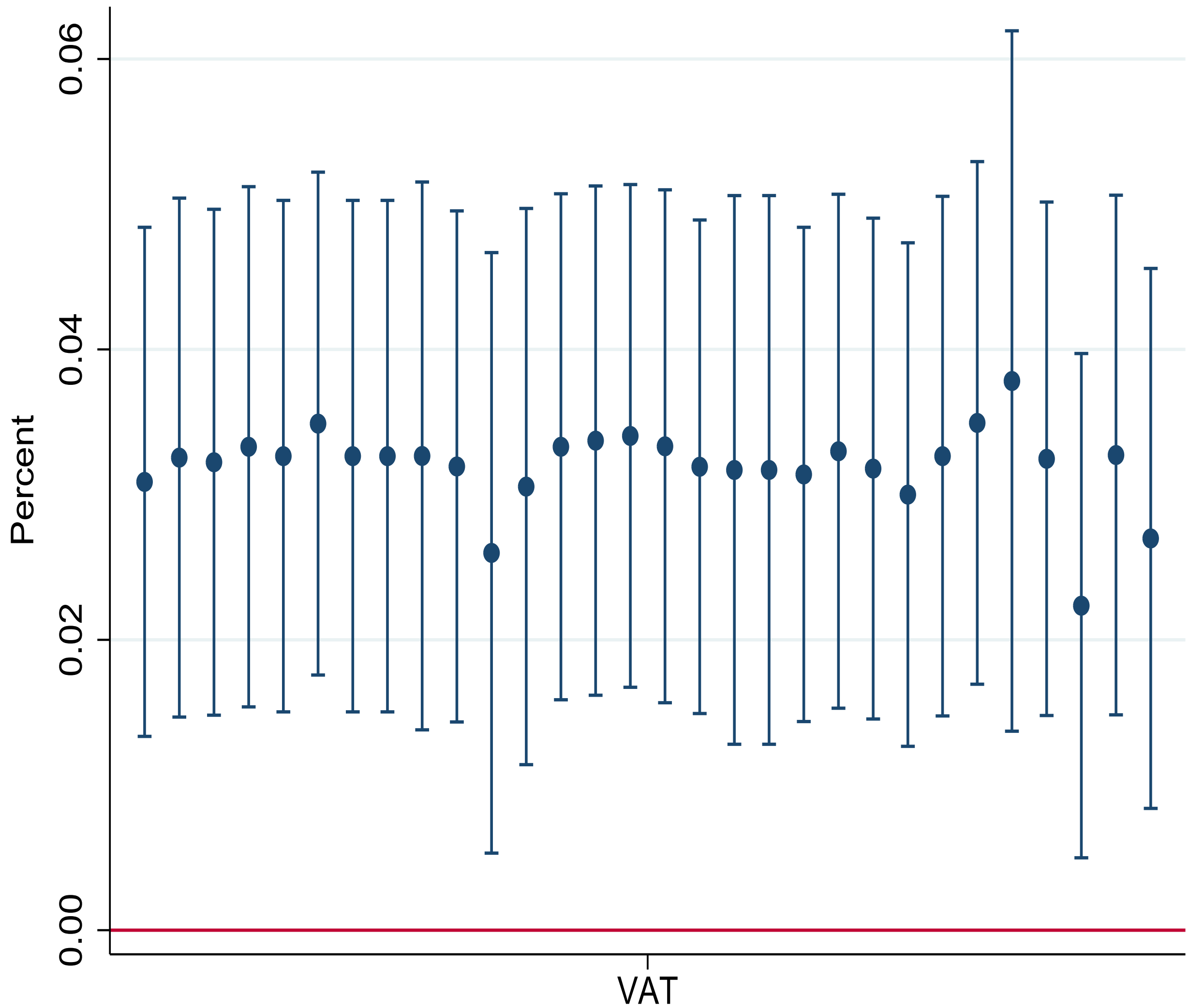
FIGURE 3
VAT Adoption and Capital: Average Annual Treatment Effects



Panel A   Panel B

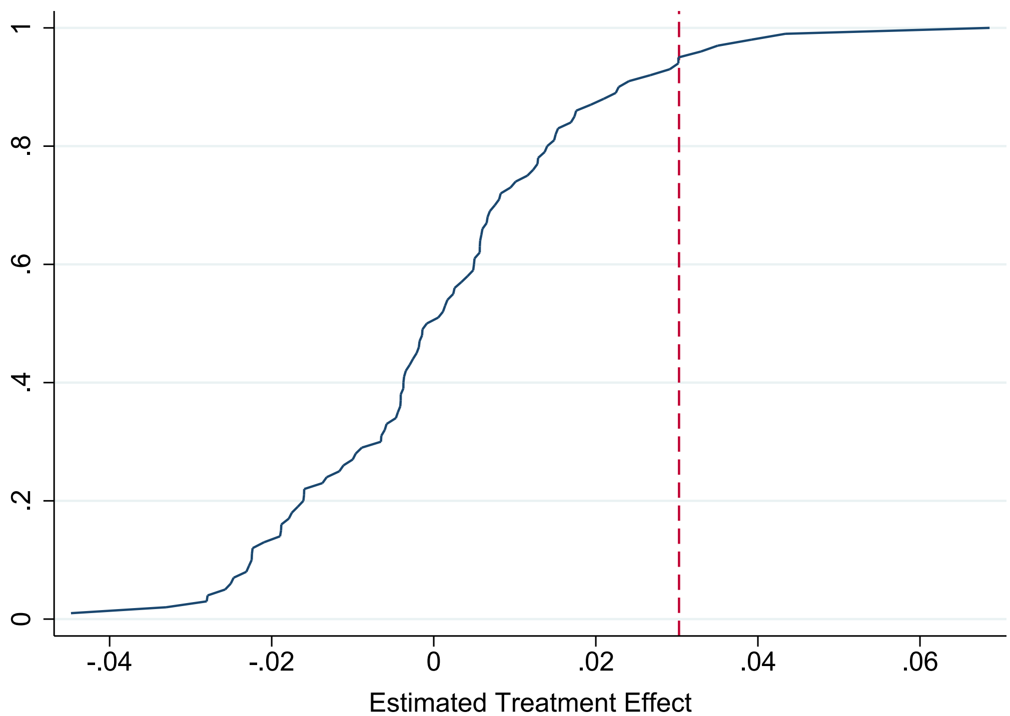
Notes: This figure shows the average annual treatment effects for capital stock. The reference year is the year prior to VAT adoption by the state (t= -1). The vertical line represents the 95 percent coefficient intervals associated with the coefficient. All specifications include firm and year fixed effects and standard errors are clustered by state. In Panel B, we plot the coefficients of the interaction of the year dummy with an indicator for the firm being financially constrained (SA index score higher than median SA index score).

FIGURE 4
VAT Adoption and Capital: Robustness to Dropping Individual States



Notes: The above figure provides the results of a robustness check of the baseline results to the dropping of individual states. The outcome of interest is capital stock. All specifications include firm and 3-digit industry-year fixed effects, along with firm and state covariates. The vertical lines reflect the 90 percent confidence intervals associated with each coefficient. Standard errors are clustered by state.

FIGURE 5
Empirical CDF of the Placebo Effect



Notes: This figure shows the empirical CDF of the placebo treatment on capital stock, based on a 100 estimations where the VAT adoption year is randomly assigned across states. The red dashed line represents the treatment effect estimated from the baseline specification. All specifications include firm and 3-digit industry-year fixed effects, along with firm and state covariates. Standard errors are clustered by state.

TABLE 1
Summary Statistics

	N	Mean	SD	P25	P50	P75
	(1)	(2)	(3)	(4)	(5)	(6)
Income	36825	1560.821	20280.658	36.000	152.000	513.000
Sales	35435	1585.442	20344.017	40.967	160.569	529.273
Capital Stock	36830	175.705	1186.433	5.000	20.000	80.000
Fixed Assets	39440	237.743	1653.335	10.000	35.000	121.000
Tangibility	37134	69.386	418.782	6.000	16.000	47.000
Current Assets	40565	419.694	3772.019	11.000	47.000	161.000
Operating Expenses	38592	1432.023	19171.949	30.079	138.047	475.400
Raw Materials	34099	782.621	8823.079	20	86.000	292.000
Employee Compensation	35991	65.216	557.558	2.000	7.000	27.000
Debt	37958	877.692	8111.427	24.000	88.000	295.000
Borrowings	37892	852.168	7973.671	23.000	86.000	285.000
Current Liabilities	40027	514.747	5463.387	12.000	45.000	154.000
Debt Equity Ratio	34887	4.393	69.656	0.000	1.000	2.000
Cash Flow	36746	123.830	2166.933	-6.000	2.000	24.000
Profits Before Interest & Taxes	40732	0.043	0.489	0.000	0.000	0.000
Return on Assets	36340	-0.005	0.146	-0.000	0.000	0.000
Current Ratio	40247	2.285	17.778	1.000	1.000	2.000

Notes: This table presents the summary statistics from the Prowess data for manufacturing firms between 2000 and 2008. Firms operating in sectors exempted from the VAT are excluded. All amounts are in 1993 INR millions. Capital stock is measured using the value of net plant and machinery; fixed assets is net fixed assets; tangibility is the value of land and buildings; operating expenses include salaries; profits are computed prior to interest and tax payments and scaled by firm income.

TABLE 2

VAT Adoption and Firm Capital

Dependent Variable	Capital (Logged)					
	(1)	(2)	(3)	(4)	(5)	(6)
VAT	.027**	.031***	.031**	.033***	.025**	.029**
	(.012)	(.011)	(.011)	(.010)	(.011)	(.011)
Observations	35502	35472	35472	35472	21119	35472
R^2	.93	.93	.93	.93	.96	.94
Dep. Var. Mean	208.05	208.05	208.05	208.05	208.05	208.05
Firm FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Firm Age	N	N	N	Y	Y	N
State Controls	N	N	N	Y	N	Y
Industry-Year FE	N	Y	Y	Y	Y	Y
Age FE	N	N	N	N	N	Y
Firm Controls	N	N	N	N	Y	N

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table shows the impact of VAT adoption by states on firm capital stock. The unit of observation is the firm. The outcome of interest is logged capital. Capital is measured using net plant and machinery. The independent variable of interest is a dummy equaling 1 if the state has adopted the VAT in a given year. All specifications include firm fixed effects. Column (1) includes year fixed effects; columns (2)-(6) includes 3-digit industry-year fixed effects; column (3) includes a quadratic in firm age; column (4) includes a quadratic in firm age and state-specific covariates; column (5) includes state-specific covariates, a quadratic in firm age and 2 lags of firm-specific covariates controlling for past return on assets, tangibility and cash flows; column (6) includes state-specific covariates and firm-age fixed effects. Standard errors are in parentheses, clustered by state.

TABLE 3
VAT Adoption and Firm Capital for Financially Constrained Firms

Dependent Variable	Capital (Logged)					
	(1)	(2)	(3)	(4)	(5)	(6)
VAT	.220***	.167***	-.042*	.027	-.005	.021
	(.067)	(.032)	(.024)	(.024)	(.011)	(.022)
VAT × SA	.078***					
	(.024)					
VAT × Alt. SA		.047***				
		(.009)				
VAT × SA^{T2}			.074*			
			(.037)			
VAT × SA^{T3}			.103***			
			(.036)			
VAT × Low Salaries				-.029		-.056
				(.042)		(.039)
VAT × Young Firm					.290***	.135
					(.049)	(.095)
VAT × Low Salaries × Young Firm						.258**
						(.124)
Observations	26875	26875	26875	26875	26875	26875
R^2	.94	.94	.94	.94	.94	.94
Dep. Var. Mean	212.07	212.07	212.07	212.07	212.07	212.07

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table identifies heterogeneous effects of VAT adoption on firm capital across financially constrained firms. The unit of observation is the firm. The outcome of interest is logged capital, measured using net plant and machinery. *VAT* is a dummy equaling 1 if the state has adopted the VAT in a given year. *SA* is the size-asset (SA) index for financial constraints developed by Hadlock and Pierce (2010) – a firm-specific measure based on the average SA index score for the firm in the pre-treatment period between 1998 and 2002. *Alt. SA* is an alternate measure of the SA index where firm-age is directly used to measure the age effect, as opposed to the SA index which uses the years a firm is listed. SA^{T2} (SA^{T3}) is a dummy equaling 1 if the firm's SA index score fell in the 2nd (top) tercile of the pre-VAT SA index distribution. *Low Salaries* is a dummy equaling 1 if the average employee compensation paid by the firm between 1998 and 2002 fell below the median level of employee compensation across all firms in this period. *Young* is a dummy equaling 1 if the firm's year of incorporation is after 1997. All specifications include firm and 3-digit industry-year fixed effects and state-specific covariates. Standard errors are in parentheses, clustered by state.

TABLE 4

VAT Adoption and Firm Capital: Robustness and Placebo Tests

Dependent Variable	Capital (Logged)				
	Robustness			Placebo	
	Firm-Level Cluster	Two-Way Cluster	Drop Largest Metros	VAT Exempt Firms	Non-Manufacturing Firms
	(1)	(2)	(3)	(4)	(5)
VAT	.033**	.033**	.030**	-.058	-.016
	(.014)	(.014)	(.012)	(.036)	(.017)
Observations	35472	35472	24506	6142	10279
R^2	.93	.93	.93	.92	.91

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table shows the robustness of the baseline results to alternate specification and sample choices, and placebo tests. The unit of observation is the firm. The outcome of interest is firm capital, measured using logged net plant and machinery. *VAT* is a dummy equaling 1 if the state has adopted the VAT in a given year. Column (1) clusters the standard errors at the level of firm; column (2) clusters the standard errors by state and year (twoway cluster); column (3) drops the two largest metropolitan centres (Delhi and Mumbai) from the sample; column (4) restricts the sample to manufacturing firms exempted from the VAT; column (5) restricts the sample to firms in the non-manufacturing sector. All specifications include firm and 3-digit industry-year effects along with firm and state-specific covariates. Standard errors are in parentheses, clustered by state in columns (3)-(5).

TABLE 5
VAT Adoption and Firm Productivity

Dependent Variable	Revenue Productivity		Marginal Revenue Product of Capital (Log)	
	(1)	(2)	(3)	(4)
VAT	.003	.041*	-.000	-.095*
	(.008)	(.023)	(.017)	(.055)
VAT × SA		.016**		-.039**
		(.007)		(.018)
Observations	31900	25188	26415	21068
R^2	.72	.70	.90	.90
Dep. Var. Mean	.00	.00	-2.03	-2.03

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table shows the impact of VAT adoption by states on firm productivity and marginal product of capital. The unit of observation is the firm. The outcome of interest in columns (1) and (2) is firm productivity, measured using firms' revenue productivity; in columns (3) and (4), logged marginal revenue product of capital. The independent variable of interest is a dummy equaling 1 if the state has adopted the VAT in a given year. SA is the size-asset (SA) index for financial constraints developed by Hadlock and Pierce (2010). All specifications include firm and 3-digit industry-year fixed effects, along with state-specific covariates. Standard errors are in parentheses, clustered by state.

TABLE 6

Aggregate Effects of VAT Adoption on Aggregate Capital and Productivity

Dependent Variable	Capital Stock		Revenue Productivity		Marginal Product of Capital	
	(1)	(2)	(3)	(4)	(5)	(6)
VAT	-.023	-.190**	.003	-.031	-.034	-.031
	(.032)	(.080)	(.015)	(.023)	(.046)	(.046)
VAT × Share constr.		.340**		.068*		-.007
		(.149)		(.034)		(.098)
Observations	4185	4185	4185	4185	2351	2351
R^2	.91	.91	.51	.51	.55	.55
Dep. Var. Mean	1244.30	1244.30	-.02	-.02	.92	.92

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table shows the impact of VAT adoption by states on aggregate capital stock, productivity and marginal product of capital. The unit of observation is state-industry (3-digit). The outcome of interest in columns (1) and (2) is total capital stock, measured as the sum of net plant and machinery across all firms in the state-industry (3-digit) combination; in columns (3) and (4), the average revenue productivity across all firms in each state-industry (3-digit) combination; in columns (5) and (6), the standard deviation in the marginal product of capital within each state-industry (3-digit) combination. *VAT* is a dummy equaling 1 if the state has adopted the VAT in a given year. *Share Constr*. is the fraction of financially constrained firms in the pre-treatment (1998-2002) period in each state-industry combination. Firms are deemed to be financially constrained if their average score on the size-asset (SA) index between 1998 and 2002 is below the median SA index score across all firms. All specifications include state-industry (3-digit) and year fixed effects. Standard errors are in parentheses, clustered by state.

TABLE 7

VAT Adoption and Decomposition of Aggregate Productivity

Dependent Variable	Covariance in Firm Productivity and Share of Output		Aggregate Weighted Productivity	
	(1)	(2)	(3)	(4)
VAT	-.010	-.036	-.007	-.066*
	(.008)	(.026)	(.018)	(.038)
VAT × Share Constr.		.052		.119*
		(.041)		(.059)
Observations	4185	4185	4185	4185
R^2	.41	.41	.47	.48
Dep. Var. Mean	.03	.03	.00	.00

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table shows the impact of VAT adoption by states on aggregate reallocation of firm productivity based on Olley and Pakes' (1996) decomposition. The unit of observation is state-industry (3-digit). The outcome of interest in columns (1) and (2) is the covariance between firm productivity and the share of firm output; in columns (3) and (4), aggregate weighted firm productivity, as computed by Olley and Pakes (1996). Firm productivity is measured using firms' revenue productivity. *VAT* is a dummy equaling 1 if the state has adopted the VAT in a given year. *Share Constr.* is the fraction of financially constrained firms in the pre-treatment (1998-2002) period in each state-industry combination. Firms are deemed to be financially constrained if their average score on the size-asset (SA) index between 1998 and 2002 is below the median SA index score across all firms. All specifications include state-industry (3-digit) and year fixed effects. Standard errors are in parentheses, clustered by state.

Tax Distortions and Financially Constrained Firms: Evidence from India's VAT Adoption

Online Appendix

A1 Distortionary Effect of Retail Sales Tax - Stylistic Example

We present here a simple stylistic example to illustrate the distortionary impact of the sales tax in the pre-VAT period in India. We consider two firms, i and j, both of which uses one unit of labor (no wage cost). The primary good is x, which firm i purchases, to produce the intermediate good y. Subsequently, firm j purchases y and produces the final good z, which is sold to consumers. The price of the primary good is p_x and the uniform consumption tax levied on each product is τ.

Under Sales Tax
Input Cost for Firm i: $(1+\tau)p_x$

We denote value addition by firm i under the sales tax regime as v^i_{RST}. This would also include any mark-up firm i chooses to impose.

Pre-tax value of good y: $(1+\tau)p_x + v^i_{RST}$.
Tax imposed on good y: $\tau * [(1+\tau)p_x + v^i_{RST}]$.

After simplifying, the selling price of good y can be expressed as:
Selling price of good y: $p_y = (1+\tau)[(p_x + v^i_{RST}) + \tau p_x]$.

The first two terms within the square brackets (in parentheses) represent the pre-tax value of good y, while the distortion induced by the sales tax is τp_x.

Profit for firm i is: v^i_{RST}.
Input Cost for Firm j: $p_y = (1+\tau)[(p_x + v^i_{RST}) + \tau p_x]$.

Let the value added by firm j (inclusive of mark-up) be denoted as v^j_{RST}.

The pre-tax value of good z is: $(1+\tau)[(p_x + v^i_{RST}) + \tau p_x] + v^j_{RST}$.
Tax on good z is: $\tau * [(1+\tau)((p_x + v^i_{RST}) + \tau p_x) + v^j_{RST}]$.
The selling price of good z is: $p_z = (1+\tau)[(p_x + v^i_{RST} + v^j_{RST}) + \tau(2p_x + v^i_{RST} + \tau p_x)]$.

Again, the pre-tax value of good z is the first three terms in the square brackets, while the distortionary effect of the tax on prices is encompassed in the latter three terms. Clearly, the distortion increases as the number of intermediate stages between the primary good and the final good rises.

Profit for firm *j* is: v^j_{RST}.
The government's tax collection is: $\tau[(\tau^2+2)(p_x+v^i_{RST})+p_x(3\tau+1)+v^j_{RST}]$.

Under VAT

The primary distinction between a sales tax and a destination-based VAT is that under VAT, only the value-added component is taxed at each stage. This is operationalized by allowing firms to file for a tax credit, the Input Tax Credit (ITC), whereby firms can claim a refund on any VAT paid during the purchase of inputs. In principle, assuming that there are no transaction costs while availing of the ITC and the ITC is also received with little lag from the time of purchase by the firm (so limited interest cost is borne by the firm between payment of tax and receipt of ITC), we can interpret the ITC provision to be akin to a reduction in the costs of input as firms transition from a sales tax to the VAT. Subsequently, one can re-write the input costs, selling prices, and tax collected by the government for the two firms in our stylistic example as:

Input Cost for Firm *i*: p_x.

This treats the ITC as a reduction in the cost of capital, implying that the ITC is seamlessly effected. If there are frictions affecting the receipt of the ITC (say due to delays in processing of the credit), the input costs can be re-written as $p_x(1+\alpha\tau)$ where α denotes the fraction of the ITC lost due to the associated time-cost. We denote value-addition (inclusive of mark-ups) by firm *i* under the VAT as v^i_{VAT}.

Pre-tax value of good *y*: $p_x+v^i_{VAT}$.
Tax imposed on good *y*: $\tau*(p_x+v^i_{VAT})$.
Selling price of good *y*: $p_y=(1+\tau)(p_x+v^i_{VAT})$.

Comparing from before, the τp_x term is now absent. Thus, if the cost of the primary good and the tax rate remains unchanged, the selling price of *y* under the VAT will exceed that under the sales tax if $v^i_{VAT}-v^i_{RST}>\tau p_x$.

Profit for firm *i* is: v^i_{VAT}.
Input Cost for Firm *j*: $p_y=p_x+v^i_{VAT}$.

Let the value added by firm *j* (inclusive of mark-up) be denoted as v^j_{VAT}.
The pre-tax value of good *z* is: $p_x+v^i_{VAT}+v^j_{VAT}$.
Tax on good *z* is: $\tau*(p_x+v^i_{VAT}+v^j_{VAT})$.
The selling price of good *z* is: $p_z=(1+\tau)(p_x+v^i_{VAT}+v^j_{VAT})$.

Comparing the sales price of good z under the two tax regimes, we see that the selling price under the VAT would exceed the sales tax only if $v^j_{VAT} - v^j_{RST} > \tau * (p_x + v^i_{RST} + \tau p_x)$. This is assuming that $v^i_{VAT} - v^i_{RST}$ is bounded above by τp_x (condition for sale price of good x under VAT to be cheaper than under sales tax). If this is not satisfied, we would need: $(v^j_{VAT} - v^j_{RST}) + (v^i_{VAT} - v^i_{RST}) > \tau * (2p_x + v^i_R ST + \tau p_x)$.

Profit for firm j is: v^j_{RST}.
The government's tax collection is: $\tau * (p_x + v^i_{RST} + v^j_{RST})$.

A2 Details on Data Construction

A2.A Computing Total Factor Productivity

As discussed in Section II, we estimate the impact of the VAT on firms' total factor productivity (TFP) and marginal product of capital. In the absence of data on output, we measure firms' productivity using their revenue productivity – firm output measured as firm revenues. To measure revenue productivity, we use an approach similar to Bau and Matray (2020). That is, we first assume firms to have a Cobb-Douglas production function where firm i's output in any given year t is a function of capital, labor, and materials. With j denoting the firm's industry of operation and dropping the year subscripts, a firm's TFP can be expressed as:

$$Y_{ij} = A_{ij} K_{ij}^{\alpha_j} L_{ij}^{\beta_j} M_{ij}^{\gamma_j}. \tag{12}$$

In (12), K, L, and M denote firms' capital, labor, and raw materials, while A denotes the unobserved productivity component. α, β and γ are capital, labor and materials' share in total output and these are invariant across firms within each industry-year group. As the Prowess databse reports the value of sales and not the quantity of physical output, we multiply Equation 12 by prices and take logs to estimate firms' revenue productivity using:

$$ln(Sales_{ij}) = ln(A_{ij}) + \alpha_j ln(K_{ij}) + \beta_j ln(L_{ij}) + \gamma_j ln(M_{ij}) + \mu_{ij}. \tag{13}$$

As the Prowess database has limited data on total workers employed in the firm, we measure L using total compensation paid to employees during the year. This is consistent with the approach adopted by Hsieh and Klenow (2009) who also use workers' labor compensation as opposed to total workers, arguing that the former is also indicative of labor quality. We measure K using capital stock (net plant and machinery), and estimate equation (13) separately for each 3-digit industry-year combination. The residual obtained from this estimation provides us with our firm-specific measure of revenue productivity (logged). To estimate firms' marginal revenue product of capital (MRPK), we use the industry-specific $\hat{\alpha}_j$ obtained from estimating (13) to compute:

$$MRPK_{ij} = \hat{\alpha}_j \frac{Y_{ij}}{K_{ij}}. \tag{14}$$

A2.B Measuring Financial Constraints

We determine the degree of financial constraints facing firms using the size-asset (SA) index developed by Hadlock and Pierce (2010). The SA index expresses the severity of financial constraints faced by a firm as a function of its size and age. Specifically, for any firm i in year t, the severity of financial constraints is expressed as:

$$SA_{it} = -0.737 * Asset_{it} + 0.043 * Assets_{it}^2 - 0.04 * Age_{it}. \quad (15)$$

where *Assets* is the logged value of firm assets and age is the number of years the firm has been listed on the stock exchange.As in Hadlock and Pierce (2010), we winsorize *Age* at 22 years. Combining qualitative statements of firm managers on difficulties faced by firms in accessing external finance and firm-level data from Compustat, Hadlock and Pierce (2010) show that this relatively simple index is better in predicting whether a firm is financially constrained compared to the measures in Kaplan and Zingales (1997) and Whited and Wu (2006).

As firm assets and the decision to be publicly listed could change in response to states' adoption of the VAT, we compute the SA index for our sample of manufacturing firms for each year over the five-year period between 1998 and 2002, when no state had adopted the VAT. We take the mean value of SA_{it} over these five years to obtain a single parameter measuring the severity of financial constraints faced by a firm in the pre-treatment period. The distribution of the pre-VAT severity of financial constraints faced by firms is shown in Figure 1, with higher values indicating increased severity of financial constraints.

Figures A1 and A2 below show the correlation between the SA index and firm characteristics using Prowess data. In each figure, the horizontal axis is divided into 50 equally-spaced bins of pre-treatment values of the SA index and each point on the graph represents the unconditional mean of the firm characteristic of interest corresponding to that bin. The red line depicts the linear relationship between the two variables and we restrict the sample to manufacturing firms. In each instance, the firm characteristic of interest is computed as the mean value for the firm between 1998 and 2002 when no state had implemented the VAT.

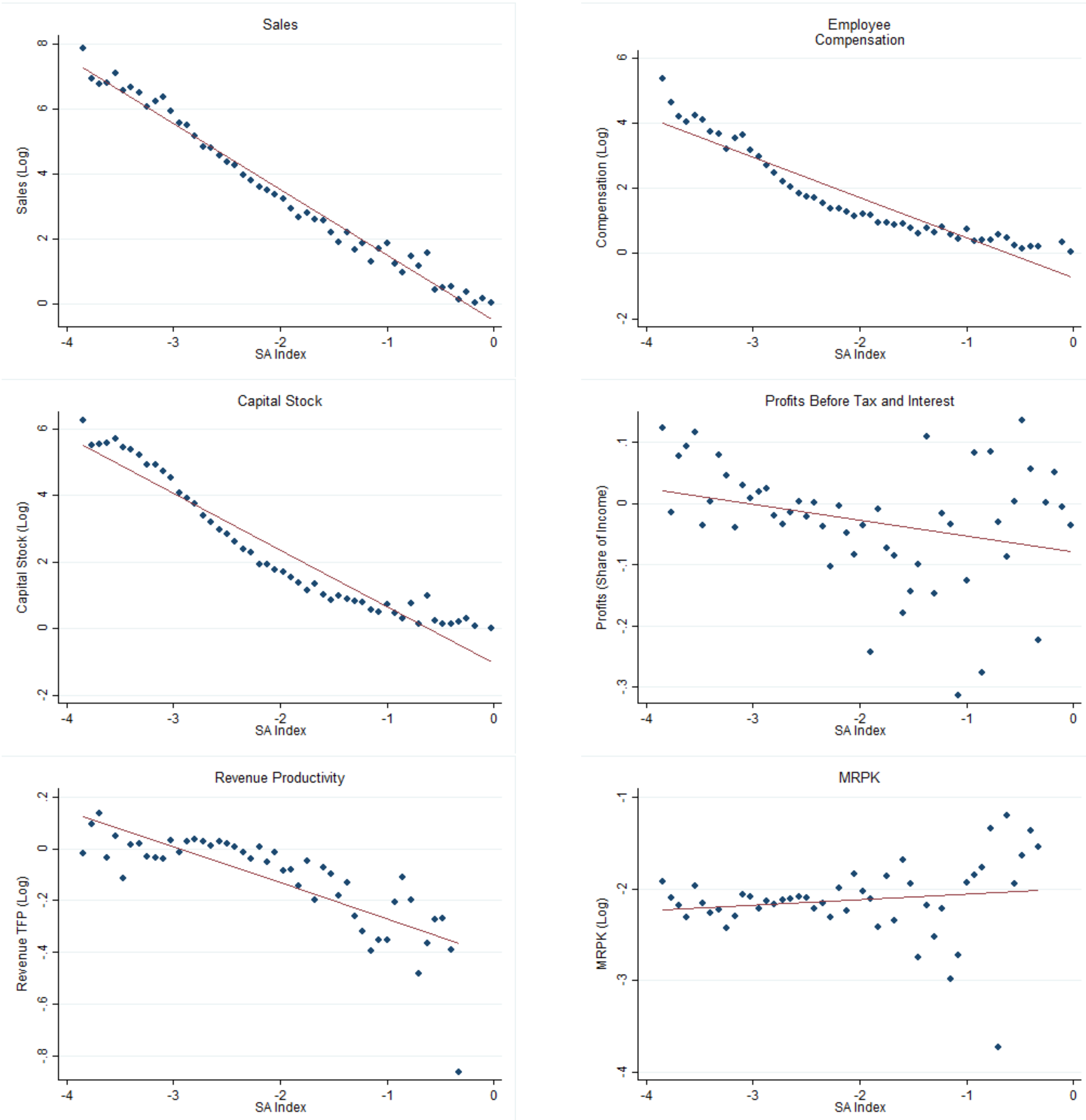
Figure A1 documents a sharp negative relationship between the severity of financial constraints faced by firms and firm sales, employee compensation, and capital. This is expected as smaller firms are more likely to be financially constrained. This negative relationship is weaker for firms' pre-tax profitability and revenue productivity, while a modest positive relationship is seen between firms' MRPK and the severity of pre-treatment financial constraints. This is consistent with equation 2 which predicts that financially constrained firms would have a higher marginal product of capital.

Figure A2 shows the correlation between firms' severity of financial constraints measured by the SA index and other firm characteristics, which are indicative of a firm being financially constrained. Firms with higher SA index have lower tangible assets (measured as the value of land and buildings), higher leverage, and hold more cash and liquid assets. The relatively large holding of liquid assets for firms with high SA index scores is consistent with the explanation that excess cash holdings by financially constrained firms stem from a precautionary motive (Hadlock and Pierce 2010). Firms with higher SA index scores are also more likely to be unrated and transact with fewer banks.

Additional Figures (Appendix)

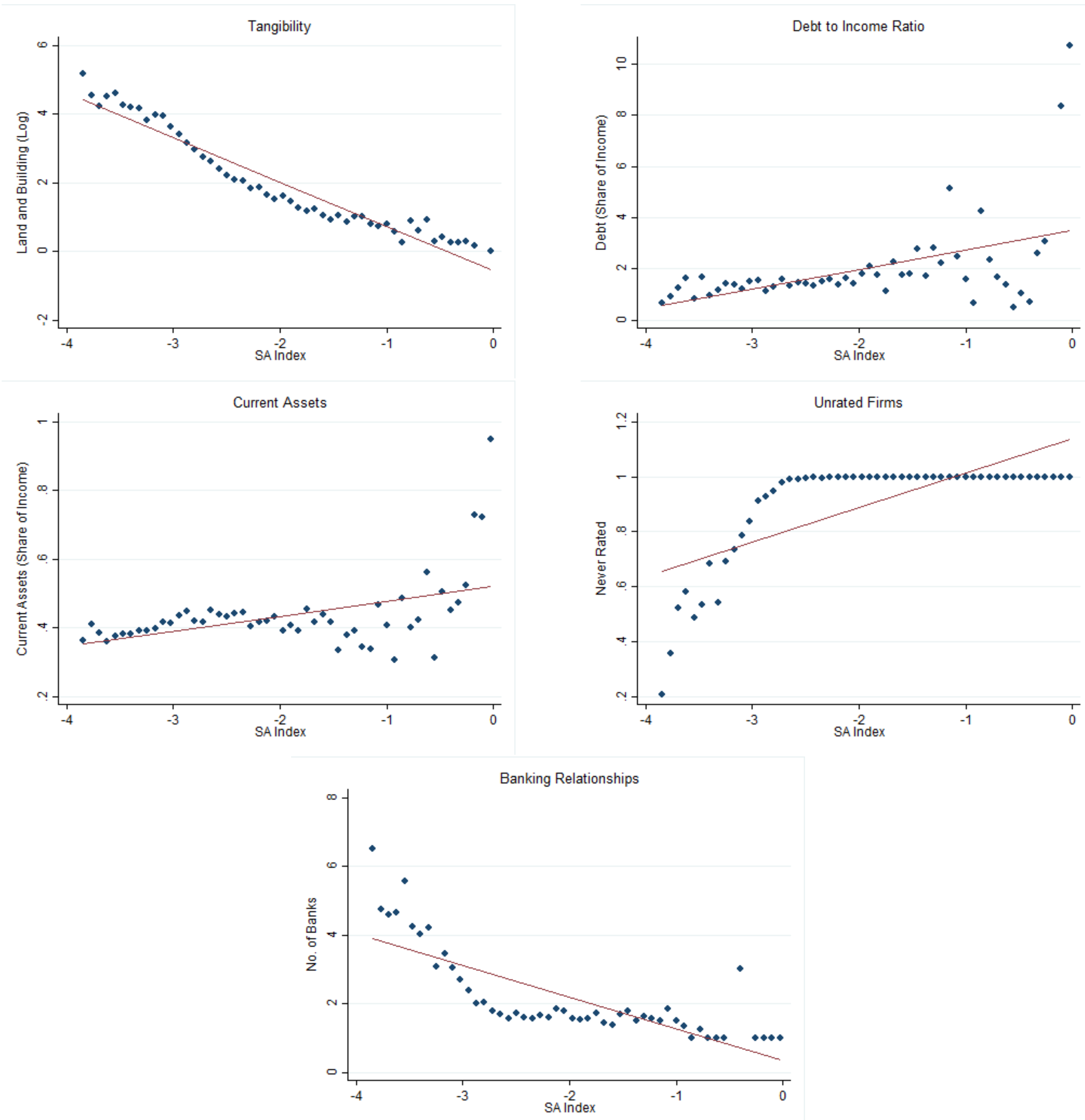
FIGURE A1

Pre-VAT Correlations between Firm Financial Constraints and Firm Outcomes



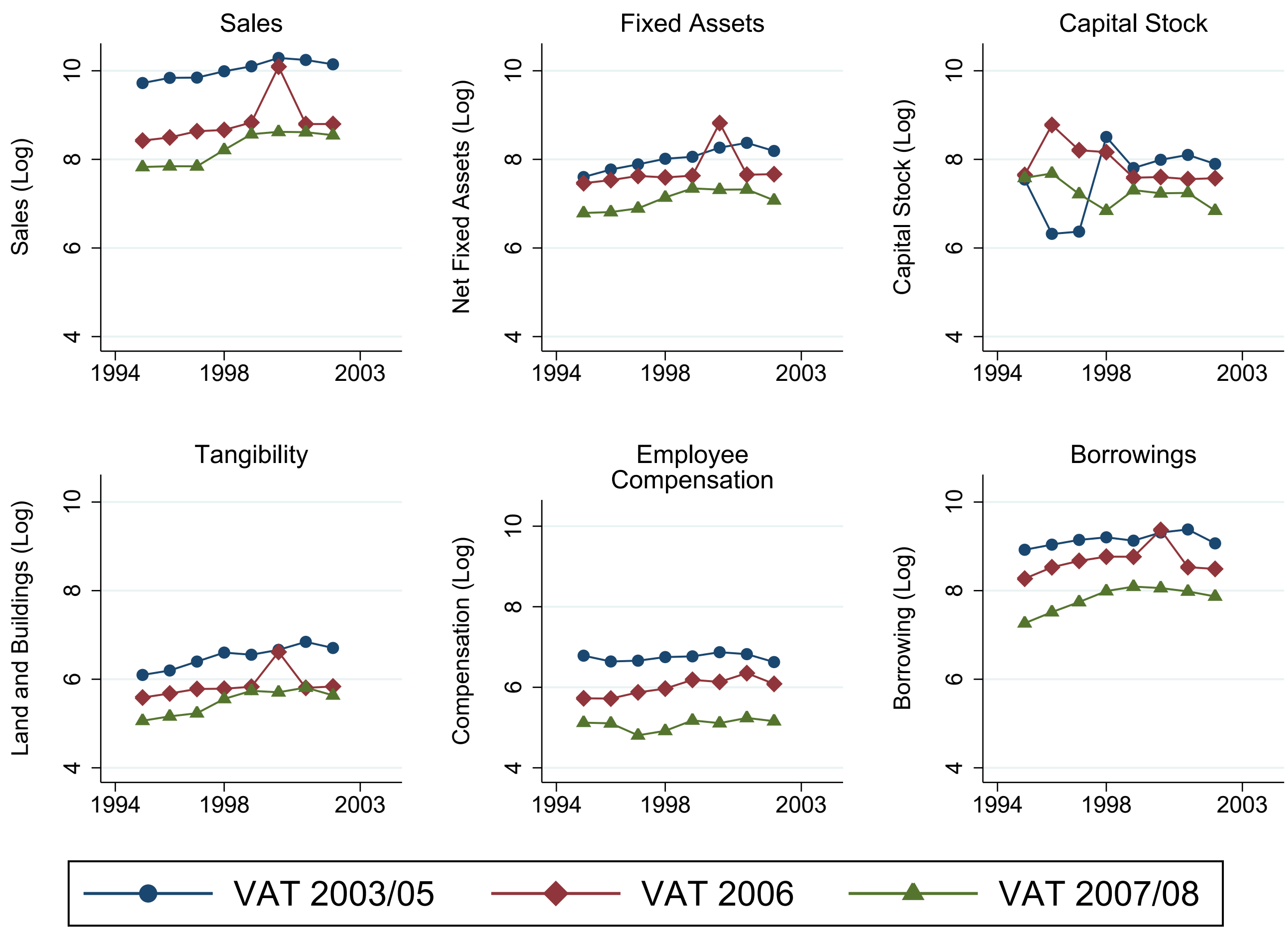
Notes: In these figure, we compare the pre-VAT correlations trends in the SA index for financial constraints and firm outcomes. The x-axis is divided into 50 equally-spaced bins of the SA index developed by Hadlock and Pierce (2010). Each point represents the unconditional mean of the outcome of interest corresponding to that bin. The red line shows the linear relationship between the two variables. All variables are measured in the five-year period between 1998 and 2002, prior to VAT adoption by any of the states.

FIGURE A2
Pre-VAT Correlations between Firm Financial Constraints and Firm Outcomes (contd.)



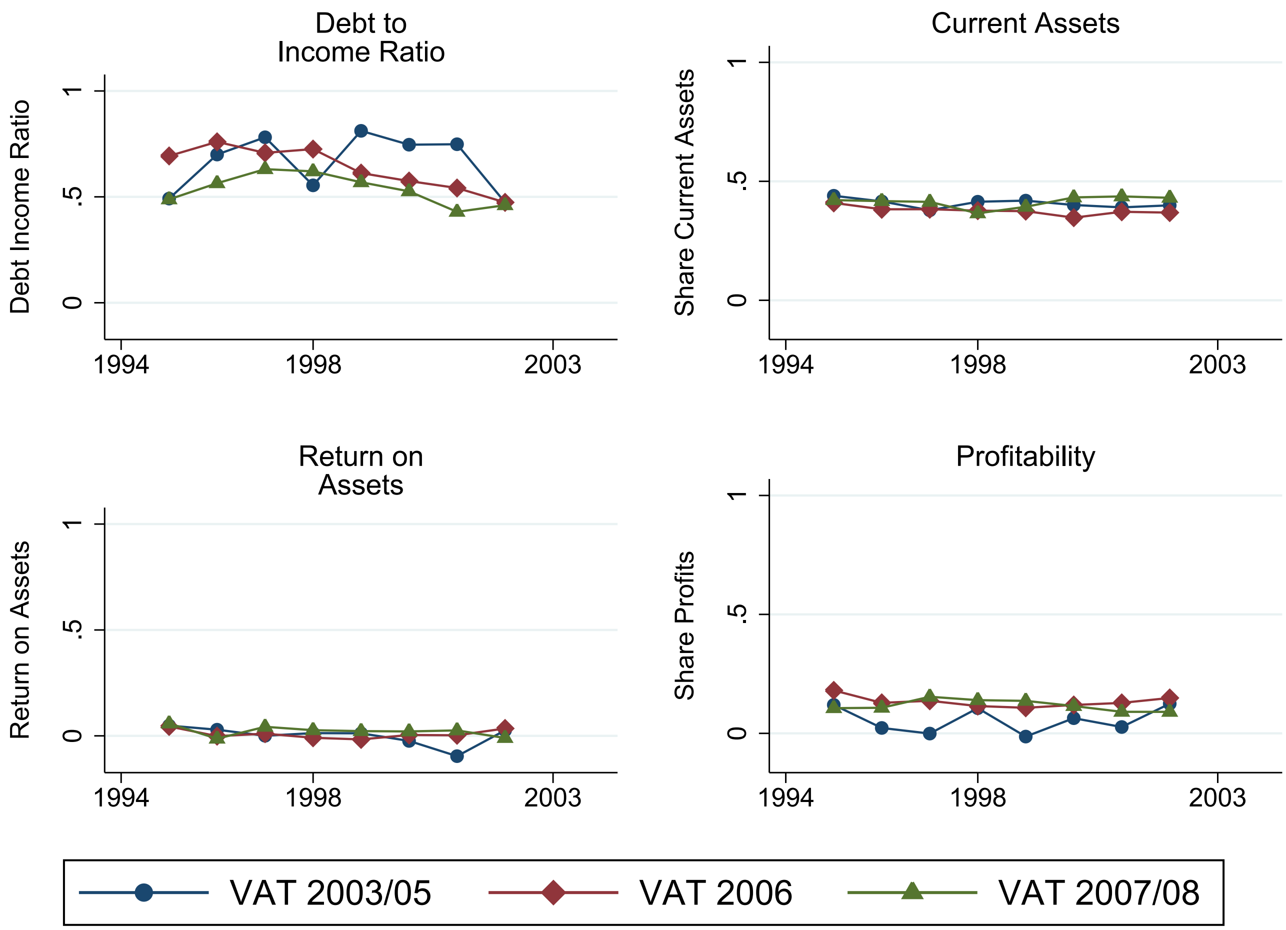
Notes: In these figure, we compare the pre-VAT correlations trends in the SA index for financial constraints and firm outcomes. The x-axis is divided into 50 equally-spaced bins of the SA index developed by Hadlock and Pierce (2010). Each point represents the unconditional mean of the outcome of interest corresponding to that bin. The red line shows the linear relationship between the two variables. All variables are measured in the five-year period between 1998 and 2002, prior to VAT adoption by any of the states.

FIGURE A3
Pre-VAT Trends in Firm Characteristics



Notes: In these figures, we compare trends in average firm outcomes in the eight-year pre-VAT period between 1995 and 2002 across groups of states, disaggregated by their year of VAT adoption. The vertical axis in each figure is measured in logs. Fixed assets are measured using net fixed assets; capital stock is measured using net plant and machinery; tangibility is measured using land and buildings; borrowings include both bank and non-bank borrowings.

FIGURE A4
Pre-VAT Trends in Firm Characteristics (contd.)



Notes: In these figures, we compare trends in average firm ratios in the eight-year pre-VAT period between 1995 and 2002 across groups of states, disaggregated by their year of VAT adoption. The vertical axis in each figure is a fraction. Current assets are scaled by total assets; profits are computed before interest and tax payments and scaled by firm income.

Additional Tables (Appendix)

TABLE A1
Do State GDP, Expenditures, and Revenues Predict Timing of VAT Adoption?

Dependent Variable	Pr(VAT = 1)					
	(1)	(2)	(3)	(4)	(5)	(6)
Population (Log), Lag1	-.082					-.078
	(.085)					(.158)
Population (Log), Lag2	.137					.331
	(.171)					(.358)
Population (Log), Lag3	.225					-.050
	(.272)					(.354)
GDP Growth, Lag1		-.303				-.198
		(.229)				(.222)
GDP Growth, Lag2		-.611				-.804*
		(.363)				(.452)
GDP Growth, Lag3		-.048				.108
		(.252)				(.267)
Manufacturing, Lag1			-1.113			-.768
			(1.073)			(1.075)
Manufacturing Share, Lag2			1.757**			1.754*
			(.702)			(.906)
Manufacturing Share, Lag3			.245			.114
			(.595)			(.556)
Revenues (Log), Lag1				.009		.168
				(.104)		(.108)
Revenues (Log), Lag2				.082		.094
				(.130)		(.127)
Revenues (Log), Lag3				-.124		-.139
				(.136)		(.150)
Expenditures (Log), Lag1					-.117**	-.143**
					(.055)	(.056)
Expenditures (Log), Lag2					-.007	-.007
					(.064)	(.068)
Expenditures (Log), Lag3					.027	.038
					(.073)	(.068)
Observations	330	336	332	330	330	325
R^2	.89	.89	.89	.89	.89	.89

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table tests whether lagged state characteristics can predict the timing of VAT adoption. The unit of observation is the state. The outcome of interest is a dummy equaling 1 if the state has the VAT operational in a year. *GDP Growth* is annual growth in state domestic product; *Manufacturing Share* is the share of state GDP accounted for by the manufacturing sector; *Revenues* and *Expenditures* are logged per capita state revenues and expenditures. All specifications include state and year fixed effects. Standard errors in parentheses, clustered by state.

TABLE A2
Do State Fiscal Characteristics Predict Timing of VAT Adoption?

Dependent Variable	Pr(VAT = 1)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Capital Exp, Lag1	-.384**						-.494*
	(.178)						(.246)
Capital Exp, Lag2	-.016						.113
	(.242)						(.240)
Capital Exp, Lag3	.116						-.042
	(.244)						(.255)
Development Exp, Lag1		.204					-.230
		(.231)					(.349)
Development Exp, Lag2		.182					.421
		(.300)					(.276)
Development Exp, Lag3		-.211					-.360
		(.341)					(.380)
Industry Exp, Lag1			1.527				1.349
			(1.909)				(2.713)
Industry Exp, Lag2			-4.607				-6.415*
			(3.345)				(3.399)
Industry Exp, Lag3			.518				1.947
			(2.961)				(3.269)
Own Tax Revenue, Lag1				.254			.411
				(.479)			(.528)
Own Tax Revenue, Lag2				-.060			-.371
				(.430)			(.487)
Own Tax Revenue, Lag3				.605			.982
				(.528)			(.592)
Sales Tax, Lag1					-.040		-.254
					(.174)		(.268)
Sales Tax, Lag2					.248		.274
					(.211)		(.215)
Sales Tax, Lag3					-.009		-.222
					(.231)		(.335)
Transfers, Lag1						.048	.067
						(.105)	(.166)
Transfers, Lag2						.026	.058
						(.180)	(.197)
Transfers, Lag3						-.221	-.058
						(.192)	(.211)
Observations	332	332	332	332	332	332	332
R^2	.89	.89	.89	.89	.89	.89	.89

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table tests whether lagged state fiscal characteristics can predict the timing of VAT adoption. The unit of observation is the state. The outcome of interest is a dummy equaling 1 if the state has the VAT operational in a year. *Capital Exp* is the fraction of capital expenditures in total state spending; *Development Exp* is the fraction of development spending in total state spending; *Industry Exp* is the fraction of spending on industrial development; *Own Tax Revenue* is the fraction of state revenue from own sources; *Sales Tax* is the fraction of state taxes from sales taxes; *Transfers* is the fraction of state taxes from federal transfers. All specifications include state and year fixed effects. Standard errors in parentheses, clustered by state.

TABLE A3
VAT Adoption and Manufacturing Prices

Dependent Variable	Manufacturing Commodity Price (Logged)				
	(1)	(2)	(3)	(4)	(5)
VAT	-.112**	-.139***	-.127**	-.127**	-.123*
	(.045)	(.039)	(.054)	(.054)	(.066)
Machinery × VAT					-.024
					(.091)
Observations	181583	178503	178476	178476	178476
R^2	.88	.88	.89	.89	.89
Dep. Var. Mean	24438	24438	24438	24438	24438
Commodity-Establishment FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Firm Controls	N	N	Y	N	Y
State Controls	N	N	Y	Y	Y
Industry-Year FE	N	Y	Y	Y	Y
Age FE	N	N	N	Y	N

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table shows the impact of VAT adoption by states on manufacturing prices, estimating the following specification:

$$\ln(Price_{cfst}) = \alpha_{cf} + \delta_t + \beta VAT_{st} + \phi \mathbf{X}_{st} + \epsilon_{cfst}, \tag{16}$$

Here, *Price* is the unit price of commodity c produced in manufacturing establishment (factory) f, located in state s, in year t. The unit of observation is commodity-establishment with α and δ denoting commodity-establishment and year fixed effects. Results are weighted by establishment-level weights and exclude sectors exempted from the VAT. The unit of observation is commodity-establishment. The outcome is logged unit price of manufactured communities. The independent variable of interest is a dummy equaling 1 if the state has adopted the VAT in a given year. Column (1) includes commodity-establishment and year fixed effects; columns (2)-(5) includes commodity-establishment and industry-year (3-digit) fixed effects; column (3) includes firm and state-level controls. Column (4) includes firm age fixed effects. All the specifications exclude industries exempted from the VAT. All specifications include establishment-specific weights. Standard errors are in parentheses, clustered by state.

TABLE A4

Robustness to Alternate Measures of Financial Constraints

	Capital (Logged)				
	(1)	(2)	(3)	(4)	(5)
VAT	-.007	-.025	-.034*	-.028	.017
	(.040)	(.018)	(.018)	(.019)	(.020)
VAT × Unrated	.044				
	(.042)				
VAT × Never Listed		.094***			
		(.024)			
VAT × Low Tangibility			.093**		
			(.034)		
VAT × Low Bank Relationships				.070**	
				(.030)	
VAT × Ext. Dep. Finance					.047
					(.032)
Observations	35472	35472	26722	18448	32346
R^2	.93	.93	.94	.94	.93
Dep. Var. Mean	206.61	206.61	206.61	206.61	206.61

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table identifies heterogeneous effects of VAT adoption by states on firm capital across firm characteristics predictive of a firm being financially constrained. The unit of observation is the firm. The outcome of interest is logged capital. Capital is measured using firm net plant and machinery. *VAT* is a dummy equaling 1 if the state has adopted the VAT in a given year. *Unrated* is a dummy equaling 1 if the firm does not have a credit rating. *Never Listed* is a dummy equaling 1 if the firm has never been publicly listed. *Low Tangibility* is a dummy equaling 1 if the firm has low tangible assets. *Low Bank Relationships* is a dummy equaling 1 if the firm has few bank relationships. A firm is deemed to have low tangible assets (low bank relations) if its average tangible assets (number of bank relations) between 1998 and 2002 falls below the median level of tangible assets (bank relations) across all firms. *Ext Dep Finance* is the 3-digit industry-level measure of an industry's dependence on external finance, developed by Rajan and Zingales (1998). All specifications include firm and 3-digit industry-year effects and state-specific covariates. Standard errors are in parentheses, clustered by state.

TABLE A5

Robustness to Alternate Measures of Capital

Dependent Variable	Gross Plant and Machinery		Gross Fixed Assets		Net Fixed Assets		Net Plant and Machinery as a Share of Assets	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VAT	.025**	.254***	.023***	.286***	.023**	.287***	.003**	.022***
	(.009)	(.061)	(.007)	(.060)	(.009)	(.063)	(.001)	(.008)
VAT $\times$ SA		.091***		.105***		.105***		.008***
		(.023)		(.022)		(.023)		(.003)
Observations	35450	27636	35450	27636	35450	27636	35450	27636
R^2	.95	.96	.96	.96	.94	.94	.86	.86
Dep. Var. Mean	358.38	358.38	477.42	477.42	291.40	291.40	.24	.24

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table identifies the VAT adoption by states on firm capital, using alternate measures of capital. The unit of observation is the firm. Capital is measured in columns (1) and (2) using gross plant and machinery; in columns (3) and (4) using gross fixed assets; in columns (5) and (6) using net fixed assets; in columns (7) and (8) using plant and machinery as a share of total assets. *VAT* is a dummy equaling 1 if the state has adopted the VAT in a given year. *SA* is the size-asset (SA) index for financial constraints developed by Hadlock and Pierce (2010). All specifications include firm and 3-digit industry-year effects and state-specific covariates. Standard errors are in parentheses, clustered by state.

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TABLE A6

VAT Adoption by States and Firm Outcomes

Panel A: Sales and Expenses

	Sales (Log)		Compensation (Log)		Raw Materials (Log)	
	(1)	(2)	(3)	(4)	(5)	(6)
VAT	.014	.257***	.009	.063	.013	.210***
	(.012)	(.061)	(.009)	(.061)	(.015)	(.060)
VAT × SA		.094***		.022		.076***
		(.023)		(.023)		(.022)
Observations	31986	25235	31986	25235	31986	25235
R^2	.94	.94	.97	.96	.93	.93
Dep. Var. Mean	1455.83	1455.83	74.77	74.77	606.51	606.51

Panel B: Profits and Cash Flow

	Profits as a Share of Income		Return on Assets		Cash Flow as a Share of Assets	
	(1)	(2)	(3)	(4)	(5)	(6)
VAT	.006	-.032	.002	.011	.005	.010
	(.010)	(.036)	(.003)	(.014)	(.005)	(.014)
VAT × SA		-.013		.004		.003
		(.013)		(.005)		(.004)
Observations	30414	24986	30414	24986	30414	24986
R^2	.49	.46	.68	.67	.47	.45
Dep. Var. Mean	.03	.03	-.02	-.02	-.02	-.02

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table shows the impact of VAT adoption by states on alternate firm outcomes of interest. The unit of observation is the firm. In Panel A, the outcomes of interest in columns (1) and (2) is logged sales; in columns (3) and (4), logged employee compensation; in columns (5) and (6), logged raw materials. In Panel B, the outcomes of interest in columns (1) and (2) is profits before interest and taxes as a share of income; in columns (3) and (4), return on assets; in columns (5) and (6), cash flow as a share of assets. *VAT* is a dummy equaling 1 if the state has adopted the VAT in a given year. *SA* is the size-asset (SA) index for financial constraints developed by Hadlock and Pierce (2010). All specifications include firm and 3-digit industry-year effects and state-specific covariates. Standard errors are in parentheses, clustered by state.

TABLE A7
VAT and Firm Outcomes - Collapse Data into Pre and Post VAT Periods

Dependent Variable	Capital (Logged)		Revenue Productivity	
	(1)	(2)	(3)	(4)
VAT	.014	.212***	.002	.032**
	(.010)	(.056)	(.004)	(.015)
VAT × SA		.091***		.014***
		(.019)		(.005)
Observations	11369	7608	10209	6987
R^2	.00	.01	.00	.00

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table shows the impact of VAT adoption by states on firm capital and productivity after collapsing the data in pre and post-VAT periods. The unit of observation is the firm. The outcome of interest in columns (1) and (2) is logged firm capital, measured using firms' net plant and machinery; in columns (3) and (4), firms' revenue productivity. In each specification, the outcome variable is first regressed on firm and 3-digit industry-year fixed effects, in addition to state and firm-level covariates. The residuals from this regression are subsequently averaged over the pre and post-VAT periods for each firm, and regressed on *VAT* and *VAT* × *SA*. *VAT* is a dummy equaling 1 if the state has adopted the VAT in a given year. *SA* is the size-asset (SA) index for financial constraints developed by Hadlock and Pierce (2010). Standard errors are in parentheses, clustered by state.