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

S. K. Ritadhi Nirupama Kulkarni Abhay Aneja †

July 5, 2021

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

*The views expressed in this paper reflect those of the authors and not necessarily that of CAFRAL. We are grateful to Viral V. Acharya, Alan Adelman, Monishankar Bishnu, Ben Faber, Chetan Ghate, Sean Higgins, Jean Imbs, Apoorva Javadekar, Amartya Lahiri, Paul Novosad, Abhinav Narayanan, Megha Patnaik, Bhanu Pratap, Andres Rodriguez-Clare, Emmanuel Saez, Anand Srinivasan, Shekhar Tomar, Reed Walker, as well as three anonymous referees and the editors at *JELS* for several useful comments and suggestions. We would also like to thank Ilisa Goenka for excellent research assistance.

†Aneja is Assistant Professor at UC Berekely School of Law. Kulkarni is Research Director at CAFRAL (Promoted by Reserve Bank of India). Ritadhi is Assistant Professor of Economics at Ashoka University. Please address correspondence to S.K. Ritadhi, Ashoka University, Department of Economics; email: sk.ritadhi@ashoka.edu.in.

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 & 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 Goolsbee (1998) argues that general equilibrium effects diminish the impact of capital subsidies due to an increase in capital prices through higher aggregate demand. Yagan (2015) and Desai and Goolsbee (2004) in particular find that the 2003 U.S. dividend tax cut — one of the biggest cuts in American history — had almost no impact on firm investment. There is relatively little evidence to date, however, of how consumption tax reform affects business investment.

In this paper, we fill this gap in the literature by examining India's replacement of a decentralized sales tax system with a federally-harmonized valued-added tax (VAT) for manufactured commodities. The transition to a VAT was considered one of the most significant reforms to the country's public finances, aimed to enhance tax compliance, boost revenues, harmonize statutory tax rates across states, and reduce prices (Empowered Committee of State Finance Ministers, 2005).

Prior to the VAT, the primary consumption tax was a state-level sales taxes, levied at each point of sale. This taxation of inputs and capital goods at every stage of the production process contributed to a cascading tax-on-tax phenomenon. India's harmonized VAT, by contrast, introduced a simple and transparent tax collection on the sale of manufactured commodities. The key distinction between the sales tax and the VAT was that the latter was levied only on the incremental value-addition at each stage of the production process. This was operationalized through an input tax credit (ITC), which permitted firms to offset their final VAT liability with the VAT paid during the purchase of inputs – reducing the tax-related cost of capital.[1]

Using firm-level financial data for a nationwide panel covering over 6,000 registered manufacturing firms, we evaluate how this extensive consumption tax reform affected firm capital. Our paper proceeds in three parts, corresponding to our main empirical findings. We first

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

measure the impact of India's VAT reform on firm capital. For causal identification, we exploit the differential timing of VAT adoption across Indian states in a difference-in-differences (DiD) framework.[2] Given that the ITC was applicable to the purchase of plant, machinery, and equipment, we identify whether this reduction in the effective cost of capital affected firms' capital stock and productive efficiency. Our DiD design offers robust evidence that switching from a sales tax to the VAT increased average firm capital by 3 percent. Importantly, these effects do not appear to be driven by the endogenous adoption of tax reform across states.

Having identified the average effect of the consumption tax reform, we subsequently explore the distributional aspects of India's VAT, to obtain a deeper insight of the beneficiaries of the tax reform (Zwick & Mahon, 2017). We focus on heterogeneity across firm financial constraints, which are known to be a major obstacle for firm growth in developing countries where credit is scarce and capital markets are incomplete (Hsieh & Klenow, 2007). Across both developed and developing economies, financially constrained firms have been found to be most responsive to capital incentives, making it an appropriate dimension to identify heterogeneity in response to a tax-related reduction in the user cost of capital [see for instance Criscuolo, Martin, Overman, and Van Reenen, 2019 and Farre-Mensa & Ljungqvist, 2016]. Using the size-asset (SA) index developed by Hadlock and Pierce (2010) to assess the intensity of financial constraints facing a firm, we find that the positive impact of the VAT on capital is concentrated amongst the most constrained firms, based on their pre-VAT score on the SA index.

Our results are robust to alternate firm-specific measures of financial constraints: thus, the capital stock of firms which are both young *and* small in size respond most to the tax reform. Similarly, our results are concentrated amongst firms which are unlisted, and have lower ex-ante tangible assets and banking relationships. We also show that the VAT-induced increase in firm capital is concentrated amongst firms operating in industries with a relatively high dependence on external finance, where financial constraints are most likely to bind (Rajan & Zingales, 1998).

Finally, we consider the aggregate consequences of the VAT's impact across firms and in-

[2]The first state adopted the VAT in 2003, and states phased into the VAT regime over the rest of the decade.

dustries. Specifically, we explore whether the expansion in firm capital translates to increased firm productivity. Consistent with our findings above, we find that while exposure to the VAT had little impact on average firm productivity, it positively affected the productivity of financially-constrained firms. At the state-industry level, we find that while the VAT increased industry capital stock, particularly in industries with a relatively high fraction of financially constrained firms, its overall impact on aggregate resource allocation remained muted.

This study contributes in a few key ways to the literature at the intersection of tax law, corporate finance, and development economics. First, we add to a large literature on the impact of tax incentives on firm investment.[3] There is mixed evidence on how tax policy affects firm capital choices, with some studies showing that tax-based incentives positively affect investment (Cummins, Hassett, Hubbard, Hall, and Caballero, 1994; Cummins, Hassett, and Hubbard, 1996; House & Shapiro, 2008; Ohrn, 2018; Zwick & Mahon, 2017) and others finding limited effects of tax incentives (Goolsbee, 1998).[4] With a few notable exceptions (Cai & Harrison, 2011; Agrawal & Zimmerman, 2019; Liu & Lu, 2015), much of this work has focused on developed economies (Giroud & Rauh, 2019; Heider & Ljungqvist, 2015). Our paper finds that even in a developing economy like India, which has imperfect tax compliance, the VAT-based capital incentive increased firm investment and productivity, especially for firms facing barriers to credit access.

Second, we add to research that seeks to understand the effects of value-added taxation structures. Empirical evidence on the effects of VAT policies have important implications for tax law reform, as recent tax law and public finance scholarship discusses the increasing worldwide presence of VAT systems as well as their viability in federal structures such as the U.S. (Avi-Yonah, 2009; Keen & Lockwood, 2010; Satterthwaite, 2018).[5] Much of this research has centered on how VAT systems can affect tax revenues and formalization through compliance incentives for business-to-business transactions (DePaulo & Scheinkman, 2010; Keen & Lock-

[3] See Graham (2003) for a review.

[4] Particularly influential studies in the latter camp include work on the 2003 dividend tax cut which is shown to have no impact on firm investment by Desai and Goolsbee (2004) and Yagan (2015).

[5] Bird and Gendron, for example, note that "[w]ith the notable exception of the United States most countries around the world now have a VAT...[the] VAT has been an enormous success. ... [n]o fiscal innovation has ever spread so widely so rapidly or been so successfully adopted in such a wide variety of countries."

wood, 2010; Kopczuk & Slemrod, 2006). Relatedly, there is a growing body of empirical research on VAT administration in developing countries using data from detailed tax records (Naritomi, 2019; Pomeranz, 2015). We add to this growing literature on the VAT by documenting its effects on firm capital structure. Closely related to our work is a recent study by Chen, Jiang, Liu, Suarez Serrato, and Xu (2020) on the impact of China's 2009 VAT reform, which similarly lowered the tax cost of investment. We differ from their paper by focusing on domestic firms, and leveraging unique temporal *and* spatial variation in VAT administration.

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, Gelfond, and Krupkin, 2016)]. Contrary to concerns regarding the adverse distributive effects of the VAT, our findings instead suggest that switching to a destination-based VAT can aid financially-constrained firms who are likely to be young, small in size, and relatively disadvantaged in capital and credit markets (Thomas, 2020).

Finally, by providing new evidence on the distributional effects of major reform to consumption tax law, we contribute to a rich body of work in law and economics (Cotropia & Rozema, 2018; Hayashi, 2014; Hemel & Rozema, 2016; Kaplow, 1994; Stolper, 2016). We add to this literature by (1) focusing on a developing country context, and (2) providing policy-relevant information on how eliminating consumption tax distortions can increase the efficiency of financially-constrained firms. On the latter point, our findings are consistent with recent work on the heterogenous effect of US tax policy (Dharmapala et al., 2011). More generally, we contribute to research on the distributional outcomes of harmonized public policy within federal administrative systems – including, for example, research on the distributional consequences of federal sentencing guideline (Fischman & Schanzenbach, 2012; Tuttle, 2021; Yang, 2015) or access to justice efforts (Niblett & Yoon, 2017).

The remainder of the paper is organized as follows. Section I provides a background on India's VAT and discusses 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. Sections IV, V and VI presents our key findings. Section VII offers some concluding thoughts.

I. Background and Conceptual Framework

We motivate our empirical analysis 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 common VAT structure, including base and rates, the 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 (Empowered Committee of State Finance Ministers, 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 over a five-year period between 2003 and 2008. The state of Haryana was the first to adopt the VAT in 2003, and other states transitioned

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

[7] Services were taxed separately under the Service Tax, administered by the federal government, with revenues annually distributed to 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. The federal and state 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 (Empowered Committee of State Finance Ministers, 2005).

in subsequent years (see Table 1).[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 pre-VAT 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]

According to India's official description of the VAT, drawn up by the Empowered Committee of State Finance Ministers (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.[11] 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 (Empowered Committee of State Finance Ministers, 2005).[12]

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

[11] The ITC was applicable for capital purchases sourced within the state in which the manufacturing activity was undertaken. Firms were not permitted to claim the ITC for out-of-state capital purchases.

[12] 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 & Zimmerman, 2019).

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

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. Given that the ITC reduces the tax-related costs of capital, our main prediction is as follows:

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

As we have alluded to above, though, there may also be distributional implications of reducing the cost of capital for firms. Particularly in developing economies where credit is scarce and capital markets are incomplete, financial constraints are widely recognized as a source of capital misallocation, which hinders optimal firm operations by limiting capital stock, output and productivity (Hsieh & Klenow, 2007). In the present context, the former International Monetary Fund's chief economist, Anne Krueger noted that Indian banks were "high cost and inefficiently run," and that allocating credit to more productive uses "would make a considerable contribution to the Indian economy's growth potential" (Krueger 2002). The possibility that the ITC may affect firms who were previously disadvantaged in credit markets thus leads us to our main hypothesis concerning distributional effects:

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.

We assess the above two hypotheses (and their aggregate implications) using a firm-level panel. Online Appendix A1 presents a formal outline of the above hypotheses, and considers how switching from a sales tax to a VAT would affect firms' optimal capital choice. We adopt a simple framework in which a price-taking profit-maximizing firm faces a borrowing constraint and chooses its optimal capital and labor. The sales tax is modeled as a tax on capital, and we offer predictions of the firm's optimal capital response to a reduction in the tax on capital due

to the ITC component of the VAT.

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 which has been extensively used to study firm behaviour in the Indian context (Lilienfeld-Toal, Mookherjee, and Visaria, 2012; Vig, 2013). Prowess provides us with a firm-level panel between 1998 and 2012, covering both listed and unlisted firms. The Prowess data 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 (exempted from the VAT base), as well as select manufacturing sectors exempted from the VAT as placebo groups to corroborate our main findings.[13] Our primary sample comprises of 5,933 firms[14], and 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 affected financially-constrained firms which rely on "costly" external finance. Our primary measure of firm financial constraints is the size-asset (SA) index developed by Hadlock and Pierce (2010). The SA index exploits firm balance-sheet information to express the severity of financial con-

[13] Within the manufacturing sector, textile, sugar, and tobacco manufacturers were exempted 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.

[14] The median firm is observed for 5 years over the 9 year period between 2000 and 2008

[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 IV.C, we demonstrate that the 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.

straints 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 the Annual Survey of Industries (ASI) – a representative survey of registered Indian manufacturing firms – which we use a) to validate our primary results obtained using the Prowess (see Online Appendix A5) and b) exploit commodity-level manufacturing prices to confirm that the cost of capital does not increase in response to states' 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 2 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. This would empirically identify whether India's VAT regime incentivized firms to increase investment in response to a reduction in the effective cost of capital due to the tax reform, which allowed firms to deduct VAT paid during the purchase of capital machinery. We test this hypothesis using a DiD design, exploiting the differential timing of VAT adoption across states using the following specification:

$$\ln(Y_{ist}) = \alpha_i + \delta_{jt} + \beta VAT_{st} + \phi \mathbf{X}_{ist} + \epsilon_{ist}. \quad (1)$$

In equation (1), 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 restricts our comparison to 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.

The 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 which testify to the credibility of 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:

$$\ln(Y_{ist}) = \alpha_i + \delta_t + \sum_{k=-4}^{4} \beta_k VAT_{st+k} + \epsilon_{ist}. \quad (2)$$

Equation (2) 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

[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 each state in this specification.

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.

We note that several recent papers have raised concerns with the standard fixed effects DiD estimator (Borusyak & Jaravel, 2017; De Chaisemartin & d'Haultfoeuille, 2020; Goodman-Bacon, 2018; Sun & Abraham, 2020). To this effect, Appendix A3 presents a stacked event study approach, consistent with (Cengiz, Dube, Lindner, and Zipperer, 2019). We also consider whether our estimates are affected by bias that arises due to heterogeneous effects across early and late-adopting states.

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 (10)]. To do so, we explore heterogeneity in the impact of the VAT across the severity of financial constraints faced by firms in the pre-VAT period. Specifically, we estimate the following equation:

$$\ln(Y_{ijst}) = \alpha_i + \delta_{jt} + \beta_1 VAT_{st} + \beta_2 VAT_{st} * SA_i + \phi \mathbf{X}_{ist} + \epsilon_{ist}. \tag{3}$$

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 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.

Farre-Mensa and Ljungqvist (2016) caution in their paper that the various indices measuring firm financial constraints might not be accurately capturing whether a firm is indeed financially constrained. To this effect, we demonstrate robustness of our heterogeneity results by following Criscuolo et al. (2019) and directly testing for treatment heterogeneity across relatively small and young firms. Young firms in particular have been shown to be a good proxy for cash constraints (Angelini & Generale, 2008; Cabral & Mata, 2003), along both the inten-

sive and the extensive margin (Kerr & 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, Graham, and Harvey, 2010 and Lin & 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 being unlisted is not a sufficient condition for being financially constrained, Farre-Mensa and Ljungqvist (2016) find that unlisted firms *do* exhibit behaviour consistent with a firm being financially constrained. Similarly, the lack of a credit rating and limited banking relationships can also affect firms' ability to obtain credit from external sources (Giroud & 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 & 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 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.

[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.

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 3 presents our baseline results, estimated using equation (1). 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 attenuated 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, Table 3 provides support for Hypothesis 1 [see also expression (10) in Online Appendix A1.B]:

[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 (see Section V), as opposed to treating them as covariates.

firm capital increased in response to replacing the sales tax with the VAT. Section IV.C discusses additional robustness checks of the baseline estimates.

A causal interpretation of the coefficients in Table 3 is subject to the standard DiD assumption: capital would have evolved similarly across firms in the *absence* of VAT adoption by states. 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 (2) 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 the timing of 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.

Finally, we probe our findings in light of several recent papers that have pointed to methodological issues in the two-way fixed effects DiD setting (Borusyak & Jaravel, 2017; De Chaisemartin & d'Haultfoeuille, 2020; Goodman-Bacon, 2018; Sun & Abraham, 2020). In Online Appendix A3, we show that our point estimates are robust to these critiques. First we decompose the individual DiD estimates as recommended by Goodman-Bacon (2018). In particular, we show that biases that can arise when treatment effects vary strongly over time (as evident in our case in Figure 3) account for a small proportion of the DiD estimate in the two-way fixed effect model. Second we use a stacked event study analysis and confirm that the estimates are consistent with our baseline estimates. VAT adoption leads to firms increasing their capital 5% – slightly higher than the 3% estimate in the baseline results in Table 3. Hence, our baseline estimates can be thought of as a lower bound for the true effect of VAT adoption on firm capital.

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 eliminated the prevalent double-taxation of commodities under the sales tax, which was expected to reduce manufacturing prices (Empowered Committee of State Finance Ministers, 2005).[19] We illustrate this in the Online Appendix (Section A1.A) 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 *reduce* manufacturing prices.

We also confirm this empirically in Table A10 of the Online Appendix 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 A10]. 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 [see also Section A5.C, Online Appendix A5].

[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 was 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.

IV.B. Effect of the VAT on Financially Constrained Firms

Having established a positive causal impact of the VAT on firm capital, we next use equation (3) to identify whether financially constrained firms drive this treatment effect by examining treatment heterogeneity across ex-ante firm financial constraints. We gauge firm-level financial constraints using the SA index (Hadlock & 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 4, 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 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 thirds of the pre-VAT SA index distribution. SA^{T2} (SA^{T3}) is a dummy equaling 1 if the firm falls in the top third of the SA index. The uninteracted VAT term now estimates the VAT's impact on the least financially constrained firms in the bottom third of the SA index. Consistent with the descriptive evidence in Figure 2, we see in column (3) of Table 4 that the treatment effects

[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 is 0.73*0.078 = 0.057.

are concentrated amongst the most financially constrained firms, lying in the top 2 thirds 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 third 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 (2) 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 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. Section A4 (Online Appendix) presents additional event-study plots showing heterogeneity in dynamic treatment effects across financially constrained firms for other outcomes of interest.

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.

[21] Specifically, we estimate:

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

where *VAT* and k are defined as per equation (2), 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.

(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 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 an additional 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 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 A5 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 significantly larger impact on financially constrained firms.[25] The positive coefficient on the interaction term in column (2) is worth noting in light of the findings of Farre-Mensa and Ljungqvist (2016), who show that while the various indices of financial constraints might not be accurately capturing whether a firm is financially constrained, unlisted firms do exhibit behaviour consistent with a firm being finan-

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

[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 A5, 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 in the aggregate displayed a 4 percent increase in capital post-VAT.

cially constrained.

Column 5 of Table A5 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. While the coefficient is significant only at the 15 percent level, the point estimate implies that the VAT has a larger impact on capital for firms in industries with a higher dependence on external finance where financial constraints are likely to bind. In terms of magnitude, 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 causes an additional 1.5 percent [(0.47-0.14)*0.047 = 0.015] increase in capital, in response to the VAT.

The heterogeneity results across industries' dependence on external finance also serves as an additional counter to the critique of Farre-Mensa and Ljungqvist (2016) that balance-sheet based indices of financial constraints are capturing life-cycle effects of a firm, as opposed to whether it is financially constrained. As industries' dependence on external finance based on Rajan and Zingales (1998) is computed using data from U.S. firms from a prior time period, it is by construction independent of individual firm characteristics for our sample of firms. With column 5 of Table A5 confirming that the impact of the VAT is concentrated amongst firms operating in industries with a relatively high dependence on external finance where financial constraints are more likely to bind, it provides additional credence to the previously discussed findings that the VAT disproportionately affected the capital of financially constrained firms, where financial constraints are inferred from firm characteristics or balance-sheet measures.

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 1, dropping one state at a time and plotting 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 5 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 5, 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 3 and significant at the 5% level.

Column (4) excludes the states of Punjab and Haryana from our sample as these states offered input tax credits even with the sales tax (Agrawal & Zimmerman, 2019). The results remain unaffected upon excluding these two states.

Finally, we show the results from two placebo tests in columns (5) and (6) of Table 5. 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 (5). Similarly, column (6) 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 coincided 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 (1). 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 3. 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 A9 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 A7 (Online Appendix), 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

[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 3 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.

assets.

IV.C.1. Robustness to Nationally Representative Survey Data

We use the Prowess database for our primary empirical analysis as it contains firm identifiers and extensive information on firm balance-sheets. However, it is worth noting that the Prowess is not a representative sample of Indian firms and is dominated by relatively larger firms. To this effect, we show the robustness of our main results to using data from a nationally representative sample of manufacturing *establishments*, collected by the Annual Survey of Industries (ASI). The principal distinction between the Prowess and the ASI is that the unit of observation in the latter is the manufacturing establishment – or factory – and not the firm. While this precludes our ability to accurately gauge financial constraints using balance-sheet information, it is nonetheless informative to verify whether our baseline results are robust to a more representative sample of manufacturing establishments. An additional feature of the ASI data is that it provides accurate information on the physical location of establishments, which minimizes any mismatch in the timing of exposure of manufacturing establishments to the VAT.

To conserve space, we offer a detailed discussion of the ASI sample and empirical analysis in Online Appendix A5. In summary, we note that the results using the ASI data are very comparable to that using the Prowess: Table A11 in the Online Appendix confirms that states' adoption of the VAT has a positive, significant and sizeable impact on the plant and machinery of manufacturing establishments. Consistent with the Prowess results, we find the treatment effects of the VAT to be concentrated amongst establishments operating in industries with a higher dependence on external finance [column (3), Table A11, Online Appendix]. Reassuringly, we identify no impact of the VAT on the capital stock of manufacturing establishments operating in industries exempted from the VAT [column (5), Table A11, Online Appendix]. We exploit the detailed employment data in the ASI to show that the positive capital response to the VAT is concentrated amongst small and medium-sized establishments with 16-60 employees [column (4), Table A11, Online Appendix].[28] The distributional effects across establishment

[28]The pre-VAT mean (median) manufacturing establishment size is 72 (19) employees.

size shows that switching to a VAT can aid capital accumulation for smaller firms in an environment featuring imperfect credit markets (Gale et al., 2016).

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 6. 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 (Online Appendix A5.C) 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. Thus, a firm with the mean pre-VAT score on the SA index experienced a 0.1 percent increase in productivity.[29] Conditional on states' adoption of the VAT, moving from the 25th to 75th percentile of the SA index resulted in an additional 1 percent (0.016*0.73 = 0.012) increase in firm productivity. Thus, unlike the findings of Cerqua and Pellegrini (2014) who show that capital subsidies affected investments but not productivity, our results show that the VAT-induced capital incentive positively affected both capital and productivity for financially constrained firms.

Similar to the results on firm productivity, the results in columns (3) and (4) show that while

[29]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 revenue productivity is computed as the residual from a regression of log sales, the coefficient estimates are interpreted as percentage changes.

the VAT had little impact on the average firm's MRPK, moving from a firm at the 25th percentile of the SA index to the 75th percentile reduced MRPK by an additional 3 percent (-0.039*0.73 = - 0.028). The results in Table 6 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 ability to obtain the capital for optimal operations (Bloom, Mahajan, McKenzie, and Roberts, 2010; Hsieh & Klenow, 2009; Larrain & Stumpner, 2017; Midrigan & Xu, 2014; Rajan & Zingales, 1998).

V.B. Heterogeneity in VAT Impact and Other Firm Outcomes

Section IV.B documented that firms' capital response to the VAT was driven by financially constrained firms. Table A6 (Online Appendix) provides additional tests of treatment heterogeneity based on the motivation and structure of the VAT. First, as the ITC was applicable solely to capital inputs and not labor, we would expect firms with a relatively high share of labor expenses to respond less to the VAT. Column (1) confirms this to be the case – only firms with a relatively low share of labor expenditures see an increase in capital in response to the VAT.[30] Second, the Empowered Committee of State Finance Ministers (2005) stated that a primary motivation for replacing the sales tax with the VAT was to eliminate the cascading effect of sales taxes levied at multiple stages of the production process. This suggests that industries which sourced a high share of inputs from other manufacturing industries would stand to gain the most from the elimination of such double taxation. We verify this in column (2) of Table A6 (Online Appendix) by identifying treatment heterogeneity across whether firms belong to an industry which sources a relatively high fraction of its inputs from the manufacturing sector.[31] The positive and statistically significant coefficient on the interaction term (p-value 0.094) suggests this to be the case.

The final two columns of Table A6 (Online Appendix) identify differential treatment effects

[30] *High Labor* is a dummy equaling 1 if the firm's pre-VAT labor compensation as a share of total firm expenses is less than the median share of labor compensation across all firms.

[31] We define the dummy *Downstream* based on the fraction of inputs sourced by the industry from other manufacturing industries. We use the input-output tables from 2003-04 provided by the Central Statistical Organisation which computes the inputs sourced by each industry from other industries, as a fraction of its total inputs. Manufacturing industries which obtain a relatively high (above median) fraction of inputs from other manufacturing industries are classified as "downstream" industries.

based on pre-VAT heterogeneity in state sales tax structures. Thus, columns (4) and (5) provide suggestive evidence that the VAT's impact on firm capital was concentrated amongst firms operating in states which had a) a larger number of sales tax rates, and by extension, higher levels of consumption tax distortion; and b) a high mean sales tax rate.[32] This indicates that the capital response to the consumption tax reform varied by the sales tax structure faced by firms in the pre-VAT period.

We also examine the impact of VAT adoption on other firm outcomes that might respond to changes in firm capital. To conserve space, these results are presented in Table A8 of the Online 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 25^{th} percentile of the SA index to the 75^{th} percentile increased sales (raw materials) by an additional 7 (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 Table A10 (Online Appendix), this finding suggests that the VAT increased firm capital by eliminating the distortionary aspect of the sales tax and reducing the cost of capital.

[32]The data on state-specific sales tax rates is collected from Purohit (2001). *Multiple Tax Brackets* is a dummy equaling 1 if the state had a relatively high (above median) number of sales tax rates in the pre-VAT period; *High Tax Rate* is a dummy equaling 1 if the state had a relatively high (unweighted) average sales tax rate in the pre-VAT period.

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

Subsection IV.B established that VAT adoption increased firm 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:

$$Y_{sjt} = \alpha_{sj} + \delta_t + \beta_1 VAT_{st} + \beta_2 Share\ Cons._{sj} * VAT_{st} + \epsilon_{sjt}. \tag{5}$$

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.*).[33] The sample is restricted to manufacturing firms operating in industries not exempt from the VAT. Standard errors are clustered by state.

Column (1) of Table 7 indicate a null effect of VAT adoption on aggregate capital for the average state-industry combination. Column (2) tests for treatment heterogeneity across the fraction of financially constrained firms in each state-industry group. The interaction term

[33] 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.

(*VAT* × *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 the VAT's Impact on Industry Productivity

Financial constraints can dampen aggregate productivity through a misallocation of resources away from the most productive firms (Hsieh & 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):

$$a_{jst} = \overline{a_{jst}} + \sum_{i=1}^{n_{jst}} \Delta s_{ijst} \Delta a_{ijst}. \tag{6}$$

The first term in equation (6) is industry j's unweighted revenue productivity – our outcome of interest in Table 7. 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

(6) decomposes the increase in aggregate industry productivity into a) increases 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 (5). The results in Table 8, 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 (6). While the VAT has no discernible 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 8 are consistent with those in Table 7, 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 insights on the spillovers emanating from eliminating consumption tax distortions on firm productivity and show that additional reforms are needed to address the misallocation of resources.

REFERENCES

Agrawal, D. R., & Zimmerman, L. (2019). *Production and evasion responses with limited state capacity: Evidence from major tax reforms in India* (IGC Working Paper No. S-89411-INC-1). International Growth Centre. https://www.theigc.org/project/production-responses-and-tax-evasion-with-limited-state-capacity-evidence-from-major-reform-in-india/

Almeida, H., & Campello, M. (2007). Financial constraints, asset tangibility, and corporate investment. *The Review of Financial Studies*, *20*, 1429–1460.

Angelini, P., & Generale, A. (2008). On the evolution of firm size distributions. *The American Economic Review*, *98*, 426–438.

Avi-Yonah, R. S. (2009). *Designing a federal VAT: Summary and recommendations* (Olin Working Paper No. 09-013) University of Michigan Law & Economics. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1422092

Bau, N., & Matray, A. (2020). *Misallocation and capital market integration: Evidence from India* (NBER Working Paper No. 27955). National Bureau of Economic Research. https://www.nber.org/papers/w27955

Bertrand, M., Duflo, E., & Mullainathan, S. (2004). How much should we trust differences-in-differences estimates? *The Quarterly Journal of Economics*, *119*, 249–275.

Bloom, N., Mahajan, A., McKenzie, D., & Roberts, J. (2010). Why do firms in developing countries have low productivity? *The American Economic Review*, *100*, 619–623.

Borusyak, K., & Jaravel, X. (2017). *Revisiting event study designs* (Working Paper No. 2826228). SSRN. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2826228

Cabral, L., & Mata, J. (2003). On the evolution of the firm size distribution: Facts and theory. *The American Economic Review*, *93*, 1075–1090.

Cai, J., & Harrison, A. (2011). *The value-added tax reform puzzle* (Working Paper No. 5788). World Bank Policy Research. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1923546

Campello, M., Graham, J. R., & Harvey, C. R. (2010). The real effects of financial constraints: Evidence from a financial crisis. *Journal of Financial Economics*, *109*, 470–487.

Cengiz, D., Dube, A., Lindner, A., & Zipperer, B. (2019). The effect of minimum wages on low-wage jobs. *The Quarterly Journal of Economics*, *134*, 1405–1454.

Cerqua, A., & Pellegrini, G. (2014). Do subsidies to private capital boost firms' growth? A multiple regression discontinuity design approach. *Journal of Public Economics*, *109*, 114–126.

Chen, Z., Jiang, X., Liu, Z., Suarez Serrato, J. C., & Xu, D. Y. (2020). *Tax policy and lumpy investment behavior: Evidence from China's VAT reform* (NBER Working Paper No. 26336). National Bureau of Economic Research. https://www.nber.org/papers/w26336

Correia, S. (2016). *A feasible estimator for linear models with multi-way fixed effects.* Working Paper. http://scorreia.com/research/hdfe.pdf

Cotropia, C., & Rozema, K. (2018). Who benefits from repealing tampon taxes? Empirical evidence from New Jersey. *Journal of Empirical Legal Studies*, *15*, 620–647.

Criscuolo, C., Martin, R., Overman, H. G., & Van Reenen, J. (2019). Some causal effects of an industrial policy. *The American Economic Review*, *109*, 48–85.

Cummins, J. G., Hassett, K. A., & Hubbard, R. G. (1996). Tax reforms and investment: A cross-country comparison. *Journal of Public Economics*, *62*, 237–273.

Cummins, J. G., Hassett, K. A., Hubbard, R. G., Hall, R. E., & Caballero, R. J. (1994). A reconsideration of investment behavior using tax reforms as natural experiments. *Brookings Papers on Economic Activity*, *1994*(2), 1–74.

De Chaisemartin, C., & d'Haultfoeuille, X. (2020). Two-way fixed effects estimators with heterogeneous treatment effects. *The American Economic Review*, *110*, 2964–2996.

DePaulo, A., & Scheinkman, J. (2010). Value-added taxes, chain effects, and informality. *American Economic Journal: Macroeconomics*, *2*(4), 195–221.

Desai, M. A., & Goolsbee, A. (2004). Investment, overhang, and tax policy. *Brookings Papers on Economic Activity*, *2004*(2), 285–338.

Dharmapala, D., Foley, C. F., & Forbes, K. J. (2011). Watch what I do, not what I say: The unintended consequences of the Homeland Investment Act. *The Journal of Finance*, *66*, 753–787.

Empowered Committee of State Finance Ministers (2005). *A white paper on state-level value-added tax.* Government of India, Ministry of Finance.

Farre-Mensa, J., & Ljungqvist, A. (2016). Do measures of financial constraints measure financial constraints? *The Review of Financial Studies*, *29*, 271–308.

Fischman, J. B., & Schanzenbach, M. M. (2012). Racial disparities under the federal sentencing guidelines: The role of judicial discretion and mandatory minimums. *Journal of Empirical Legal Studies*, *9*, 729–764.

Gale, W., Gelfond, H., & Krupkin, A. (2016). *Value-added taxes and small business* [Policy Brief]. Economic Studies at Brookings. https://www.brookings.edu/wp-content/uploads/2016/07/galegelfondkrupkin_vatandentrepreneurship_policybrief_03092016_DP.pdf

Giroud, X., & Mueller, H. M. (2015). Capital and labor reallocation within firms. *The Journal of Finance*, *70*, 1767–1804.

Giroud, X., & Rauh, J. (2019). State taxation and the reallocation of business activity: Evidence from establishment-level data. *Journal of Political Economy*, *127*, 1262–1316.

Goodman-Bacon, A. (2018). *Difference-in-differences with variation in treatment timing* (NBER Working Paper No. 25018). National Bureau of Economic Research. https://www.nber.org/papers/w25018

Goolsbee, A. (1998). Investment tax incentives, prices, and the supply of capital goods. *The Quarterly Journal of Economics*, *113*, 121–148.

Graham, J. R. (2003). Taxes and corporate finance: A review. *The Review of Financial Studies*, *16*, 1075–1129.

Hadlock, C. J., & Pierce, J. R. (2010). New evidence on measuring financial constraints: Moving beyond the KZ index. *The Review of Financial Studies*, *23*, 1909–1940.

Hassett, K. A., & Hubbard, R. G. (2002). Tax policy and business investment. In M. Feldstein & A.J. Auerbach (Eds.), *Handbook of Public Economics* (Vol. 3, pp. 1293–1343). Amsterdam, Netherlands: North Holland Publishing Company.

Hayashi, A. T. (2014). The legal salience of taxation. *University of Chicago Law Review*, *81*, 1443–1507.

Heider, F., & Ljungqvist, A. (2015). As certain as debt and taxes: Estimating the tax sensitivity of leverage from exogenous state tax changes. *Journal of Financial Economics*, *118*, 684–712.

Hemel, D., & Rozema, K. (2016). Inequality and the mortgage interest deduction. *Tax Law Review*, *70*, 667–706.

House, C. L., & Shapiro, M. D. (2008). Temporary investment tax incentives: Theory with evidence from bonus depreciation. *The American Economic Review*, *98*, 737–768.

Hsieh, C.-T., & Klenow, P. J. (2007). Relative prices and relative prosperity. *The American Economic Review*, *97*, 562–585.

Hsieh, C.-T., & Klenow, P. J. (2009). Misallocation and manufacturing TFP in China and India. *The Quarterly Journal of Economics*, *124*, 1403–1448.

Kaplan, S. N., & Zingales, L. (1997). Do investment-cash flow sensitivities provide useful measures of financing constraints? *The Quarterly Journal of Economics*, *112*, 169–215.

Kaplow, L. (1994). The standard deduction and floors in the income tax. *Tax Law Review*, *50*, 1–31.

Keen, M., & Lockwood, B. (2010). The value-added tax: Its causes and consequences. *Journal of Development Economics*, *92*, 138–151.

Kerr, W. R., & Nanda, R. (2009). Democratizing entry: Banking deregulations, financing constraints, and entrepreneurship. *Journal of Financial Economics*, *94*, 124–149.

Kopczuk, W., & Slemrod, J. (2006). Putting firms into optimal tax theory. *The American Economic Review*, *96*, 130–134.

Larrain, M., & Stumpner, S. (2017). Capital account liberalization and aggregate productivity: The role of firm capital allocation. *The Journal of Finance*, *72*, 1825–1858.

Lilienfeld-Toal, U. v., Mookherjee, D., & Visaria, S. (2012). The distributive impact of reforms in credit enforcement: Evidence from Indian debt recovery tribunals. *Econometrica*, *80*, 497–558.

Lin, H., & Paravisini, D. (2013). The effect of financing constraints on risk. *Review of Finance*, *17*, 229–259.

Liu, Q., & Lu, Y. (2015). Firm investment and exporting: Evidence from China's value-added tax reform. *Journal of International Economics*, *97*, 392–403.

Midrigan, V., & Xu, D. Y. (2014). Finance and misallocation: Evidence from plant-level data. *The American Economic Review*, *104*, 422–458.

Naritomi, J. (2019). Consumers as tax auditors. *The American Economic Review*, *109*, 3031–3072.

Niblett, A., & Yoon, A. H. (2017). Unintended consequences: The regressive effects of increased access to courts. *Journal of Empirical Legal Studies*, *14*, 5–30.

Ohrn, E. (2018). The effect of corporate taxation on investment and financial policy: Evidence from the DPAD. *American Economic Journal: Economic Policy*, *10*(2), 272–301.

Olley, G. S., & Pakes, A. (1996). The dynamics of productivity in the telecommunications equipment industry. *Econometrica*, *64*, 1263–1297.

Pomeranz, D. (2015). No taxation without information: Deterrence and self-enforcement in the value-added tax. *The American Economic Review*, *105*, 2539–2569.

Purohit, M. C. (2001). National and sub-national VATs: A road map for India. *Economic and Political Weekly*, *36*(9), 757–772.

Rajan, R. G., & Zingales, L. (1998). Financial dependence and growth. *The American Economic Review*, *88*, 559–586.

Satterthwaite, E. A. (2018). On the threshold: Smallness and the value-added tax. *Columbia Journal of Tax Law*, *9*, 177–227.

Stolper, S. (2016). *Local pass-through and the regressivity of taxes: Evidence from automotive fuel markets.* University of Michigan Working Paper. https://sites.google.com/view/sstolper/research?authuser=0

Sun, L., & Abraham, S. (2020). *Estimating dynamic treatment effects in event studies with heterogeneous treatment effects* (Working Paper No. 3158747). SSRN. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3158747

Thomas, A. (2020). *Reassessing the regressivity of the VAT* (OECD Taxation Working Paper No, 49). OECD Publishing. https://www.oecd-ilibrary.org/taxation/reassessing-the-regressivity-of-the-vat_b76ced82-en

Tuttle, C. (2021). *Racial disparities in federal sentencing: Evidence from drug mandatory minimums* (Working Paper No. 3080463). SSRN. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3080463

Vig, V. (2013). Access to collateral and corporate debt structure: Evidence from a natural experiment. *The Journal of Finance*, *68*, 881–928.

Whited, T. M., & Wu, G. (2006). Financial constraints risk. *The Review of Financial Studies*, *19*, 531–559.

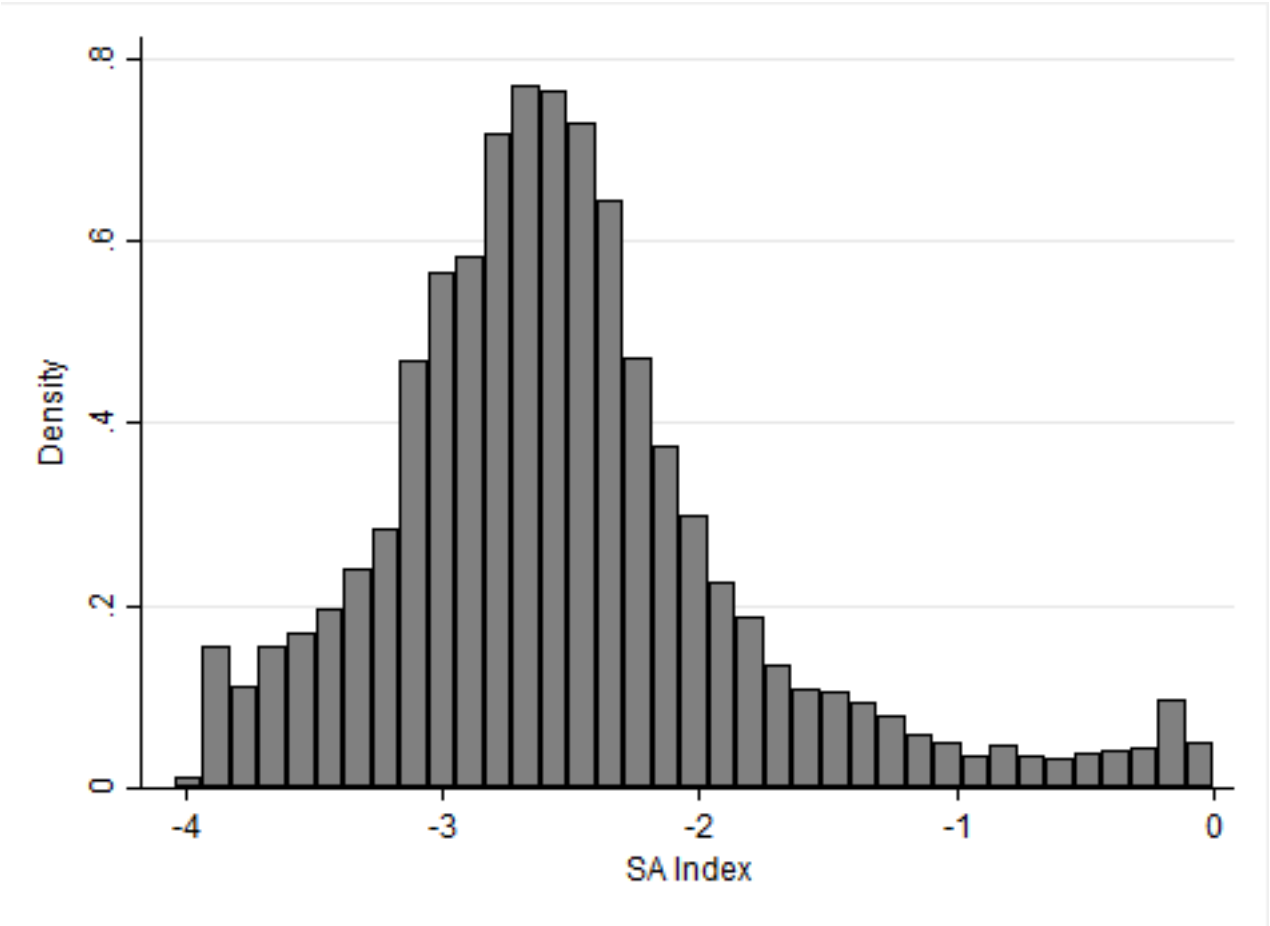
Yagan, D. (2015). Capital tax reform and the real economy: The effects of the 2003 dividend tax cut. *The American Economic Review*, *105*, 3531–3563.

Yang, C. S. (2015). Free at last? Judicial discretion and racial disparities in federal sentencing. *Journal of Legal Studies*, *44*, 75–111.

Zia, B. H. (2008). Export incentives, financial constraints, and the (mis) allocation of credit: Micro-level evidence from subsidized export loans. *Journal of Financial Economics*, *87*, 498–527.

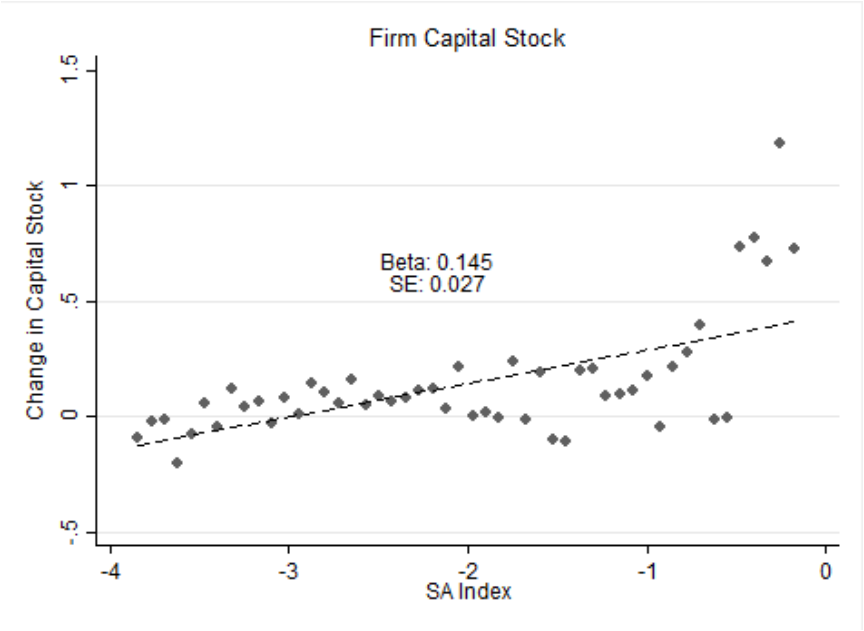
Zwick, E., & Mahon, J. (2017). Tax policy and heterogeneous investment behavior. *The American Economic Review*, *107*, 217–248.

Figure 1: Pre-VAT Distribution of Firm Financial Constraints

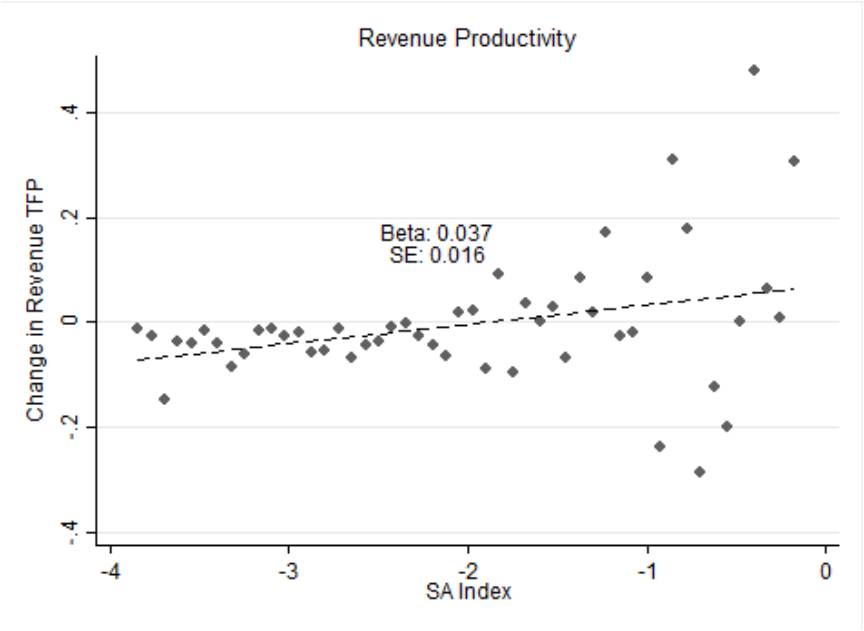


NOTES: This figure shows the distribution of firms' average score on the size-asset (SA) index (Hadlock & Pierce, 2010) in the pre-VAT period between 1998 and 2002. Higher scores on the index indicate the increasing severity of financial constraints.

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



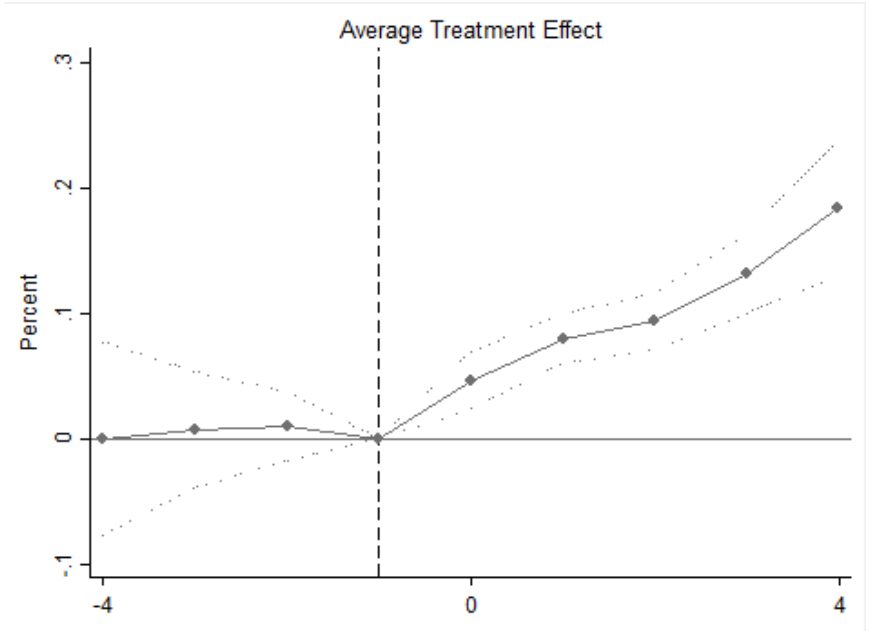
Panel A



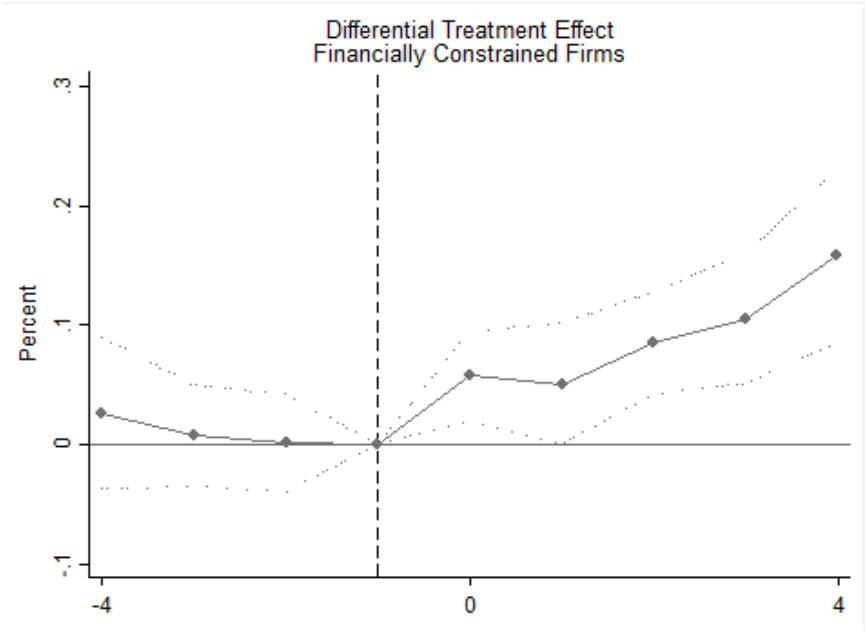
Panel B

NOTES: Panels A and B show the average change in firm capital stock and productivity, before and after states' adoption of the VAT, binned across the ex-ante intensity of firm financial constraints. The x-axis represents the SA index (Hadlock & 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



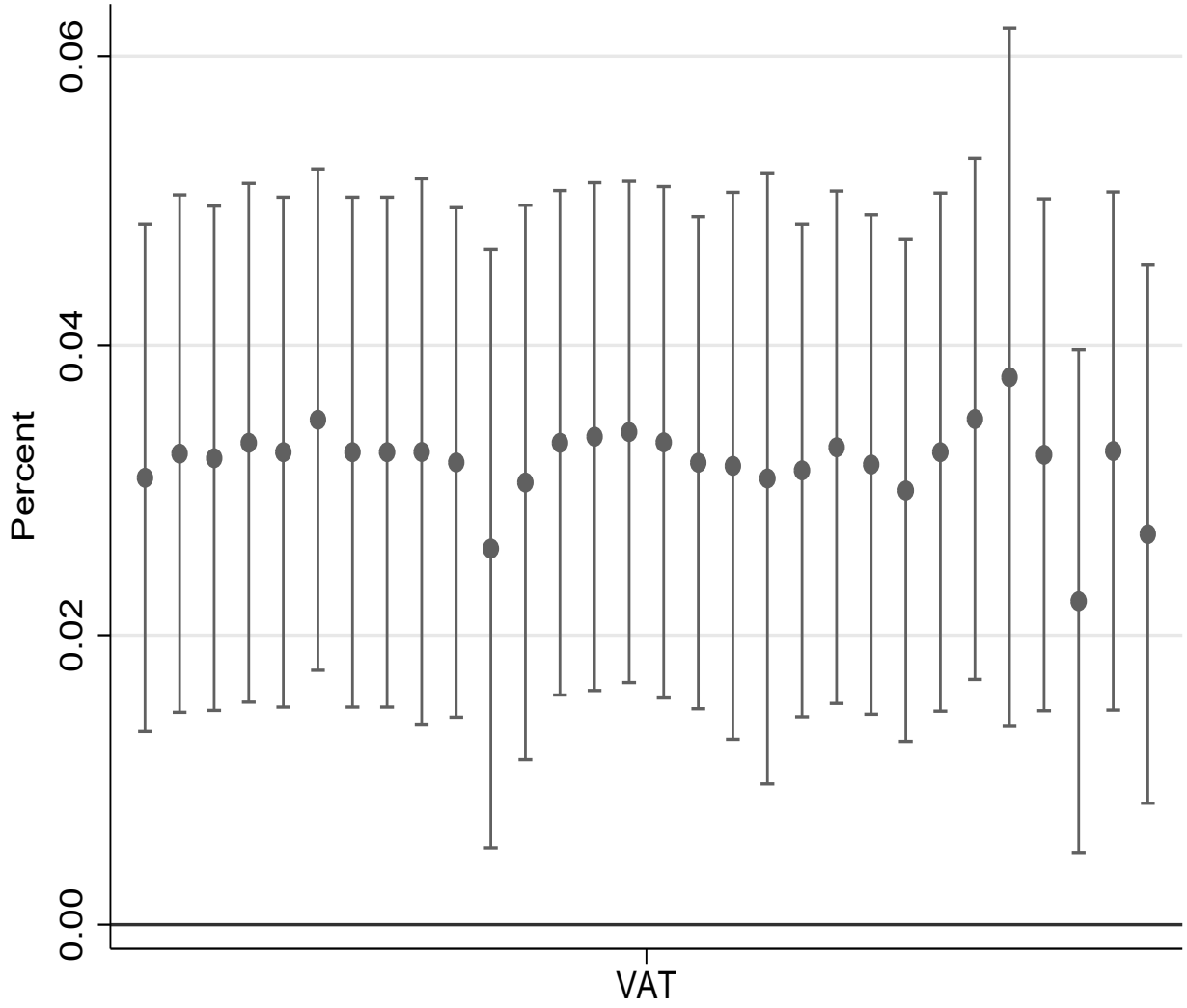
Panel A



Panel B

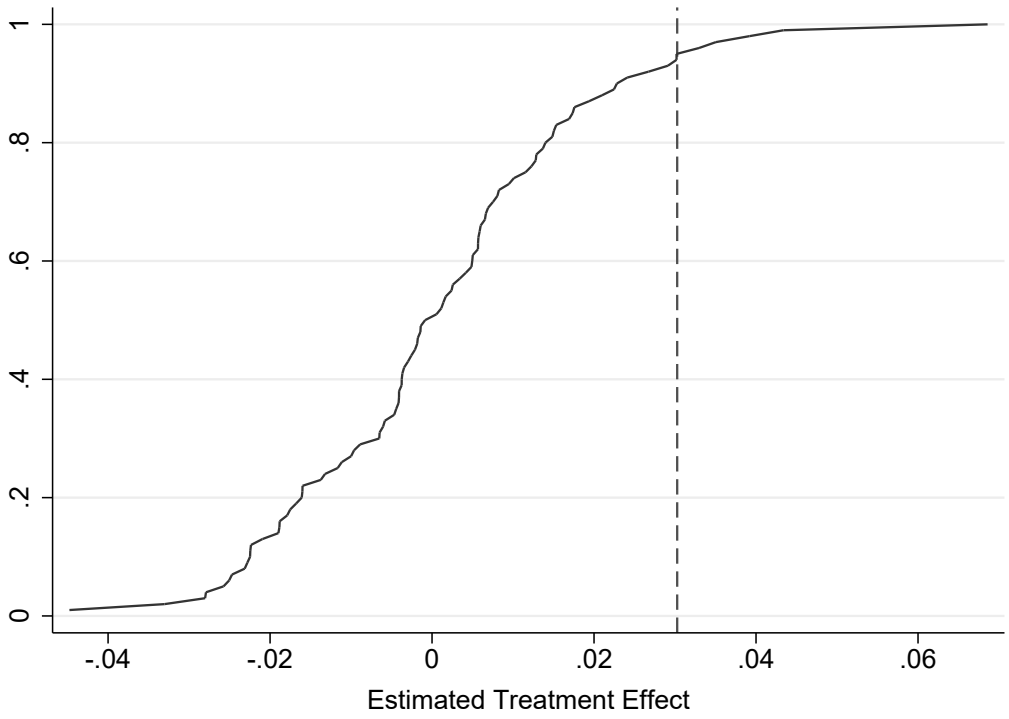
NOTES: This figure shows the average annual treatment effects for capital stock. The reference year is the year prior to VAT adoption by the state (t= -1). The vertical lines represent the 95 percent confidence interval associated with the coefficients. All specifications include firm and year fixed 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 (pre-VAT SA index score higher than median pre-VAT SA index score).

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



NOTES: The above figure shows the robustness 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 interval 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 100 estimations where the VAT adoption year is randomly assigned across states. The dashed vertical 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: Chronology of VAT Adoption by States

State	VAT Adoption Year
Andhra Pradesh	2005
Arunachal Pradesh	2005
Assam	2005
Bihar	2005
Chandigarh	2006
Chhattisgarh	2006
Dadra Nagar and Haveli	2005
Daman and Diu	2005
Delhi	2005
Bihar	2005
Goa	2005
Gujarat	2006
Haryana	2003
Himachal Pradesh	2005
Jammu and Kashmir	2005
Jharkhand	2006
Karnataka	2005
Kerala	2005
Madhya Pradesh	2006
Maharashtra	2005
Meghalaya	2005
Nagaland	2005
Odisha	2005
Puducherry	2007
Punjab	2005
Rajasthan	2006
Tamil Nadu	2007
Tripura	2005
Uttar Pradesh	2008
Uttarakhand	2006
West Bengal	2005

NOTES: This table shows the year of VAT adoption for each state and union territory.

Table 2: 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 3: 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 4: VAT Adoption and Firm Capital: Differential Effect 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 employee compensation across all firms in this period. *Young* is a dummy equaling 1 if the firm's year of incorporation is after 1996. All specifications include firm and 3-digit industry-year fixed effects and state-specific covariates. Standard errors are in parentheses, clustered by state.

Table 5: VAT Adoption and Firm Capital: Robustness and Placebo Tests

Dependent Variable	Capital (Logged)					
	Robustness				Placebo	
	Firm-Level Cluster	Two-Way Cluster	Drop Largest Metros	Drop Punjab Haryana	VAT Exempt Firms	Non-Manufacturing Firms
	(1)	(2)	(3)	(4)	(5)	(6)
VAT	.033**	.033**	.030**	.027**	-.058	-.016
	(.014)	(.014)	(.012)	(0.011)	(.036)	(.017)
Observations	35472	35472	24506	33631	6142	10279
R^2	.93	.93	.93	.92	.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) excludes the states of Punjab and Haryana; column (5) restricts the sample to manufacturing firms exempted from the VAT; column (6) 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)-(6).

Table 6: 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 the 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 7: 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 unweighted 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 8: 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 the decomposition of firm productivity based on Olley and Pakes (1996). 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.

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

Online Appendix

A1. VAT Adoption, Cost of Capital and Optimal Capital Response

This section uses a simple conceptual framework to illustrate how the replacement of a sales tax with a VAT affects the tax-related cost of capital, and predicts firms' optimal response to this change in the cost of capital.

A1.A. VAT and the Cost of Capital

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 use one unit of labor (no wage cost). The primary commodity is x, which firm i purchases, to produce the intermediate commodity y. Subsequently, firm j purchases y and produces the final commodity z, which is sold to consumers. The price of the primary commodity is p_x and the uniform consumption tax levied on each commodity 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 as v^i_{RST}. This would also include any mark-up firm i chooses to impose.

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

After simplifying, the selling price of commodity y can be expressed as:
Selling price of commodity 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 commodity 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 commodity z is: $(1+\tau)[(p_x + v^i_{RST}) + \tau p_x] + v^j_{RST}$.
Tax on commodity z is: $\tau * [(1+\tau)((p_x + v^i_{RST}) + \tau p_x) + v^j_{RST}]$.
The selling price of commodity 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 commodity 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 commodity and the final commodity 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 the 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 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 the payment of tax and receipt of ITC), we can interpret the ITC provision to be akin to a reduction in the cost of inputs 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 commodity y: $p_x+v^i_{VAT}$.
Tax imposed on commodity y: $\tau*(p_x+v^i_{VAT})$.
Selling price of commodity 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 commodity 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 commodity z is: $p_x + v^i_{VAT} + v^j_{VAT}$.
Tax on commodity z is: $\tau * (p_x + v^i_{VAT} + v^j_{VAT})$.
The selling price of commodity z is: $p_z = (1+\tau)(p_x + v^i_{VAT} + v^j_{VAT})$.

Comparing the sales price of commodity 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 commodity 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: $\tau * (p_x + v^i_{RST} + v^j_{RST})$.

A1.B. Firms' Optimal Capital Response to VAT Adoption

The previous section established the conditions under which replacing the sales tax with the VAT is expect to reduce the cost of capital. We now provide a simple framework to trace out firms' optimal capital response to the replacement of the sales tax with the VAT.

Formally, consider a profit-maximizing firm that chooses capital k and labor 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.[34] 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:

$$\pi(k,l) = (1-\tau)pf(k,l) - wl - r(1+\alpha\tau)k, \tag{7}$$

where α in equation (7) 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:

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

$$f_k(k^*, l^*) = \frac{r}{p} * \frac{(1+\alpha\tau)(1+\lambda)}{1-\tau} \tag{8}$$

and

$$f_l(k^*, l^*) = \frac{w}{p} * \frac{1+\lambda}{1-\tau}. \tag{9}$$

In equations (8) and (9), 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 (8), 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 (8) that the optimal capital response would be:

$$\frac{dk^*}{d\alpha} = \frac{r(1+\lambda)\tau}{p(1-\tau)f_{kk}}. \tag{10}$$

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.[35] This expression leads to *Hypothesis 1*, presented in Section I.B.

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 (10). This forms the motivation for *Hypothesis 2* in Section I.B.

[35] 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:

$$\frac{\partial k^*}{\partial \alpha} = \frac{1}{f_{kk}}\left[\frac{(\alpha r(1+\lambda) + pf_l)(\tau r(1+\lambda))}{p^2 f_{lk}(1-\tau^2)} + \frac{f_l}{1-\tau}\right] < 0. \tag{11}$$

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 (MRPK). 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 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 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 computed 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 (Online Appendix) 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 (Online Appendix) 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 (8) which predicts that financially constrained firms would have a higher marginal product of capital.

Figure A2 (Online Appendix) 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 scores 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 & Pierce, 2010). Firms with higher SA index scores are also more likely to be unrated and transact with fewer banks.

A3. Issues Related to Difference-in-Difference Design

In this section we discuss our use of the difference-in-difference (DiD) approach (we focus on Table 3 since it presnts our core findings). Our empirical specification in equation (1) uses the basic two-way fixed effect estimator with time and firm fixed effects. Recent work, however, has shown that these estimates can be biased when treatment adoption is staggered over time (Goodman-Bacon, 2018; Sun & Abraham, 2020; De Chaisemartin & d'Haultfoeuille, 2020). We follow two approaches to show robustness to these critiques. First, we conduct the decomposition proposed by Goodman-Bacon (2018) to identify the individual 2×2 DiD estimates driving the two-way fixed effect DiD estimate. Second, we show robustness of our results to using a "stacked event study" approach that reduces this bias.

A3.A. Goodman-Bacon (2018) decomposition

The approach of Goodman-Bacon (2018) decomposes the two-way fixed effects DiD model into the weighted average of all two-group/two-period estimators. We can then pinpoint which individual 2×2 estimators are driving our results. Column (1) in Table A4 reproduces the estimate in column (1) of Table 3. Since this examination requires a balanced panel, we estimate the equation with a balanced panel in column (2) and see that post VAT adoption, firm capital increased by 12%.[36] The decomposition gives us the weighting for the following DiD groups: earlier versus later treated; later versus earlier treated, and the treated versus untreated group (see Table 1 for earlier and later treatment groups).

The average effect and weight given for these three types of 2×2 DiD comparisons are shown in Table A3. In addition, Figure A5 also plots each 2×2 DiD against its weight in the two-way fixed effect DiD estimate. The two-way fixed effects estimate from the balanced panel regression of 0.12 (column 2, Table A4) is an average of the y-axis values weighted by their x-axis values. The largest weight (43%) is placed on earlier-treated vs. later-treated group, and has a DiD estimate of 8% (as shown in Table A3). The treated versus untreated group also receives a high weight of 41%, and delivers a DiD estimate of 20%. We see that the comparisons of later- to earlier-treated units, however, receives the smallest weight (15%), and a small, negative estimate of -0.01. This portion accounts for any bias in the overall DiD estimate.[37] This bias is likely to arise when treatment effects vary over time, as we observe above. Reassuringly, as these problematic DiDs account for a smaller fraction of the two-way fixed effect estimate, we believe this isn't a cause for concern in our baseline specification.

Goodman-Bacon (2018) further recommends using the decomposition theorem to remove problematic terms from the (weighted average) two-way fixed effect estimate. This exercise yields an overall effect of 14% – greater than the base 12% estimate – when we remove the

[36] We create a balanced panel filling missing observations with the last available data for the stock of capital.

[37] The bias due from the later- versus earlier treated groups is also evident in Figure A5 and account for most of the negative 2*2 DiD estimates. However, most weights barring 1 estimate are closer to 0 as seen in the figure.

weight on the later vs. earlier treated group (which has the DiD estimate of -0.01). In summary, the overall effect is a net positive and higher than the point estimate of the balanced panel in column 2 in Table A4.

Figure A5 further indicates that the outlier DiD estimate with a weight of 0.24 and an estimate of 0.21 may be driving the treated vs. untreated estimate of 0.20 documented in the above table. Even if we ignore the treated to the untreated group given this outlier estimate and restrict to the earlier vs. later treated group, the overall effect is positive and indicates an 8% increase in firms' capital post VAT adoption.

A3.B. Stacked Event Study Analysis

To address the biases arising in the two-way fixed effect estimations one could use a stacked event study approach.[38] We group the states into different adoption cohorts based on the year of adoption as shown in Table 1. Thus, Haryana belongs to the 2003 cohort; Chandigarh, Chattisgarh, Gujarat, Jharkand, Madhya Pradesh, Rajasthan, and Uttarakhand belong to the 2006 cohort, and so on. Subsequently, for each cohort we define an event window as ± 2 years (and ± 3 years) around the date of adoption. We retain only the pure control cohorts that did not undergo VAT adoption in this window. We also drop the cohorts that underwent VAT adoption to avoid bias arising from comparing the late adopters to the earlier adopters when the treatment effects vary strongly over time. Thus, for the 2003 cohort, we exclude the 2005 cohort because it falls within the estimation window and include the remaining cohorts as the control group. Similarly, for the 2005 cohort, we drop the 2003 cohort, 2006 cohort, and the 2007 cohort.[39] Thus, for each cohort we now have a clean set of control groups. We then stack all these cohorts and run our estimation with logged capital as the dependent variable with cohort-by-state and industry-by-year fixed effects. Since this artificially increases the sample size, we correct for standard errors using multi-way clustering as in Correia (2016) and cluster by state, cohort, and year.

The results are shown in columns (3) and (4) in Table A4 corresponding to an event window of ± 2 and ± 3 years respectively. The point estimates are similar and indicate a 5.56% [column (3)] and 5.33% [column (4)] increase in firm capital post VAT adoption. Since this uses the unbalanced panel, the comparison is to the 2.7% estimate in column (1) of Table 3. The true estimates are more than twice as large as the baseline two-way fixed estimates. This suggests that if anything, the baseline estimates in the paper are a lower bound of the true effect of VAT adoption. This finding is also consistent with the Goodman-Bacon (2018) decomposition discussed above wherein we found that only the problematic DiDs (later vs. earlier treated groups) had negative estimates.

[38] See Cengiz et al. (2019) for a similar robustness check. We also thank an anonymous referee for this suggestion.

[39] Ideally, we should use the event window of +/-4 as in Figure 3, but this would severely limit the sample size and yields unreliable estimates. Hence, we show robustness using the two event windows of +/-2 and +/-3 periods around the event date.

A4. Dynamic Treatment Effects of the VAT on Firm Outcomes

This section uses event-study plots to present the dynamic treatment effects of the VAT on key firm outcomes of interest using the Prowess data. As our paper identifies the impact of the VAT on financially constrained firms, we present event-study plots identifying the differential impact of the VAT across financially constrained firms on firm outcomes of interest. Specifically, we estimate:

$$\ln(Y_{ist}) = \alpha_i + \delta_t + \sum_{k=-4}^{4} \beta_{1k} VAT_{st+k} + \sum_{k=-4}^{4} \beta_{2k} FC_i \times VAT_{st+k} + \epsilon_{ist} \tag{16}$$

where Y is the firm-level outcome of interest for firm i in year t, located in state s. FC is a dummy equaling 1 if the firm is classified to be financially constrained. A firm is considered to be financially constrained if it's pre-VAT score on the SA index is less than the median pre-VAT SA index score across all firms. For each state, we include firm observations within an 8 year window – 4 years prior to VAT adoption, and 4 years post-VAT adoption, with the year prior to VAT adoption serving as the reference period. If the VAT differentially affected firm outcomes for financially constrained firms as identified in Tables 4 and A8 (Online Appendix), we would expect $\beta_{2k} > 0$ for $k \geq 0$ and a null effect for $k < 0$. Standard errors are clustered by state.

The results in Figures A6 and A7 (Online Appendix) are broadly consistent with those obtained in Table A8 (Online Appendix), and Figure 3. The top-left panel of Figure A6 (Appendix) shows that like capital, fixed assets for financially constrained firms differentially increase immediately upon VAT adoption by states, while sales and employee compensation increase only 2 years following states' adoption of the VAT. Unexepctedly however, we find no differential impact on firm productivity for financially constrained firms – the coefficients β_{2k} for $k \geq 0$ are positive but not statistically significant. Consistent with the impact of the VAT on capital stock for financially constrained firms, the top-left panel of Figure A7 (Online Appendix) identifies a positive differential effect on raw materials for financially constrained firms, starting in the year of states' adoption of the VAT. No such effect is discernible for firm profitability or cash flows. Importantly, we do not observe any differential pre-treatment trends for financially constrained firms in any of the event-study plots. This provides further support to the credibility of our DiD design: financially constrained firms did not exhibit differential pre-treatment trends for any major firm outcome of interest.

A5. VAT and Capital: Empirical Results using ASI Data

Our primary results are obtained using data from the Prowess. While the Prowess provides firm identifiers and has rich information on firm balance-sheets, the data is not representative of firms in the Indian context. In particular, since the Prowess only covers firms with public balance-sheets, the data is dominated by large firms. Additionally, the absence of data on firm employees limits our ability to accurately identify the impact of the VAT over the firm size distribution. We address these inadequacies in the Prowess by replicating our key results using data from the Annual Survey of Industries (ASI) – a nationally representative survey of registered manufacturing establishments in India.

A5.A. Data Description

The Annual Survey of Industries is a nationally representative survey of registered manufacturing enterprises in India, covering all states and districts. The unit of observation is the manufacturing enterprise (or "factory"), and the survey is conducted annually, comprising of a Census and a Sample frame. The former consists of factories which employ in excess of 100 workers and are covered every year by ASI; the latter is drawn from a random sample of remaining factories. The ASI contains information on the manufacturing establishment's capital, sales, raw materials, inputs, workers, wages and the unit sales price of commodities produced. The physical location (state) of the factory and whether it is located in a rural or urban area is also known. The precise information on enterprise locations minimizes the chances of misattributing the timing of an enterprise's exposure to the VAT – something which remains a concern in the Prowess where we infer firm locations by assuming that the firm's site of manufacturing is the same as its headquarters. The ASI however does not contain information on core financial variables or link manufacturing establishments to their parent firm. We are thereby unable to observe firm-level balance sheet variables such as firm assets, liabilities, borrowings and profitability.

We use the ASI data over an eight year period between 2000 to 2007. All monetary values are deflated using the wholesale price index to 1993 values (INR). We end our sample in 2007 as the ASI switches to an alternate form of industry classifications in 2008 which makes it challenging to consistently apply industry fixed effects. The publicly available ASI data does not provide establishment identifiers, making the final data of the form of a repeated cross-section and disallowing us from using enterprise fixed effects. In the absence of enterprise fixed effects, we use instead 3-digit industry-year fixed effects – akin to our main specifications using the Prowess data, and also include state fixed effects to control for state-specific time-invariant factors affecting enterprise outcomes. We also control for factory-level factors such as rural or urban location, a quadratic in establishment age, and days of operation over the past year. Pre-VAT state-specific covariates, interacted with a linear time-trend are also included.

A5.B. VAT and Enterprise Outcomes

We identify the impact of the VAT on factory-level outcomes using the following specification:

$$\ln(Y_{fjst}) = \alpha_{jt} + \phi_s + \beta VAT_{st} + \theta \mathbf{X}_{fjst} + \epsilon_{fjst} \tag{17}$$

The unit of observation in equation (17) is the manufacturing establishment, or factory f, operating in 3-digit industry j, located in state s and observed in year t. We include 3-digit industry-year fixed and state fixed effects. Thus, we continue to compare factories in the same industry and year, with the identifying variation stemming from whether states have adopted the VAT or not. The *VAT* dummy captures this, and is defined as in specification (1). $\mathbf{X}$ includes establishment and state-specific covariates. Standard errors are clustered by state and all the specifications are weighted by establishment-specific weights provided by the ASI. We exclude establishments operating in industries exempted from the VAT.

Our primary outcome of interest remains capital stock, measured using the factory's net value of plant and machinery. The results are shown in Table A11 (Online Appendix). Column (1) excludes firm and state-specific covariates and only includes state and industry-year fixed effects. The coefficient in column (1) estimates a positive and statistically significant impact of VAT adoption on firm capital stock, and is stable to the inclusion of factory and state-specific covariates [column (2)].

The coefficient in column (2) reflects that states' adoption of the VAT resulted in a 10 percent increase in capital stock. The coefficient is significantly larger than that obtained using Prowess. A possible explanation of this is that the unit of observation in the Prowess is the firm, while that in the ASI is the manufacturing establishment. Since the Prowess is dominated by larger firms, it is possible that these firms have multiple manufacturing units, which are recorded in the ASI data as individual establishments. In the absence of firm identifiers, we are unable to aggregate manufacturing units to their parent firm. Since the base capital of each enterprise is likely to be smaller than that of the parent firm, it can reflect as a larger change in percentage terms. Based solely on the pre-VAT mean establishment capital [INR 6 million (1993 INR)], column (2) implies that the VAT increases the average establishment's capital stock by 0.6 million – one-tenth of the increase in rupee terms as recorded using Prowess.

Column (5) of Table A11 (Online Appendix) shows the results from the placebo test by restricting the sample to select industries which were exempted from the VAT across all states. Reassuringly, we see that the coefficient corresponding to the VAT indicator is negative, small, and not statistically significant. This assuages concerns that our results are being driven by secular factors which are correlated with states' timing of VAT adoption and is also positively correlated with capital stock of manufacturing establishments. If so, we would have expected this factor to also affect industries not exempted from the VAT.

The absence of firm-level data means that we are unable to compute the size-asset (SA)

index of Hadlock and Pierce (2010) as we lack data on firm assets and listing status. As a consequence, we identify treatment heterogeneity using the index of Rajan and Zingales (1998) pertaining to industries' dependence on external finance. As financial constraints are more likely to bind for firms operating in industries with a higher dependence on external finance, if the VAT response is concentrated amongst financially constrained firms, we would expect the treatment to have a larger impact on capital stock for factories operating in industries with a higher dependence on external finance.

Column (3) shows the results from this exercise. The results are consistent with our expectations. While the interaction coefficient is not statistically significant (p-value of 0.141), it is positive and sizeable in magnitude: moving from an industry at the 25th percentile of the Rajan and Zingales (1998) index to the 75th percentile causes a near 6 percent additional increase in factory capital post VAT adoption. The results in columns (1)-(3) thus confirm a) that VAT adoption increases capital stock for manufacturing establishments, and b) the increase is driven by factories operating in industries which are dependent on external finance for purely technological factors – industries where firms have a higher likelihood of being financially constrained.

A significant advantage of the ASI data is that it provides information on workers hired by the firm. This allows us to identify the impact of the VAT across the establishment size distribution. As states' VAT adoption can affect the number of employees hired, we use data between 2000 and 2002 to assess the pre-VAT distribution of establishment size. Based on the pre-VAT data, we disaggregate the establishment size distribution by quintiles, and identify differential treatment effects across pre-VAT establishment-size quintiles.[40] Specifically, we estimate:

$$\ln(Y_{fjst}) = \alpha_{jt} + \phi_s + \beta_1 VAT_{st} + \sum_{i=2}^{5} \beta_j Q_{fjst}^{Size_i} \times VAT_{st} + \theta \mathbf{X}_{fjst} + \epsilon_{fjst} \tag{18}$$

Q^{Size_i} in (18) is a dummy corresponding to the i^{th} quintile of the pre-VAT estalishment-size distribution. β_1 identifies the impact of the VAT for establishments in the bottom quintile of the establishment-size distribution, and each subsequent β_j ($j \in \{2,3,4,5\}$) identifies the differential treatment effect in each subsequent establishment size quintile. Column (4) shows that the VAT's impact on capital stock was concentrated amongst mid-sized establishments in the 3rd and 4th quintiles of establishment size (factories with 16-60 employees).[41] Thus, for factories in the 3rd (4th) quintile of the firm size distribution with 16-26 (27-60) employees, VAT adoption by states increased capital stock by 14 (12 percent), equivalent to 0.27 (0.57) million INR in 1993 values.

[40] We measure establishment-size using the total number of employees hired by the establishment (employees = hired workers + contract workers + supervisory staff). The factory sizes corresponding to each quintile is: Q^1: 0-10 employees; Q^2: 11-15 employees; Q^3: 16-26 employees; Q^4: 27-60 employees; and Q^5: 60 + employees.

[41] The differential β_3 coefficient has a p-value < 0.001; the p-value with the β_4 coefficient is 0.112.

Table A12 (Online Appendix) shows the impact of the VAT on other factory outcomes of interest such as fixed assets, sales, revenue productivity and marginal revenue product of capital (MRPK). We measure revenue productivity and MRPK for each establishment using the procedure described in A2.A (Online Appendix). The odd-numbered columns identify the average treatment effect while the even-numbered columns identify the differential effect across industries' dependence on external finance (Rajan & Zingales, 1998). The results are mostly consistent with those obtained using the Prowess data. VAT adoption increases net fixed assets, sales and raw materials.

There are two major departures though: first, column (6) informs us that the VAT had a positive effect on employees for establishments operating in industries with a relatively high dependence on external finance. This suggests complementarities between capital and labor for enterprises operating in industries with a relatively high dependence on external finance. Second, contrary to the results obtained using the Prowess data, the VAT no longer has a positive impact on revenue productivity for establishments operating in industries with a relatively high dependence on external finance. The interaction term in column (10) is negative, albeit weakly significant (p-value 0.077). There is however some weak evidence in column (12) that the VAT reduced the marginal revenue product of capital for establishments operating in industries with a relatively high dependence on external finance. This indicates that VAT adoption contributed to improvement in capital allocation across establishments. In summary, the results from Tables A11 and A12 (Online Appendix) confirm the positive impact of the VAT on enterprise capital, though there remain some ambiguities in its impact on productivity.

A5.C. VAT and Commodity Prices

Goolsbee (1998) showed that capital subsidies have a muted effect on firm investment as the general equilibrium effect, manifested through an increase in the aggregate demand for capital increases the cost of capital. The key mechanism explored in our paper is that the ITC component of the VAT served akin to an investment credit which induced firms to expand their capital stock. However, this explanation would be inconsistent if the general equilibrium effects in response to the ITC causes an overall increase in the cost of machinery and equipments. We rule out this channel using the ASI data which records the specific commodities produced by each establishment and their unit prices.

We use the following estimating equation to test this hypothesis:

$$\ln(Price_{cfjst}) = \alpha_c + \delta_{jt} + \beta VAT_{st} + \phi X_{fjst} + \epsilon_{cfjst} \tag{19}$$

Price in (19) is the unit price of commodity c, produced by factory f. The unit of observation is commodity-establishment with α and δ denoting commodity and industry-year fixed effects. The remaining variables are defined as in specification (17). A negative impact or null coefficient on β_1 would negate the contention that the replacement of the sales tax with the VAT

increased the price of manufactured commodities. All the specifications are weighted using establishment-specific weights and standard errors are clustered by state.

Column (1) of Table A10 (Online Appendix) presents the results from a parsimonious specification including only commodity and year fixed effects, and no other covariates. We identify a large negative correlation between the VAT and commodity prices, significant at the 5% level. Columns (2)-(4) shows that the inclusion of 3-digit industry year fixed effects, state-specific covariates, a quadratic in establishment age or age fixed effects has no impact on the coefficient size or it's precision. As the outcome is measured as log prices, the coefficients in columns (1)-(4) reflect that VAT adoption by states caused a 12-14 percent *decline* in the average price of manufactured commodities. Importantly, the results provide no evidence supporting that the VAT might have *increased* manufacturing prices.

Finally, as our primary outcome of interest is measured using the stock of plant and machinery of firms/factories, column (5) tests for differential treatment effects across establishments manufacturing machinery and equipments. Using 2-digit industry classifications, we define the dummy *Machinery* to equal 1 if the factory operates in an industry involved in the manufacture of machinery (including office, computing and electrical machinery) and interact it with the *VAT* indicator. The interaction term in column (4) is positive, but small and not statistically significant, ruling out evidence of any differential impact of the treatment on the price of capital equipments.

Collectively, the results in Table A10 (Online Appendix) negate the concern that investment incentives would have a muted effect on firms' capital investment as the price effect would be outweighed by an increase in aggregate demand. The results also rule out concerns expressed in Empowered Committee of State Finance Ministers (2005) that an increase in firm mark-ups can wash out the anticipated decline in manufacturing prices effected through the ITC provision in the VAT.

A5.D. Aggregate VAT Impact

We conclude our empirical analysis with the ASI data by estimating the aggregate impact of the VAT on industry outcomes. To this effect, we use the establishment-level weights to aggregate the data to the state-industry (3-digit) level for each year. In addition to outcomes such as aggregate industry capital and average within-industry productivity, we exploit the fact that the ASI is a nationally representative sample of manufacturing establishments to gauge the impact of the VAT on industry-level measures of competition. We use a) average establishment size (number of employees), and b) the fraction of entrants in each state-industry cell as measures of industry competition. Average industry productivity is decomposed using Olley and Pakes (1996) (see Section VI.B) to identify whether the VAT affected aggregate resource allocation in the economy.

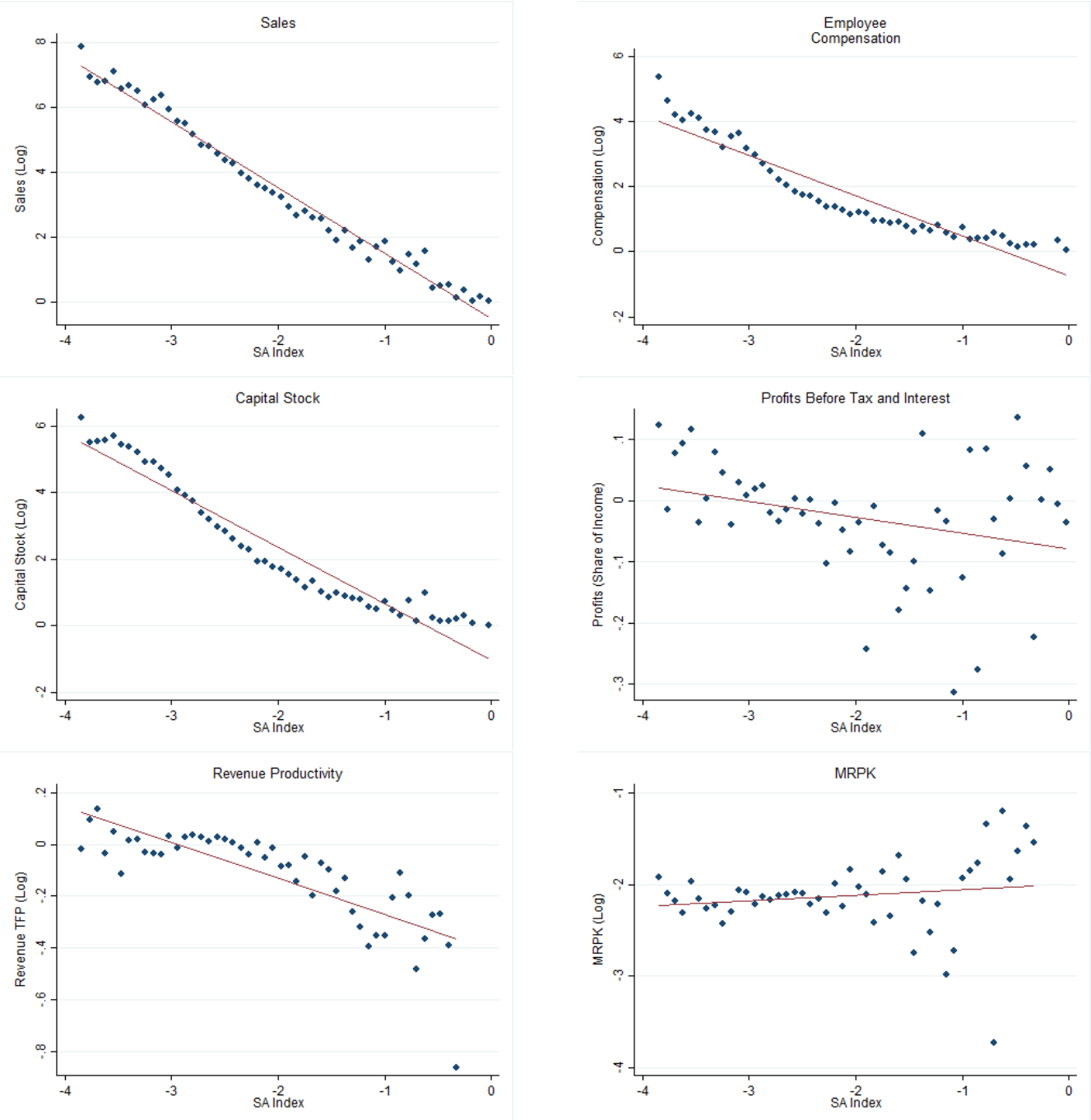
The results estimating the aggregate impact of the VAT are shown in Table A13 (Online

Appendix). All specifications include state-industry and year fixed effects, along with time-varying state-specific covariates. Standard errors are clustered by state. Column (1) documents a large and positive impact of the VAT on aggregate capital stock, although the coefficient is significant only at the 10% level. We also identify a positive effect of the VAT on average capital per worker: VAT adoption by states increased aggregate capital per worker by almost 8 percent. Columns (3)-(4) present our estimates of industry competition: consistent with the establishment-level results, the VAT does not affect average establishment size in the aggregate, but has a positive and significant impact on the fraction of entrants. This could be possible if the VAT through the ITC eased entry for new establishments through a reduction in the cost of capital.

Finally, consistent with the Prowess data, we identify no impact of the VAT on average industry productivity [column (5)] or aggregate resource allocation in the economy [column (7)]. If anything, there's weak evidence in column (6) that the VAT might have increased the dispersion in marginal revenue product of capital within industries. Thus, while the VAT had a positive robust impact on both establishment and aggregate industry capital, it did not translate into an aggregate reduction in resource misallocation in the economy.

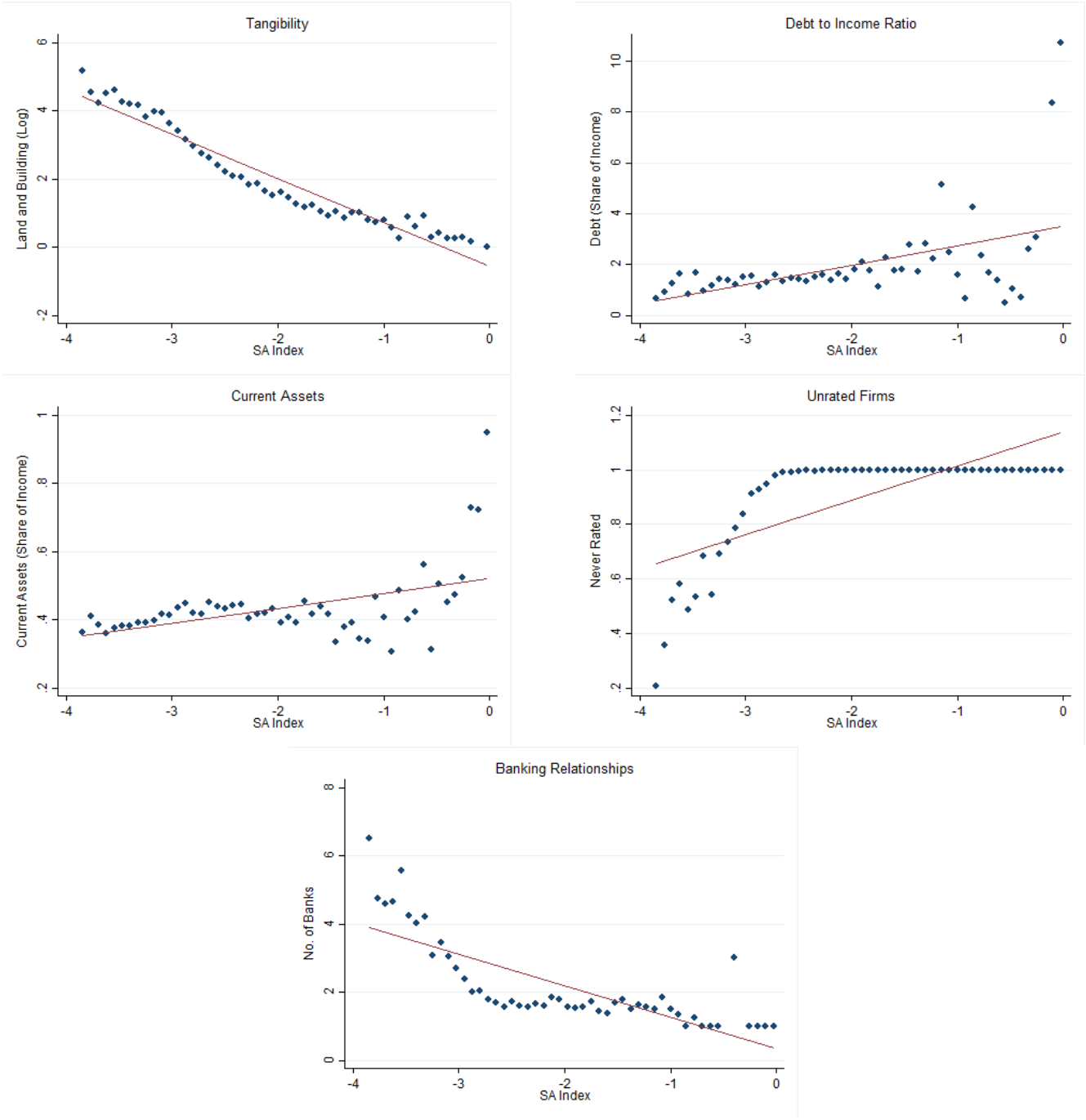
Additional Figures (Appendix)

Figure A1: Pre-VAT Correlations between Firm Financial Constraints and Firm Outcomes



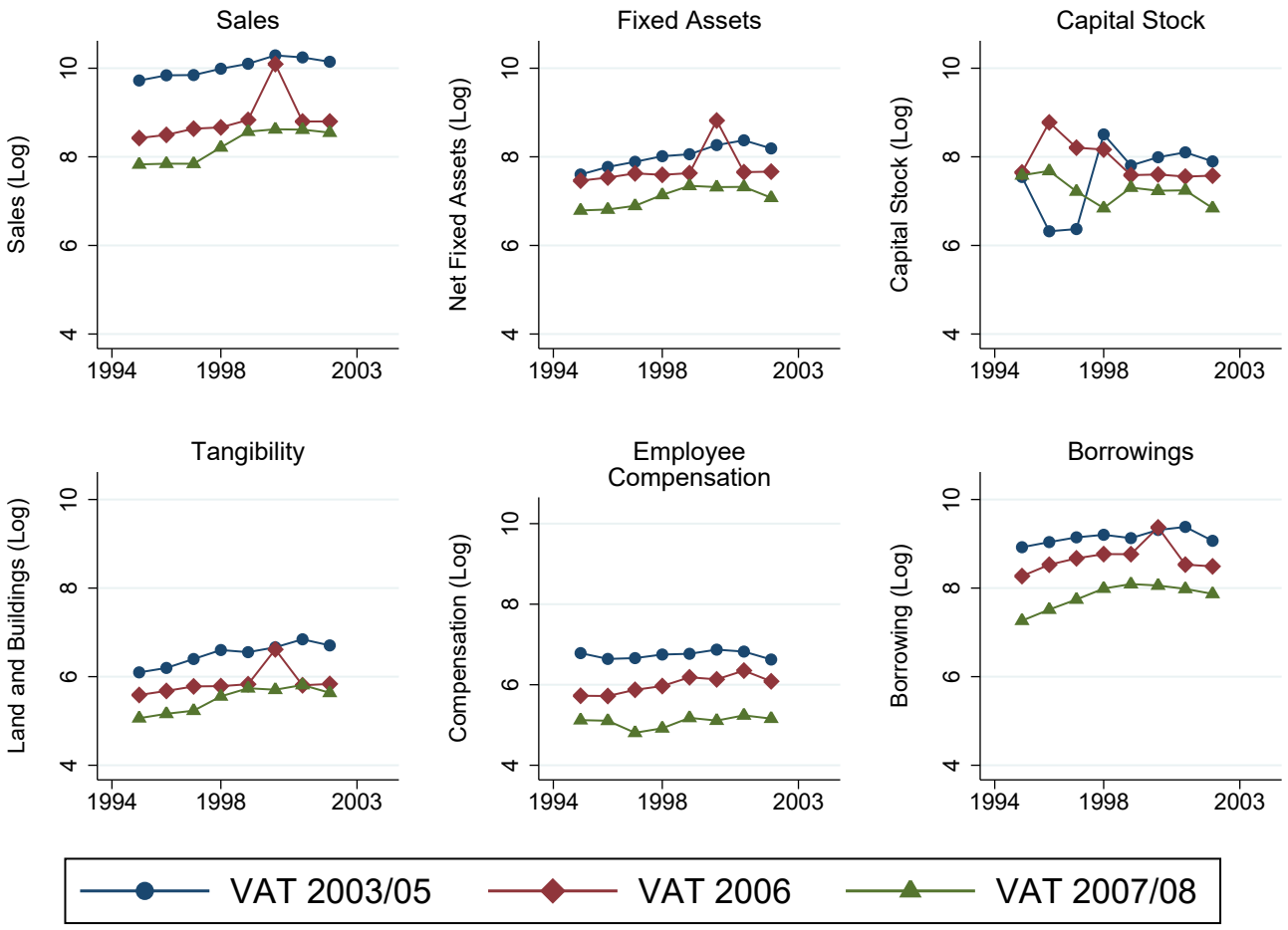
NOTES: In these figures, we compare the pre-VAT correlations in the SA index for financial constraints and firm outcomes. The x-axis is divided into 50 equally-spaced bins of the SA index developed by Hadlock and Pierce (2010). Each point represents the unconditional mean of the outcome of interest corresponding 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 state.

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



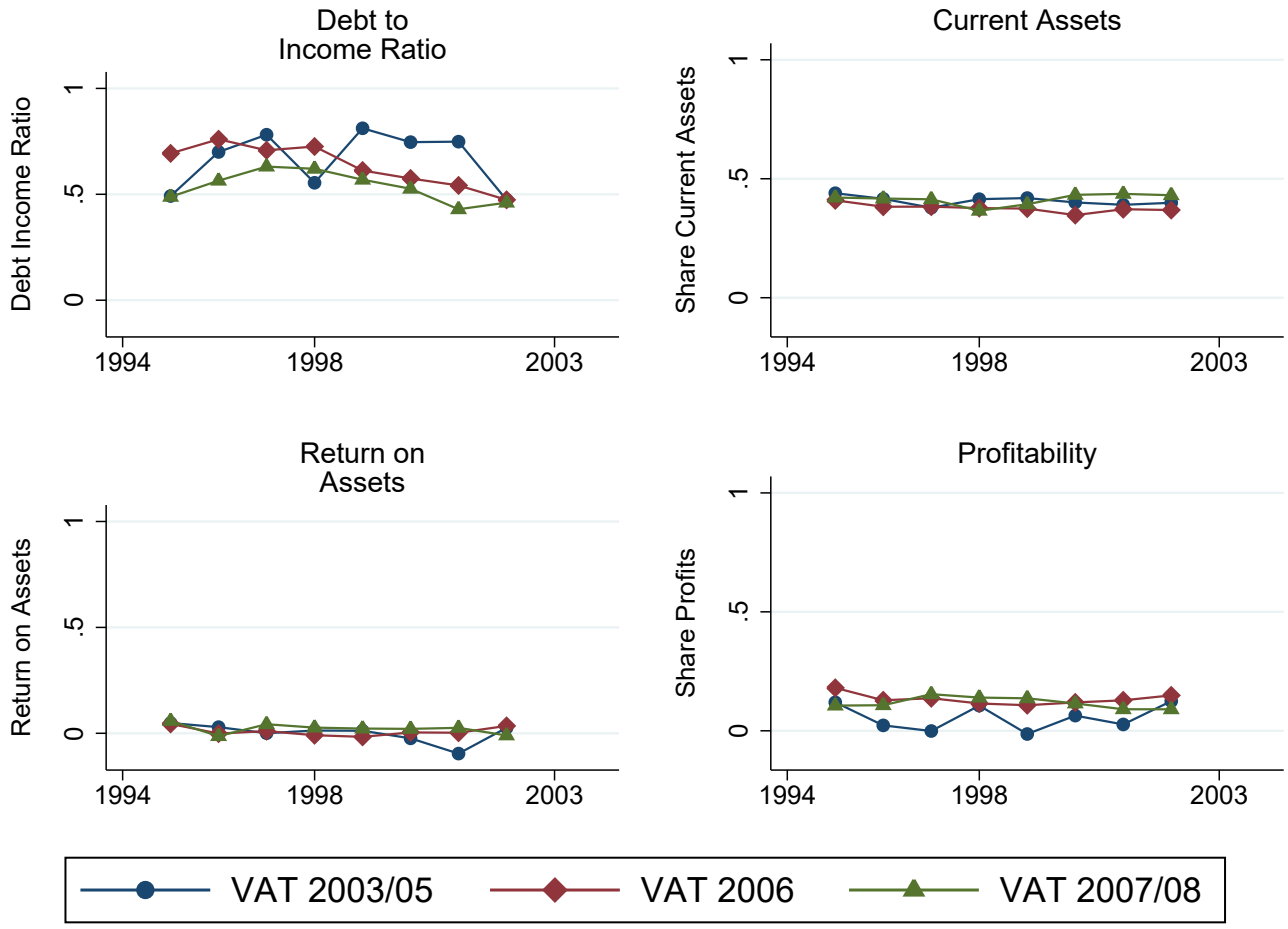
NOTES: In these figures, we compare the pre-VAT correlations in the SA index for financial constraints and firm outcomes. The x-axis is divided into 50 equally-spaced bins of the SA index developed by Hadlock and Pierce (2010). Each point represents the unconditional mean of the outcome of interest corresponding 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 state.

Figure A3: Pre-VAT Trends in Firm Characteristics



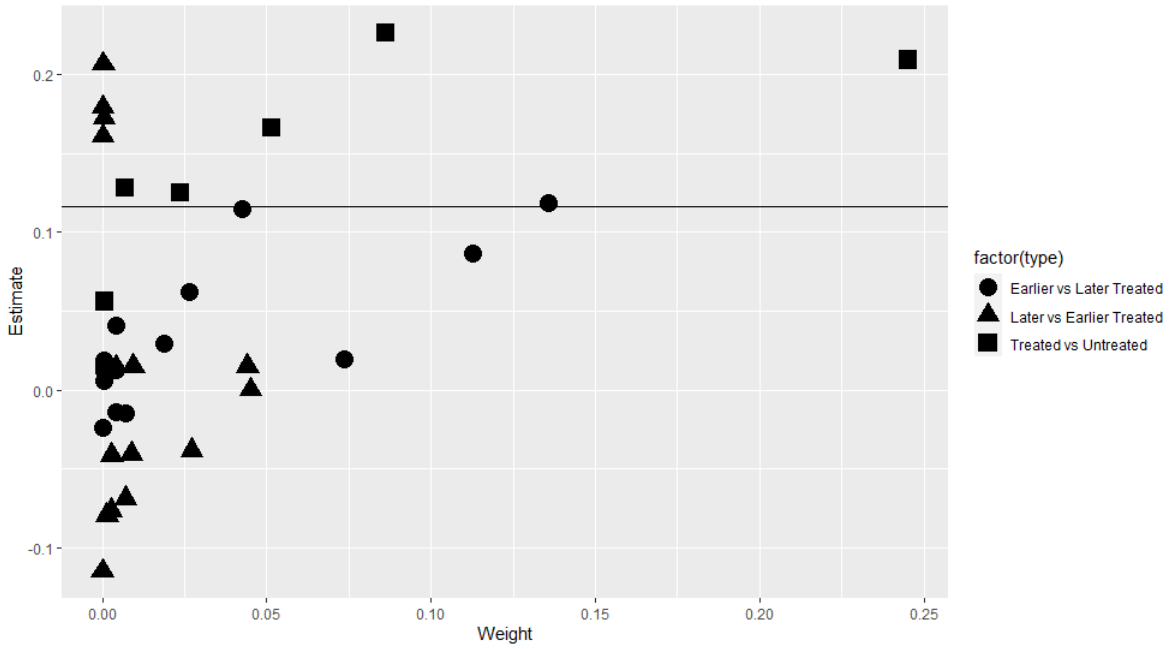
NOTES: In these figures, we compare trends in average firm outcomes in the eight-year pre-VAT period between 1995 and 2002 across groups of states, disaggregated by their year of VAT adoption. The vertical axis in each figure is measured in logs. Fixed assets are measured using net fixed assets; capital 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.)



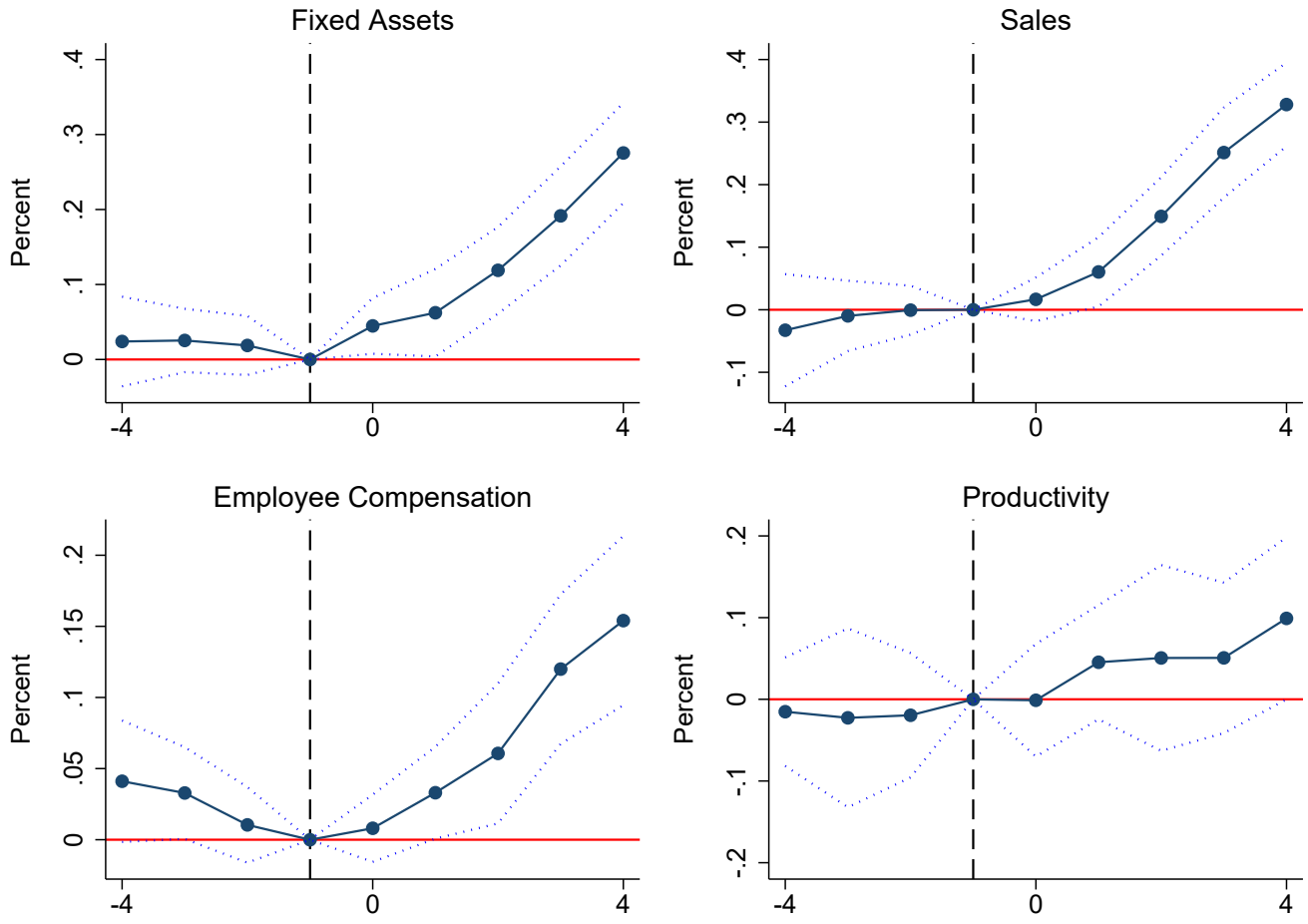
NOTES: In these figures, we compare trends in average firm ratios in the eight-year pre-VAT period between 1995 and 2002 across groups of states, disaggregated by their year of VAT adoption. The vertical axis in each figure is a fraction. Current assets are scaled by total assets; profits are computed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

Figure A5: Goodman-Bacon decomposition



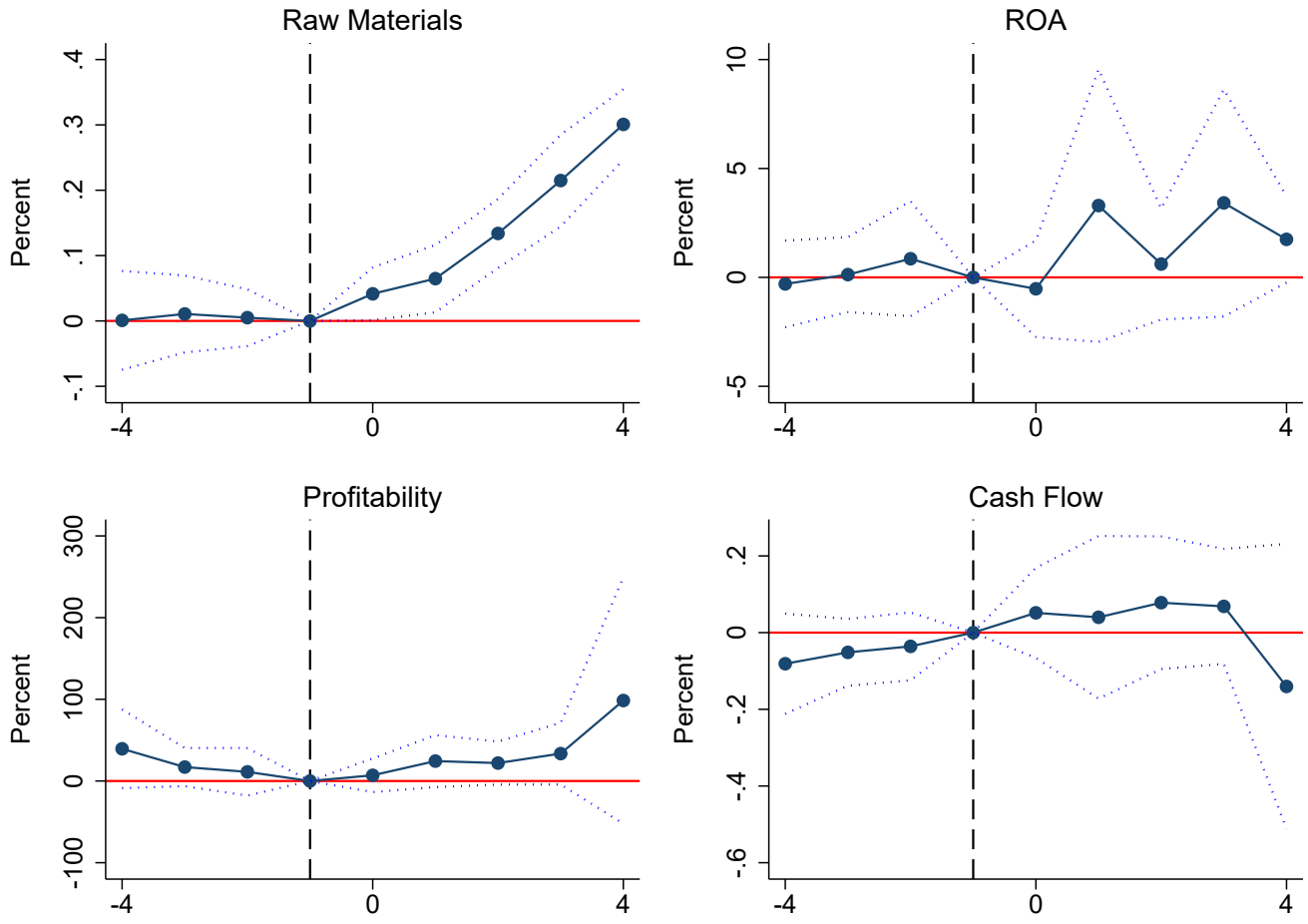
NOTES: The figure plots each 2 *times* 2 DiD components from the decomposition theorem from Goodman-Bacon (2018) against the weight for the baseline analysis in column (2) of Table A4 (Online Appendix). The dark circles are terms in an earlier treated group compared to a later treated group; the triangles compare a later treated group to an earlier treated group; and the squares compare a treated group to an untreated group. The figure shows the average DiD estimate and total weight on each type of comparison. The two-way fixed effects estimated in column (2) in Table A4 (Online Appendix), equals the average of the y-axis values weighted by their x-axis value.

Figure A6: Dynamic Treatment Effects of VAT: Heterogeneity by Financially Constrained Firms



NOTES: The above figures shows the annual differential treatment effects for financially constrained firms, for various firm outcomes of interest. The coefficients are estimated by interacting the year dummy with an indicator for the firm being financially constrained (SA index score higher than median SA index score) – see equation (16) in Section A4 (Online Appendix). The reference year is the year prior to VAT adoption by the state (t= -1). The dashed lines represents the 95 percent confidence intervals associated with the coefficient. All specifications include firm and year fixed effects and standard errors are clustered by state.

Figure A7: Dynamic Treatment Effects of VAT: Heterogeneity by Financially Constrained Firms (Contd.)



NOTES: The above figures shows the annual differential treatment effects for financially constrained firms, for various firm outcomes of interest. The coefficients are estimated by interacting the year dummy with an indicator for the firm being financially constrained (SA index score higher than median SA index score) – see equation (16) in Section A4 (Online Appendix). The reference year is the year prior to VAT adoption by the state (t= -1). The dashed lines represents the 95 percent confidence intervals associated with the coefficient. All specifications include firm and year fixed effects and standard errors are clustered by state.

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: Goodman-Bacon (2018) decomposition weighting for the 2×2 difference-in-difference groups.

	Weight	Estimate
Earlier vs. later treated	0.43	0.08
Treated vs. untreated	0.41	0.20
Later vs. earlier treated	0.15	-0.01

NOTES: The figure shows the weighting and difference-in-difference estimates. The 2 × 2 DiD components (weighting and estimate) come from the decomposition theorem of Goodman-Bacon (2018). The estimates are for the following comparisons: earlier treated group, compared to a later treated group; treated group to untreated group; and later treated group to an earlier treated group.

Table A4: Robustness of the staggered DiD estimates

Dependent Variable	Capital Stock (Logged)			
	(1)	(2)	(3)	(4)
VAT	.027**	0.116***	0.0556***	0.0533***
	(0.012)	(0.0166)	(0.00828)	(0.0111)
Observations	35502	62235	30668	32493
R^2	.93	0.941	0.0894	0.0926
Firm FE	Y	Y	N	N
Year FE	Y	Y	Y	Y
State-Cohort, Industry-year FE	N	N	Y	Y
Event Window			± 2	± 3

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

NOTES: This table shows the robustness of the baseline results using the staggered difference-in-difference (DiD) two-way fixed effect. The unit of observation is the firm. The dependent variable is logged capital stock. Column (1) repeats the baseline estimate from column (1) in Table 3. Column (2) shows the estimate from the balanced panel. The balanced panel is created by filling missing observations with the last available data for stock of capital. Columns (1) and (2) include firm and year fixed effects. Standard errors are in parentheses, clustered by state in columns (1)-(2). Columns (3) and (4) show the estimates using a staggered event study analysis where we group the states into different adoption cohorts based on the date of adoption as shown in Table 1. For each cohort we define an event window as ± 2 years in column (3) and ± 3 years in column (4) around the date of adoption. The control groups for each cohort are those that have not undergone VAT adoption in the event window. The control group also excludes cohorts that have undergone VAT adoption in any year prior to the cohort-year. All cohort groups are stacked and form the estimation sample. Columns (3)-(4) also include cohort-by-state and industry-by-year fixed effects. Standard errors are clustered using multi-way clustering at the state, year, and cohort level.

Table A5: Robustness to Alternate Measures of Financial Constraints

Dependent Variable	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, corresponding to 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 A6: VAT Adoption and Firm Capital: Treatment Heterogeneity by Firm, Industry and State Characteristics

Dependent Variable	Capital (Logged)				
	(1)	(2)	(3)	(4)	(5)
VAT	.059***	.011	.014	.010	.005
	(.014)	(.019)	(.037)	(.022)	(.020)
VAT × Labor Intensive	-.072*				
	(.036)				
VAT × Downstream Industry		.052*			
		(.030)			
VAT × High Machinery State			.021		
			(.045)		
VAT × Multiple Tax Brackets				.027	
				(.029)	
VAT × High Tax Rate					.037
					(.024)
Observations	35472	33092	35384	34406	34406
R^2	.93	.93	.94	.93	.93
Joint Sig	N	Y	Y	Y	Y

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 pre-VAT firm, industry and state characteristics. 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. *Labor Intensive* is a dummy equaling 1 if the firm's pre-VAT share of labor expenses exceeded the median pre-VAT share of labor expenses across all firms. *Downstream Industry* is a dummy equaling 1 if the industry in which the firm operates sources a relatively high share (above median) of its inputs from other manufacturing industries. *High Machinery State* is a dummy equaling 1 if the state in which the firm is located accounts for a relatively high share (above median) of production of machinery and capital equipments in the pre-VAT period. *Multiple Tax Brackets* is a dummy equaling 1 if the firm operates in a state which had a relatively high (above median) number of statutory sales tax rates in 2001. *High Tax Rate* is a dummy equaling 1 if the firm operates in a state which had a relatively high average (unweighted) sales tax rate in 2001. The row *Joint Sig* tests whether the sum of the VAT coefficient and the interaction of interest is statistically significant at the 5% margin. All specifications include firm and 3-digit industry-year fixed effects and state-specific covariates. Standard errors are in parentheses, clustered by state.

Table A7: 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 × 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 impact of VAT adoption by states on firm capital, using alternate measures of capital stock. 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.

Table A8: 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 firm 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 A9: 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 into 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 $VAT \times SA$. 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.

Table A10: 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 FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Establishment 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. 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 and year fixed effects; columns (2)-(5) includes commodity and industry-year (3-digit) fixed effects; column (3) includes establishment and state-level controls. Column (4) includes establishment age fixed effects. All the specifications exclude industries exempted from the VAT and include establishment-specific weights. Standard errors are in parentheses, clustered by state.

Table A11: VAT Adoption and Establishment Capital - ASI Data

Dependent Variable	Net Plant and Machinery (Logged)				
	(1)	(2)	(3)	(4)	(5)
VAT	.096**	.103***	.062	.001	-.023
	(.041)	(.030)	(.049)	(.052)	(.044)
Rajan Zingales × VAT			.177		
			(.117)		
Firm Size$^{Q^2}$ × VAT				.070	
				(.049)	
Firm Size$^{Q^3}$ × VAT				.142***	
				(.033)	
Firm Size$^{Q^4}$ × VAT				.124	
				(.075)	
Firm Size$^{Q^5}$ × VAT				.086	
				(.086)	
Observations	174826	174620	158284	174620	69341
R^2	.14	.25	.26	.51	.30
Dep Var Mean	6293380	6293380	6293380	6293380	6293380
Year FE	Y	Y	Y	Y	Y
Firm Controls	N	Y	Y	Y	Y
State Controls	N	Y	Y	Y	Y
Industry-Year FE	Y	Y	Y	Y	Y

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 establishment capital based on the ASI data. The unit of observation is the manufacturing establishment. The outcome of interest is logged establishment capital stock, measured using the net value of establishment plant and machinery. The independent variable of interest is a dummy equaling 1 if the state has adopted the VAT in a given year. Column (1) includes 3-digit industry-year and state fixed effects and no other covariates; columns (2)-(5) includes establishment and state-specific covariates. $Est.SizeQ^2$ is a dummy equaling 1 if the establishment hires between 10 and 16 employees; $Est.SizeQ^3$ is a dummy equaling 1 if the establishment hires between 16 and 27 employees; $Est.SizeQ^4$ is a dummy equaling 1 if the establishment hires between 27 and 60 employees; $Est.SizeQ^5$ is a dummy equaling 1 if the establishment hires in excess of 60 employees. The size cutoffs are based on the employee size distribution of establishments between 2000 and 2002. Column (5) restricts the sample to establishments operating in industries exempted from the VAT. All specifications include establishment-specific weights. Standard errors are in parentheses, clustered by state.

Table A12: Impact of VAT on Manufacturing Outcomes: ASI Data

Dependent Variable	Fixed Assets		Sales		Workers		Raw Materials		TFP		MRPK	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VAT	.093***	.033	.067**	.033	.014	-.047*	.084*	.033	.008	.031*	-.029	-.002
	(.024)	(.032)	(.030)	(.041)	(.016)	(.027)	(.043)	(.039)	(.017)	(.016)	(.024)	(.022)
VAT × Ext. Dep. Fin.		.197**		.117		.187***		.112		-.059*		-.084
		(.079)		(.073)		(.052)		(.089)		(.032)		(.053)
Observations	176207	159534	176211	159538	176211	159538	170395	154789	170391	154785	174259	158359
R^2	.27	.28	.32	.33	.16	.17	.20	.21	.02	.02	.19	.18
Dep Var Mean	11.01	11.01	37.23	37.23	62.91	62.91	3.47	3.47	-.02	-.02	-.00	-.00

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

NOTES: This table identifies the impact of the VAT on various manufacturing outcomes. The unit of observation is the manufacturing establishment. All outcomes are logged. Fixed assets in columns (1) and (2) refer to net fixed assets. Workers in columns (5) and (6) include contract workers and supervisory staff. TFP is measured as revenue TFP. MRPK refers to the marginal revenue product of capital. The even-numbered columns identify VAT heterogeneity across industries' dependence on external finance (Rajan & Zingales, 1998). All specifications include 3-digit industry-year and state fixed effects, along with establishment and state-specific covariates. All specifications are weighted using establishment-level weights. Standard errors are in parentheses, clustered by state.

Table A13: Aggregate Industry-Level Impact of VAT: ASI Data

Dependent Variable	Capital Stock	Capital Per Worker	New Entrants	Establishment Size	TFP	MRPK	Covariance in TFP and Output Share	Weighted Productivity
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VAT	.122*	.086**	.009**	.004	.021	.045*	.003	.035
	(.069)	(.039)	(.004)	(.020)	(.024)	(.023)	(.005)	(.025)
Observations	9377	9377	9390	9390	9329	8397	9327	9327
R^2	.87	.76	.35	.84	.51	.39	.33	.55

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

NOTES: This table identifies the aggregate impact of the VAT on industry-level outcomes for manufacturing industries. The unit of observation is state-industry (3-digit). Capital stock is the sum of capital stock across all firms in each state-industry cell; capital stock is measured using net plant and machinery. New Entrants is the fraction of new establishments in each state-industry cell in an year. Establishment Size is the average number of employees in an establishment. TFP (MRPK) is the unweighted TFP (MRPK). The final two columns decompose aggregate industry productivity using Olley and Pakes (1996). All specifications include state-industry and year fixed effects, along with state-specific covariates. Standard errors are in parentheses, clustered by state.