Essays on Sub-National Value Added Tax of India and Tax Incidence

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ABSTRACT
ESSAYS ON SUB-NATIONAL VALUE ADDED TAX OF INDIA AND TAX INCIDENCE

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The three essays of this dissertation inform tax policy design. It is a compilation of empirical and experimental research work. The first and the second essays explore the performance of a recent tax policy reform at the sub-national level in India in terms of revenue efficiency as well as economic efficiency. India is among the only three countries in the world to have adopted a sub-national VAT. Therefore, empirically examining its performance not only improves the understanding of this important tax policy reform but also informs tax policy decision-making at the sub-national level in other developing countries.

India transitioned to the state-level VAT between the years 2003 and 2008. Among other things, it was expected to achieve revenue growth and decrease tax cascading on commodities by improving economic efficiency of the indirect tax system. In the first essay, I model the impact of the VAT on revenue by adding revenue dependent administrative and compliance costs associated with taxation to an existing model developed by Keen and Lockwood (2010). The theoretical results show that replacing one type of indirect tax with another improves long-run revenue efficiency only if there is a net decrease in the administrative, compliance and
distortionary costs of taxation at the margin. I then compile a unique state-level dataset for the years 1990 to 2010 to determine changes in the long-run revenue efficiency from the use of the VAT. This essay contributes to the literature by extending an existing revenue efficiency model and testing it in the unique situation of India’s sub-national VAT. The results reveal a significant improvement in the long-run revenue efficiency of the sales tax instrument used by state governments. The model implies this improvement is driven by a net fall in the marginal taxation costs from the use of the state-level VAT. This finding has important implications on the role of a sub-national VAT in the future as an effective tax instrument in the developing countries.

The second essay appeals to the general theory of tax incidence which suggests that a VAT will have less impact on prices than a traditional turnover tax because the VAT does not “get stuck” in the production process as a turnover tax does. The impact should be larger for goods that have more components to the production process as the tax then “touches” more of the final product. In this essay I measure the change in the level of tax cascading with VAT by using multiple waves of the state- and household-level expenditure surveys. Specifically I test the impact of the VAT on the real consumption of households on a variety of consumption goods. I find the biggest significant decrease in the tax cascading burden of the long-term durable goods which essentially involve the maximum production components. This result is found in the 18 more developed states of India which are the focus of the empirical analysis due to data constraints.

The third essay is an experimental research which looks at the influence of institutions on the economic burden of an excise tax. The traditional long-run tax incidence theory establishes that the economic incidence of an excise tax is independent of the assignment of the liability to pay tax. However, the theory is silent on the possible effects of the market institutions on tax
incidence. Since all markets need an institution to function and every market institution has its own unique price and quantity determination property, it is important to understand its bearings on the incidence of taxes. Existing experimental research has tested economic incidence under many different market institutions but no previous research systematically analyzes and compares the incidence of a unit tax under two important market institutions we deal with in everyday life. One of these institutions is posted offer which dominates the consumer goods markets in developed countries and the other is double auction which is frequently observed in developing countries. I report a significant impact of these market institutions on tax incidence. In particular, I find that consumers bear a much higher burden of a unit tax in the posted offer markets as compared to the double auction markets and their burden further increases when the liability to pay the tax is on the seller.
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By

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ACCEPTANCE

This dissertation was prepared under the direction of the candidate's Dissertation Committee. It has been approved and accepted by all members of that committee, and it has been accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Economics in the Andrew Young School of Policy Studies of Georgia State University.

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DEDICATION

Most of all, this dissertation is dedicated to my parents and my husband Nikhil Mathur. My parents always believed in me and taught me to be sincere and honest towards whatever I chose to pursue. They endlessly motivated me to work hard. My father has been my idol and I have always tried to be as hard-working and sincere towards my work as he has been all his life. My words cannot begin to thank my parents for their endless love and support. My husband has been there for me and I am extremely grateful to him for his unfathomable support and encouragement throughout my PhD years. I also extend my heartfelt thanks to my younger brother, the rest of my family and my friends for their unyielding and unbroken support, love and encouragement.
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CHAPTER ONE – THE REVENUE EFFICIENCY OF INDIA’S SUB-NATIONAL VAT.

1 ABSTRACT

Despite the demonstrated success and widespread adoption of a national level value-added tax (VAT), there is a great deal of skepticism among tax policy experts regarding the administrative feasibility and potential efficiency of this same tax as a revenue source for sub-national governments. Canada is one of only three countries in the world with a sub-national VAT and its success is generally attributed to the high quality of its tax administration. Since few countries have tax administrations of comparable quality, it is widely believed that Canada’s success cannot be replicated in other countries, particularly in low- and middle-income countries which generally have weak tax administrations. Between 2003 and 2008 the states of India transitioned from distortionary sales taxes as their main source of revenue to a more uniform sub-national VAT. This transition provides an ideal natural experiment to gauge the efficiency gains from substituting a consumption type, sub-national VAT for a sales tax. Our theoretical model shows that substituting one type of indirect tax for another improves long-run revenue efficiency when there is a net marginal decrease in the administrative, compliance and distortionary costs of taxation. We test this prediction of the model using a unique data set on state finances for all 29 states of India over the past 21 years. We report a 6.5 to 8 percent increase in the long-run revenue efficiency in the 18 most developed states of India from the transition to the VAT. This is an important finding because it suggests that a sub-national,
consumption type VAT may be a feasible and efficient tax for sub-national governments even in low- and middle-income countries.

2 INTRODUCTION

The rise of the value-added tax (VAT) has undoubtedly been one of the most significant tax developments since its inception in 1954 in France. The VAT has become a prime instrument in tax policy among a majority of the developed and developing countries. The main reason for the popularity of the VAT is its efficiency over other types of indirect taxes. Not only does it eliminate production inefficiencies associated with the turnover tax, it also is generally thought to be superior to retail sales taxes as they are more vulnerable to evasion and avoidance. This is because with retail sales tax, the revenue is lost completely if the tax is evaded at the final point of sale. On the other hand, the VAT is collected at all the stages of production. Therefore, if the sale of goods escapes tax at one point, the hope is to catch it at another point in the chain of production under the VAT regime. In addition, the VAT is compliance incentivizing because under the VAT regime, wholesalers and retailers have to ensure that the traders they deal with pay the tax in order to be eligible for input tax credit. This self-policing of the VAT has a higher probability of exposing forged accounts and an informal economy than the retail sales tax (Bird 2005 and Agha et al 1996). Primarily for the same reason, a VAT is generally regarded as a more promising consumption tax for developing countries where the size of the informal sector is bigger. However, opponents of the VAT do not quite agree. Some studies argue that the opposite is true. For example, Emran and Stiglitz (2005) show that in the presence of a substantial ‘informal’ sector, the VAT that falls on the formal sector acts to deter the growth and development of the economy as a whole. Also, the retail sales tax may be cheaper to administer
since there are fewer taxpayers and thus it is less complicated. Despite these contradictory views, the VAT has replaced the retail sales tax regime in many developing countries and it continues to do so.

From the arguments advanced above, questions which naturally come to mind are: do countries with the VAT have a more efficient system than the ones without it? Has the VAT improved revenue mobilization in these countries? There is no simple way to answer these sorts of questions. The answers clearly depend on many factors including the federal structure of the country we are looking at, the type of a VAT (national, sub-national or/and origin–based or destination based, income-type or consumption-type), base of the VAT, its threshold limit, and its many other design features. Additionally, no one type of a VAT is supreme to the other. Different VATs may be best for different nations at different points of time as Bird (2005) points out that ‘no one size fits all’. Therefore the questions raised above demand empirical investigation.

Nellor (1987) performed one of the earliest analyses of the impact of a VAT on revenue growth on a sample of 11 European countries and his results establish that the VAT improves revenue performance. Bogetic and Hassan (1993) examine the main determinants of the VAT revenue using a cross country framework of 34 countries. Their main findings show that, other things being constant, the VAT generates higher revenue in countries with a single VAT rate than in countries with multiple VAT rates. Keen and Lockwood (2010) answer the same question using a panel of 143 countries over 26 years. They establish that in general the VAT has a significant but modest effect on the revenue performance. Martinez and Bird (2011) build on the empirical question of Keen and Lockwood (2010) using different econometric techniques and focusing more on the comparisons of the impact on developing versus developed countries. Their
research shows that the positive effect of the VAT is significant only in the developing countries.

At the same time, other related studies provide evidence of poor revenue performance of a VAT in the low-income countries. Bird and Gendron (2006) assert that the unsatisfactory performance of the VAT in the developing countries is grounded in its inefficient administration and poor tax design. Tanzi (2000) points out the formidable challenges faced by the developing countries in the establishment of efficient tax systems. These include large informal sector activities, a large share of agriculture in total output and employment, many small establishments, and limited capacity of the tax administration. Also, opponents of a VAT argue that a broken VAT chain gives rise to production inefficiencies and this could more than offset the benefits from the VAT leading to an overall reduction in the efficiency. All this cited research brings out one critical fact, that is, in reality the presence of the VAT may or may not improve overall government revenue efficiency.

All of the above cited literature evaluates the performance of a national level VAT. The reality becomes even more complicated in the case of a sub-national VAT. Effective implementation of a sub-national VAT gets more challenging because of the cross border trade and the non-uniformity of the VAT rates across the states or regions within a country. All these facts make it imperative to empirically evaluate performances of the existing VAT reforms to better understand their accomplishments and to continually improve their designs. This paper explores the performance of a recently implemented consumption type, sub-national VAT in

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1 Baunsgaard and Keen (2005) raise concerns of revenue gains from a VAT in low-income countries. Emran and Stiglitz (2005) show that the VAT reduces welfare in the developing countries.

2 The application of a VAT on the interstate trade is often pointed out, by tax policy experts, as the most serious practical issue with the use of a sub-national VAT (Bird and Gendron (1998)). There is no general consensus on the best way to apply a destination-based VAT to the interstate trade. (McLure (2005) explains why a sales tax with a destination principle is more desirable). Bird (1993) points out other problems related to a sub-national VAT. These include coordination of federal and regional taxes, loss of macroeconomic control and high administrative and compliance costs.

3 The logical reasoning behind the existence of the non-uniform rates is to preserve the regional government’s autonomy.
India. We believe it is a valuable contribution because performance of a sub-national, consumption type VAT is far from well-understood in low and middle-income countries.

The type of a sub-national VAT which was put in place in India neither resembles the theoretically optimal form of a sub-national VAT suggested by Charles McLure (2000)\(^4\) or Keen and Smith (1999)\(^5\) nor replicates a successful ‘Dual-VAT’ system thriving in Canada. The VAT in the states of India replaced an administratively complex and economically distortionary turnover type of sales tax. However, the homegrown design of a state level VAT which came into existence casts concerns regarding its performance so far. Therefore it is worthwhile to empirically evaluate the performance of this major tax reform of India. As far as we know, no existing research work systematically examines the performance of the state level VATs introduced in India.

The purpose of this paper is to analyze changes in revenue efficiency from substitution of a consumption type VAT for a highly distortionary sales tax at the sub-national level in India. By *increase in revenue efficiency we mean an increase in the level of optimal revenue raised by a benevolent government*. We first build on the theoretical model developed by Keen and Lockwood (2010) by incorporating revenue dependent administrative and compliance costs of taxation in the model, to gauge the change in revenue efficiency from a tax innovation like a VAT. Our theoretical model differentiates between long-run revenue dependent administrative costs and short-run exogenous administrative costs. We then proceed to empirically investigate a change in the revenue efficiency using data on all the 29 states of India (including the national

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\(^4\) Subnational VATs are considered infeasible or undesirable for varied reasons (Bird (1993)). The sub-national VAT recommended by McLure (2000) is called Compensating VAT (CVAT). This VAT proposes a feasible solution for implementing a destination-based VAT on inter-state trade.

\(^5\) Keen and Smith (1999) propose a viable integrated VAT (VIVAT). This type of VAT implements differential tax rates on the interstate sales made to registered merchants and sales made to non-registered buyers (which implies final consumption).
capital territory of Delhi) for the years 1990 to 2010. In the empirical analyses we use revenue per capita to measure the revenue efficiency.

The paper proceeds as follows. Section 3 broadly reviews the fiscal background of the states of India before the VAT in 1990s and briefly outlines the salient features of the existing state-level VAT. Section 4 explains the theoretical model and Section 5 presents the results and Section 6 concludes.

3 BACKGROUND

3.1 FISCAL CRISIS IN THE STATES BEFORE THE VAT

The second half of the 1990s is characterized by a period of fiscal crisis for all the states of India. At this time the states were grappling with serious erosion of the state finances lead by the unsustainable debt trends and a remarkable pressure on the availability of resources for the infrastructure and the basic social services (World Bank, Policy Notes (2008)). The reasons for high fiscal and revenue deficits in the states in the second half of the 1990s include inadequate increases in the tax receipts, negative or negligible returns from the public investments due to public sector units (PSU) losses, large subsidy payments, increases in expenditures on salaries due to pay revisions, and higher pension payments (Reserve Bank of India (RBI), State Finances (2002-03)). State Finances (2002-03) pointed out that the tax to GSDP (Gross State Domestic Product) ratio of the states did not change much throughout the 1990s.

The trend in the state’s own tax revenue (OTR) as a percent of its GSDP during the year 1990s is shown in figure 2. Figure 2 shows this trend separately for the special and the non-special category of states. The states in India are classified as special and non-special category states by the Government of India (Saxena 1999). In 2001, 11 out of the 29 states were classified
as the special category states (or less developed states), which share the common characteristics of poor infrastructure, hilly and difficult terrain, and large tribal populations. They have limited revenue generating capacity of their own. According to the Gadgil formula (which determines the allocation of central assistance for development to the states of India), special category states are given preference in terms of the development based financial assistance from the federal government over the non-special states.

Figure 2 shows that in the late 1990s, the state’s own tax revenue remained between 6 to 7% for the non-special category states and between 2 to 3% for the special category states. While the own revenue of the states was decreasing or flat, they were consistently required to undertake increasing developmental responsibilities. Consequently the states had to turn to an increased level of borrowing to meet their expenses. This led to an increase in their revenue deficits as an absolute figure and also as a proportion of the gross fiscal deficit.

A trend in the revenue deficit (RD), which is the deficit on the current or the revenue account as a percentage of Gross state domestic product (GSDP) for the years 1991 to 2010 is shown in Figure 3. Figure 3 shows the five year time trends in RD of the states of India between years 1991 to 2010. The figure also shows these trends separately for the special and the non-special states. As clear from the figure, the severity of this crisis was more intense in the non-special states, or the more developed states, of India as compared to the special category states. Driven by this uniformly spread financial structural weakness across the states, the majority of the state governments actively initiated various fiscal and institutional reforms. As a result of the

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6 Saxena (1999) and Das-Gupta (2012)
7 30 percent of these funds to the states go to the special category states. In addition, 90 percent of the center’s development plan assistance received by these states is in the form of grants and just 10 per cent is in the form of loans as opposed to 30 percent grant and 70 percent loan to the non-special category states.
8 A negative value of revenue deficit implies a surplus on the revenue account.
9 There are 11 special category states in India. These states are considered to have geographical hindrances in infrastructural development. The centre sanctions 90% in grants in plan assistance to these states as they are less developed.
improved economic growth in India since 2003-04 and the fiscal correction efforts initiated by both the center and the states (World Bank, Policy Notes (2008)), the states achieved fiscal improvement during 2000-06. The overall fiscal correction for the states of India can also be seen in Figure 3 where the revenue deficit for the non-special states or the more developed states turned into surplus over the time period of 2006 to 2010.

The Twelfth Finance Commission\(^\text{10}\) recommended that the states implement a “golden rule” by 2008/09. This golden rule specifies that the state government’s current account must not be in deficit. The golden rule was one of the main objectives of the state governments in the Fiscal Responsibility Acts of 2003 (State Finances (2002-03)). Since the year 2000, these acts were put in place in majority of the states as one of the main fiscal reform policies. Figure 3 shows the average value of the revenue deficit for all the state governments in the second-half of 2000s. It can be seen in the figure that the states achieved this objective over a five year period from 2006 to 2010. Implementation of the VAT was one of the most important tax reforms undertaken by the states on the revenue side in the second-half of 2000s. Among other things, the near stagnation in the tax to GSDP ratio of the states at around 8% throughout the 1990s triggered the initiation of a VAT implementation. The states realized that they needed a strategy to augment their revenue receipts. In this paper we evaluate the performance of this pivotal tax reform.

3.2 FEATURES OF THE INDIRECT TAX SYSTEM AT THE SUB-NATIONAL LEVEL

\(^{10}\)The Twelfth Finance Commission was appointed by the President of India on 1st November 2002, (Report of the Twelfth Finance Commission (2004)). Among other things, the Commission makes recommendations on the distribution between the union and the states of the tax revenues which are shared between them under Chapter I Part XII of the Constitution and the allocation of such proceeds between the states.
The indirect taxes have always been more important than the direct sources of taxes in developing countries at the sub-national level and India is no exception to this. Table 1 shown supports this contention. The first column of Table 1 reports the state’s indirect tax revenue from its own sources (which we refer to in the paper as indirect tax revenue or ITR) as a percentage of the total revenue from its own sources (which we refer to in the paper as Own Tax Revenue or OTR). Essentially, the numbers in the first column of the table reports the states’ average ITR as a percentage of OTR. These numbers show that the percentage share of revenue from the state’s own indirect sources has remained at 87% for periods prior to the VAT and it has gone up slightly in the time period of 2005 to 2010, when the majority of the states of India embraced the VAT. The second column of Table 1 emphasizes the importance of the sales tax component of the indirect taxes. The second column shows the average revenue for the states from the sales tax (and then after the substitution of the VAT for the sales tax, it shows the average revenue from the VAT) as a percentage of the state’s ITR. This percentage has also gone up to 64.4% in the period after the VAT adoption.

At the state level, the existing sales tax component of the indirect tax system was replaced by the VAT between the years 2003 to 2008. Before this transition to the VAT, the state governments used to levy a turnover type sales tax on goods. Since it was a turnover type tax, states ended up taxing the input goods. This double taxation created incentives for vertical integration of the firms in the production chain. On the top of this inefficient form of sales tax, most states used to levy an additional tax called surcharge tax on final consumption goods. Furthermore, there existed other inefficient forms of indirect taxes which were charged on the interstate sale of goods such as an entry tax and a central sales tax (CST). Such complex taxation

11 The states of India can levy tax only on goods and not on services. The services have always been taxed by the federal government in India.
system is expected to impose significant compliance, administrative and distortionary costs. To remove these inefficiencies a VAT at the state level was proposed and instituted in all the states by the end of the year 2008. The federal government of India proposed its implementation to abolish the burden of the turnover type sales taxes and the additional surcharge taxes which were levied on top of the sales taxes (White Paper 2005). The Government of India (GOI), in general, expected the VAT to rationalize the overall tax burden, eliminate inefficiencies, decrease tax evasion and eventually lead to the state’s tax revenue growth. Although the VAT successfully replaced the turnover type sales tax of the states, other unnecessary indirect taxes such as the CST continue to exist. The surcharge taxes were removed by the states at the time of the transition to the VAT. Some states also held onto the entry taxes but others removed them with the introduction of VAT.

The initial official commitment towards a sub-national VAT was made by the Finance Minister of India in his 1993/94 Budget Speech in which he alluded to India’s long-term aim to move to a VAT system. He also stated that a broad agreement would have to be reached between the central and the various state governments regarding the design of such a system\textsuperscript{12}. In May 1994, a committee of the state finance ministers was formed. During its meetings in 1995, the Committee reached an agreement on the principle of introducing a state VAT but its implementation was postponed. The next initiative took place on 16 November 1999, when the Ministry of Finance, set up a committee called Empowered Committee of State Finance Ministers. This Committee, after several rounds of consultations and the consent of all the states for the VAT’s implementation, made final decisions on the design of the VAT system by 2005.

\textsuperscript{12} S. Mukhopadhyay (2005)
On 17 January 2005, the Committee released a White Paper\textsuperscript{13} which revealed the salient features of the sub-national VAT. The White Paper mentions that the VAT is a state subject. It laid down the foundation of a common model based on which each state was expected to develop its own VAT legislation. This way the states got to choose the specific features in the design under the basic rules set by the central government, for example the threshold limit and the specific list of the exempted goods. Three main rates of the VAT were outlined by the central government. The first is the 12.5\% standard rate. The second is the 4\% reduced rate which is applicable to most of the items of basic necessities.\textsuperscript{14} The third and the last rate is the 1\% rate which is applicable on gold, silver and precious and semi-precious stones. All the states of India uniformly adopted all the three VAT rates outlined by the central government at the time of their transition to the VAT. However, since the year 2010, some of the states have increased the standard rate from 12.5\% to 14\% or 14.5\% and very few have increased the 4\% rate on the basic necessities to 5\%. These rates exist in addition to a specific category of exempted goods\textsuperscript{15}. India’s state-level VAT allows input tax deductions on the basis of invoices with respect to the purchases made within the state for the purposes of both sales within the state and to the other states. In the case of capital goods, the input tax is deductible over a period of one year from the date of purchase. Also the state VAT does not allow input tax deductions on petroleum or natural gas as these are not treated as inputs by the state governments.

The state of Haryana introduced a VAT on its own initiative in 2003 and became the first state to adopt it. According to the White Paper, all the other states agreed to embrace the VAT on

\textsuperscript{13} White paper on state level value added tax (Jan 2005)

\textsuperscript{14} These include goods such as medicines, agricultural and industrial inputs, capital goods etc. This category includes 270 goods approximately on average.

\textsuperscript{15} The states have the discretion to decide which goods to exempt from VAT. Although the White paper stated that the exempted goods would include 46 commodities including natural and unprocessed goods in the unorganized sector. The states were allowed to choose 10 items of these goods. However, the states do not strictly follow the number of exemption goods restriction specified by the central government.
April 1, 2005 but later seven states backed out. Six out of these seven states were ruled by the BJP political party (opposition party at the centre). Five of these six states adopted the VAT in the following year. By the year 2008 all the 29 states (including the national capital territory) had replaced their turnover type sales taxes on goods with the VAT. The political factors brought in the timing variation in the adoption of the VAT by the states. Figure 4 shows the adoption of the VAT by the states$^{16}$ of India by year on a geographical map.

The next section develops a theoretical model to gauge a change in the optimal level of revenue from the change in the use of an indirect tax instrument from one type to another.

4 THEORETICAL FRAMEWORK

Consider an economy with a representative consumer with preferences $U(C, G)$ defined over private consumption $C$ and public expenditure $G$. Assume that $U$ is strictly increasing in both of its arguments and is quasi-concave. Let $C$ represent consumption of a normal good. Public expenditure is financed by a type of tax instrument that generates revenue $R$. Let this type of tax instrument be a distortionary tax. Given $R$ represents the level of revenue from this type of tax, consumer’s welfare is $U(Y-R, R)$ where $Y$ denotes this consumer’s gross income. This gross income $Y$ is also consumer’s pre-tax income. Note that the revenue level $R = G$ where $G$ is the level of expenditure on the public good and $C = Y - R$. Consequently in this model the government operates a balanced budget and we assume no presence of externalities. When the government tax revenue is equal to the government expenditure ($R = G$) then revenue collection

$^{16}$ In 2000 three new states were carved out in India from three existing ones. Chhattisgarh was formed out of Madhya Pradesh, Jharkhand from Bihar and Uttarakhand from Uttar Pradesh. This increased the total number of states in India from 26 to 29 in the year 2000, including the national capital state of Delhi. Delhi became a state in 1992 under the NCT act. Under this act central government approved the autonomy of the government of Delhi under certain restrictions.
efficiency is one hundred percent. This happens when the revenue collection costs incurred by the government are zero and there is no leakage in the form of tax evasion or tax avoidance or in the form of corruption. The basic model explained below is the model developed by Keen and Lockwood (2010). In sections 3.1 and 3.2 we modify their model by including endogenous compliance and administrative costs associated with the process of taxation. These two types of costs imposed by taxation play a compelling role in determining the effectiveness of a tax policy. Theoretical implications of the model become more realistic with incorporation of these two important forms of costs. We conclude this section by comparing the modified optimization rule derived here with the one derived by Keen and Lockwood (2010) and discussing the implications of the extended model.

4.1 BASIC MODEL

Y (gross income) is a function of R and V. R is the level of tax revenue collected by the government from the use of a given type of tax instrument and V is the type of tax instrument used. A change in V implies a change in the tax instrument from one type to another. In our empirical case a change in V can be thought of as a tax innovation brought about by the replacement of a turnover type sales tax by the consumption-type VAT. In this model Y is assumed to be a function of R in order to make the loss coming from the excess burden of a tax explicit. The excess burden or deadweight loss is taken away from the consumer but is not recovered from the government’s tax revenue. It is a pure distortionary cost\(^\text{17}\) which arises from the act of levying an indirect tax or a consumption tax. The excess burden is created from the generation of the tax revenue R and it leads to a loss in consumer’s utility from the reduction of gross income available to the consumer for the purchase of the private and the public good. Also,

\(^{17}\) This distortionary cost is separate from administrative costs incurred by the government in the process of levying a tax.
this utility loss created from excess burden is a function of the level of tax revenue raised i.e. R. It is a function of R because the excess burden increases with the increase in tax revenue (as $\text{deadweight loss} \approx \frac{1}{2} \times \text{tax rate} \times \Delta \text{quantity}$). Therefore $Y$ is a nonlinear function of R.

The decrease in gross income ($Y$) with one unit increase in R is defined here as marginal deadweight loss (MDL). Since it is a loss, it is negative and denoted by $Y_R < 0$ (throughout this paper subscripts denote derivatives). Also, since MDL increases with the amount of tax revenue which is explained above, we have, $Y_{RR} < 0$. Note in the special case of lumpsum taxes or head taxes (when there is no excess burden incurred) there will be no loss of utility because of the presence of taxation and so $Y_R$ will be zero. Therefore under this case $Y$ is independent of R. However, here we only consider distortionary taxes. The excess burden or the utility loss is also a function of the type of the tax instrument used i.e. V as MDL will change with the change in the tax instrument. This explains the dependence of $Y$ on V. Note that a change in the tax instrument (or tax innovation like adoption of a VAT in our empirical analyses) will raise the revenue productivity of the tax system if and only if it decreases MDL, so that $Y_{RV} > 0$. A decrease in MDL will increase the consumer’s gross income which could be used to consume more of the private good or the public good or both. This will increase the consumer’s total utility.

To summarize, the gross income function $Y$ is a nonlinear function of R and is inversely related to R. $Y$ decreases with R because of the loss of utility associated with excise taxation. Additionally, $Y$ decreases at an increasing rate as R increases. $Y$ is also a function of V because V determines the magnitude of $Y_R$ for every level of R. Figure 1 shows this relationship in a graphical form.
In Figure 1, $YR$ is the original relationship between $Y$ and $R$ when a type of tax instrument $V$ is used. It also shows an example where the type of the tax instrument used changes from $V$ to say $V'$. This example illustrates a hypothetical case where the change to $V'$ increases the excess burden or efficiency costs associated with every level of revenue. Now the new curve is shown by $YR'$. Due to the increase in the excess burden associated with the new tax instrument $V'$, if the entire gross income were to be collected as tax revenue by the government to finance the public good, then only $R'$ instead of $R$ could be raised.

Summary of the functional form of $Y$:

$Y = f (R, V)$ where

$R$ = Revenue collected by the government

$V$ = Type of tax instrument used (In the empirical analyses it will be a dummy variable and will take a value of unity in the presence of a VAT. In its absence it will take a value zero)

We also assume that the government is benevolent. Keeping this in mind, for a given value of $V$, this economy’s government chooses $R$ to maximize the representative consumer’s utility $U(Y(R, V) – R, R)$ subject to the balanced budget constraint. The objective function is shown below:

$$\max_R \{ U(Y(R, V) – R, R) \} \quad \text{s.t. } R = G \text{ and } C = Y(R, V) – R$$
Maximizing representative consumer’s utility $U(C,G)$ with respect to $R$, subject to the condition of balanced budget, $R = G$, gives the following first order condition:

F.O.C

\[
\frac{\partial U}{\partial C} \frac{\partial C}{\partial R} + \frac{\partial U}{\partial R} = 0
\]  
(1)

\[C = Y(R,V) - R\]  
(2)

If we take derivative of equation (2) w.r.t $R$, we obtain:

\[\frac{\partial C}{\partial R} = \frac{\partial Y}{\partial R} - 1\]  
(3)

Substitute (3) into (1), we get

\[\frac{\partial U}{\partial C} \left( \frac{\partial Y}{\partial R} - 1 \right) + \frac{\partial U}{\partial R} = 0\]

\[\frac{\partial U}{\partial R} = \frac{\partial U}{\partial C} \left( 1 - Y_R \right) \text{ Where } \frac{\partial Y}{\partial R} = Y_R\]

\[\frac{U_R}{U_c} = 1 - Y_R > 1 \quad \text{Where } \frac{\partial U}{\partial R} = U_R \text{ and } \frac{\partial U}{\partial C} = U_c\]  
(4)

Note: As pointed earlier, $Y_R \neq 0$ in this model as the tax system under consideration here is excise tax or the commodity tax and other distortionary taxes. $Y_R = 0$ only for a lumpsum tax.

Also $Y_R < 0$. This explains the strict inequality in equation (4)

\[\frac{U_G}{U_c} = 1 - Y_R = 1 - MDL\]  
(5)

Equation (5) follows from equation (4) as $U_R = U_G$ because $R = G$ in this model. $Y - R^*$ is the amount spent on the consumption of the private good at the optimum. The more is spent on
public good in form of $R^*$, the lesser is available to spend on private consumption in the form of $Y - R^*$. We always get a unique maximum point because of the well-defined properties of utility function.

Equation (5) can be thought of as a modified Samuelson rule as Keen and Lockwood (2010) point out. The ratio of marginal utilities on the left hand side gives the marginal rate of substitution between the public and the private good. Equation (5) shows that under the optimization rule the marginal rate of substitution between the public and the private good will be set equal to unity minus the MDL ($Y_R$) from taxation. To understand the intuition behind equation (5), let’s consider a case where the left hand side of equation (5) is greater than the right hand side. This implies that at the margin, the utility gained by the consumer from consumption of the public good is more than the consumption of the private good. In such a case it will be welfare improving to consume more of the public good\(^\text{18}\). With higher consumption of the public good, the consumer’s total utility will increase. However, there will be a simultaneous fall in the marginal utility of the public good $U_G$ with the increase in government expenditure $G$. An increase in $G$ implies an increase in $R$. This increase in $R$ will increase $Y_R$. As $Y_R$ (MDL) or the loss increases, the right hand side of equation (5) gets bigger. This means that although greater consumption of the public good brings in more utility, it also simultaneously increases the loss (MDL) associated with its consumption. Essentially, in equation (5), the left hand side will decrease and the right hand side will increase with more and more consumption of the public good until equality holds. The consumer will prefer to consume the public good up until the gain equals the loss from its consumption.

---

\(^{18}\) Public Good is considered a normal good here.
Impact of a change in V on the optimal revenue level R*

In the described economy let us start at the point of equilibrium where equation (5) holds with equality. Now suppose that the absolute value of \( Y_R \) decreases (or MDL decreases) because of an exogenous change in V (or a tax innovation). As a result, the right hand side of equation (5) will become smaller as compared to the left hand side. In order to restore the equality in equation (5), the amount of consumption of the public good must go up and this in turn will increase the expenditure G on it. This means the tax revenue (R) will also increase to sponsor the increased expenditure on the public good. This explanation of changes illustrates that the fall in efficiency cost or MDL increases the optimum level of tax revenue (R’).

4.2 MODEL WITH ENDOGENOUS COMPLIANCE COST

The basic model explained above is the revenue efficiency model presented by Keen and Lockwood (2010). Keen and Lockwood (2010) include only the deadweight loss of tax in their revenue efficiency model. Although they discuss the presence of a variable called resource loss (K) which is defined as a fixed amount of loss arising from administrative and compliance activities, they do not include it in the objective function. We modify their revenue efficiency model by introducing compliance and administrative costs in their model as two different types of costs and as a function of R. The compliance costs are introduced at the consumer’s end because consumers bear this cost and the administrative costs come into play through the government’s budget constraint because the government incurs it. Both the costs come into play as a tax is levied by the government. It is important to recognize them in revenue optimizing problem as they account for a sizeable proportion of the taxation costs. Absence of these costs in the revenue efficiency model will underestimate the overall costs of taxation. The compliance and administrative costs can be thought of as substitutes of each other to an extent. An increase
in one may reduce the other. For example, with a VAT, traders need to maintain a record of all the transactions in order to obtain a refund of the input taxes which makes the VAT self-enforcing. This record keeping by the traders increases the compliance costs while reduces the government’s administrative costs. The compliance costs incorporated in this sub-section are assumed to be a function of the level of tax revenue, R. Both exogenous and revenue varying administrations costs are also integrated later in the model.

In simple terms, the compliance costs involve both money and time costs which arise from the process of estimation of the tax liability, filing of the tax related paperwork, maintenance of the record of all the transactions, and keeping with the latest updates in the tax laws. In other words, these are simply costs of abiding by the law. These costs are expected to depend on characteristics of a tax instrument such as multiplicity of tax rates. The more complex a tax system, the more expensive and time consuming it is to comply with it. If more hours are spent by the consumer in complying with the tax code, then the consumer has lesser time to be productive at work or consume leisure. Therefore an increase in the compliance costs reduces private consumption. The compliance costs are also a function of time simply because over time, taxpayers learn how to comply if the tax system is stable.

With compliance costs, the modified equation for private consumption looks like the following:

\[ C = Y(R, V) - R - t(R, V; h) \]  

(6)

Where,

t = compliance costs

h = hours spent in maintaining and filing of tax records

All other variables in equation (6) are defined as before.
Compliance costs depend on both the amount of revenue raised by the government \( R \) and the type of the tax instrument used \( V \). \( t \) is a function of \( R \) because \( t \) is assumed to increase with the increase in tax liability. This is primarily the reason why businesses employ tax analysts / experts to maintain and calculate the amount businesses owe in corporate tax, sales tax, turnover tax and so on. Also, \( t \) may increase with \( R \) at a decreasing rate because of the economies of scale. However, we are not assuming any specific form \( t \) takes as a function of \( R \) in this model. \( t \) could be a linear or a non-linear function of \( R \) of any form. All we assume here is that \( t \) is revenue dependent and increases with an increase in \( R \). Given this, we re-optimize using equation (6)

The new objective function is shown below:

\[
\max_R \{ U(Y(R, V) - R - t(R, V; h), R) \} \quad \text{s.t. } G = R \tag{7}
\]

F.O.C

\[
\frac{\partial U}{\partial C} \frac{\partial C}{\partial R} + \frac{\partial U}{\partial R} = 0 \tag{8}
\]

\[
C = Y(R, V) - R - t(R, V; h) \tag{9}
\]

Take derivative of equation (9) above w.r.t \( R \), we get,

\[
\frac{\partial C}{\partial R} = \frac{\partial Y}{\partial R} - 1 - \frac{\partial t}{\partial R} \tag{10}
\]

Substitute (10) into (8), we get

\[
\frac{\partial U}{\partial C} \left( \frac{\partial Y}{\partial R} - 1 - \frac{\partial t}{\partial R} \right) + \frac{\partial U}{\partial R} = 0
\]

\[
U_R = U_C \left[ 1 + (t_R - Y_R) \right] \quad \text{(Subscripts denote derivatives as in section 3.1)} \tag{11}
\]

Equation (11) above can be rewritten as follows:
\[
\frac{u_G}{u_C} = 1 + (t_R - Y_R) > 0
\]  \hspace{1cm} (12)

Equation (12) is the modified form of equation (5). In this equation the marginal rate of substitution between the public and the private good is equal to unity plus the marginal compliance cost (MCC) and MDL.

Define TMC (total marginal cost) as:

\[
TMC = MCC + MDL
\]

\[
TMC = t_R - Y_R
\]  \hspace{1cm} (13)

TMC > 0 since \( t_R > 0 \) and \( Y_R < 0 \)

Therefore, \( 1 + (t_R - Y_R) > 1 \) and \( (1+ TMC) > 1 \) in Equation (12)

Equation (12) above can be re-written as:

\[
\frac{u_G}{u_C} = 1 + TMC
\]  \hspace{1cm} (14)

**Impact of a change in V on the optimal revenue level \( R^* \)**

In equation (12), TMC (total marginal cost) will change with a change in V (tax instrument), which will change the optimal revenue level \( R^* \). A change in TMC depends on the change in MCC and MDL.

(a) If \( t_R \ (MCC) \) increases or \( Y_R \ (MDL) \) increases or both increase then TMC will increase.

(b) If \( t_R \ (MCC) \) decreases or \( Y_R \ (MDL) \) decreases or both decrease then TMC will decrease.

Following the reasoning in section 3.1, a change in V leading to an increase in the overall marginal cost or TMC will decrease the optimal level of tax revenue \( R^* \) raised by the
government. On the other hand, a decrease in TMC will increase the optimal revenue level of $R^*$. A benevolent government is able to increase the representative consumer’s welfare by increasing the tax revenue iff the total taxation costs borne by the consumer fall at the margin. A given tax instrument is associated with a higher level of revenue efficiency only when the government is able to raise more tax revenue optimally. Therefore an increase in the optimal level of $R^*$ is indicative of the use of a more efficient tax system. We now move on to introduce administrative costs in this model. We then compare the new derived optimization rule with the optimum condition derived by Keen and Lockwood (2010).

4.3 EXTENDED REVENUE EFFICIENCY MODEL

Administrative costs are the costs incurred by the tax levying authority or the government in the process of establishing and operating a tax system. The basic model presented above makes one prominent assumption that $R = G$. This implies zero revenue collection costs incurred by the government which is not realistic as in the real world a government has to typically bear substantive tax enforcement and collection costs. We now modify this unrealistic assumption. As the administrative costs come into play $G < R$ because the amount the government is able to spend on the public good $G$ is strictly less than the revenue collected$^{19}$. Part of the collected revenue is lost in the form of the administrative costs. Real world examples of such costs include computerization and technological advancement of the tax administrative system, tax audits conducted by the government to reduce tax evasion, training of the government employees in new technology, reforming of the tax laws and the maintenance of taxpayer’s records. Before we discuss endogenous administrative costs and their inclusion in the model, we take a look at the exogenous form of administrative costs and discuss its impact on the optimal level of

$^{19}$ We assume no government borrowing.
revenue. For the moment let us assume that the administrative costs are independent of the revenue R. Then this type of cost takes the following functional form.

**Case of exogenous (or temporary) administrative cost**

\[ A = a (V,D,T) \] (15)

where,

- **A** = administrative cost
- **D** = regional or country’s characteristics which includes institutions, corruption, level of education and existing revenue productivity
- **T** = time and
- **V** = type of tax instrument

Administrative cost \( A \) depends on \( V \) as a change in the tax instrument used is expected to lead to a modification of the existing tax collection system or installation of a new system. With the use of a new tax instrument, this cost could increase or decrease. This models a temporary impact of a change in \( V \) on \( A \). The idea is analogous to some type of a start-up cost associated with a change in the tax instrument. This startup cost or a fixed cost is like a onetime exogenous shock in the government’s administrative costs. We believe this is a short-run or a temporary impact of a change in tax instrument. \( A \) is also expected to be a function of some regional characteristics \( D \) and the time \( T \). For example, for a given region, its specific institutional characteristics or the existing education level may keep the administrative costs of the government lower in this region as compared to other regions or states thereby making it cheaper to administer any tax instrument. Note that in the analysis presented below we only consider a case of positive exogenous shock. The magnitude of an increase in the onetime costs or a
positive shock is determined by the regional characteristics outlined by D. We rule out the case of a negative exogenous shock in the government’s administrative costs because it does not seem realistically possible. Such administrative costs when greater than zero reduces the amount of the tax revenue collected and make lesser amount available to the government for financing of the public good. The new budget constraint is as follows:

\[ G = R - \alpha(V, D, T) \]  

With \( A \) in equation (15), the new objective function is shown by equation (17) below.

New objective function:

\[
\max_{R} \left\{ U\left( Y(R, V) - R - t(R, V; h), G \right) \right\} \text{ s.t. } G = R - A \tag{17}
\]

The optimization rule remains the same as in equation (14) for the above maximization problem.

Equation (14) is:

\[
\frac{U_G}{U_C} = 1 + TMC
\]

Where, \( TMC = t_R - Y_R \) and \( TMC > 0 \)

**Impact of a change in \( V \) on the optimal revenue level \( R^* \)**

A change in the optimal level of \( R \) from a change in \( V \) for the modified maximization problem in the equation (17) is *not the same as for the maximization problem in section 3.2.*

With the change of \( V \) now two things are changing simultaneously for every given level of \( R \), which are the absolute values of \( A \) and \( TMC \) (MDL and MCC). \( A \) increases with a change in \( V \) for a given region at a point of time. Note that the increase in \( A \) in this argument is a pure effect of a change in the tax instrument used. With increase in \( A \) with a change in \( V \), the government expenditure on the public good \( G \) will decrease for a given level of revenue \( R \). This follows from equation (16). As public expenditure decreases, the consumer is now able to consume less
quantity of the public good as compared to before for the same amount of the tax revenue $R$. Since the public good considered here is a normal good, a decrease in its consumption for a given level of $R$, will decrease the consumer’s total utility but increase the marginal utility i.e. $U_G$. If this economy was in equilibrium before the change in $V$ then, after the change, $A$ will rise and the left hand side of equation (14) will be greater than the right hand side. However, this is not a complete description of the changes occurring. With a change in $V$, the absolute value of TMC will also change. The net effect on the optimal level of revenue $R^*$ due to a change in $V$ is determined by the magnitude and direction of the simultaneous changes in $A$ and $Y_R, t_R$ in TMC.

One possible scenario is that a change in $V$ increases TMC and also $A$. The final change in the optimal $R$ is then determined by the magnitude of the increase in the two losses. Below we consider all the possible scenarios associated with a change in $V$ leading to an increase in $A$ and their net effect on the optimal level of $R^*$

Scenario III.A1: With a change in $V$, both TMC and $A$ increase. Note that the increase in $A$ implies a decrease in the total utility and a simultaneous increase in the marginal utility of the public good $U_G$. The net effect is discussed below:

(i) If $TMC \uparrow > U_G \uparrow$ then in equation (5) $\frac{U_G}{U_C} < 1 + TMC$ and $R^*$ will decrease with a change in $V$

(ii) If $TMC \uparrow < U_G \uparrow$ then in equation (5) $\frac{U_G}{U_C} > 1 + TMC$ and $R^*$ will increase with a change in $V$.

---

Note that we are doing a purely partial equilibrium analysis here. Better tax administration in period zero may lead to higher consumption in period one, but we are not modeling the dynamic time component here.
(iii) If $TMC \uparrow = U_G \uparrow$ then in equation (5) $U_G/U_C = 1 + TMC$ and $R^*$ will not change with a change in $V$.

**Intuition:** At the margin, if the increase in revenue-varying taxation costs are greater than the loss in the total utility from lower expenditure on the public good due to an increase in the administrative costs, the consumer would want to consume lesser of the public good and so the optimal revenue $R^*$ will decrease. If the increase in costs is smaller than the loss in the total utility from a lower level of $G$, then the consumer would desire more of the public good and so $R^*$ will increase.

**Scenario III.A2:** With a change in $V$, the absolute value of $Y_R$ decreases and $A$ increases

(i) If $TMC \downarrow$ and $U_G \uparrow$ then in equation (5) $U_G/U_C > 1 + TMC$ and $R^*$ will increase with a change in $V$.

**Intuition:** At the margin, if the revenue-varying costs decrease and the total utility also decreases from lower expenditure on the public good due to an increase in the administrative costs, the consumer would want to consume more of the public good and so the optimal revenue $R^*$ will increase.

The above explanations show that the net impact of the change in costs on $R^*$ is not straightforward. When both the endogenous and exogenous costs are rising simultaneously, then the net effect on $R^*$ could be an increase or a decrease (depending on the magnitude of the costs) and vice versa. We now move on to solve the optimization problem in an economy when the administrative costs also vary with the level of revenue.
Case of endogenous administration costs

For a given tax instrument, in the long-run part of the administrative costs will vary with the level of tax revenue raised by the government. This section models the long-run impact of a change in V on A by incorporating the revenue-varying component of the administrative costs. As the size of the government expands, the costs of administering this government are expected to go up. We know from Wagner’s law that the size of the government increases with an increase in national income. So if R increases because of an increase in the per capita income, then a simultaneous increase in the government size is expected to lead to an increase in the administrative costs. Therefore an increase in R would cause an increase in A. However these administrative costs could increase with R at a decreasing rate because of the economies of scale. As in the case of compliance costs, we are not making any assumptions about the functional form of A. The only assumption we make here is that the administrative costs are revenue dependent and directly proportional to R i.e. the first derivative of A w.r.t R is positive. The modified equation of A is shown below:

\[ A = a(V, D, t, R) \]  

(18)

\( A_R \) denotes the partial derivative of A w.r.t R. \( A_R \) is defined as the marginal administrative cost (MAC) associated with a change in R. Following presents the consumer maximization problem with A as a function of R.

\[
\max_R \left\{ U(Y(R, V) - R - t(R, V; h), G) \right\} \quad \text{s.t. } G = R - A
\]

(19)

Differentiating equation (19) w.r.t R, we obtain:

\[
\frac{\partial U}{\partial C} \frac{\partial C}{\partial R} + \frac{\partial U}{\partial G} \frac{\partial G}{\partial R} = 0
\]

(20)

From equation (9) we know,
\[ C = Y(R, V) - R - t(R, V; h) \]

Taking derivative of the above w.r.t R, we obtain:

\[ \frac{\partial C}{\partial R} = \frac{\partial Y}{\partial R} - 1 - \frac{\partial t}{\partial R} \]

Also, we know

\[ G = R - A \]

Differentiate w.r.t R, we obtain:

\[ \frac{\partial G}{\partial R} = 1 - A_R \] (21)

Now, Substitute \( \frac{\partial C}{\partial R} \) and \( \frac{\partial G}{\partial R} \) into equation (20)

\[ \frac{\partial U}{\partial C} \left( \frac{\partial Y}{\partial R} - 1 - \frac{\partial t}{\partial R} \right) + \frac{\partial U}{\partial G} (1 - A_R) = 0 \]

\[ U_G (1 - A_R) = U_C \left[ 1 + (t_R - Y_R) \right] \]

\[ \frac{U_G}{U_C} = \left[ 1 + (t_R' - Y_R') \right] / (1 - A_{R'}) \] (22)

Now substitute \( t_R = MCC \) and \( Y_R = MDL \) in equation (22) above and \( MAC = A_R \), we get

\[ \frac{U_G}{U_C} = \frac{(1 + MCC - MDL)}{(1 - MAC)} > 0, \text{ where } MDL < 0 \] (23)

The Samuelson rule from Keen and Lockwood (2010) is as follows:

\[ \frac{U_G}{U_C} = 1 - MDL > 0, \text{ where } MDL < 0 \] (24)
Equation (23) presents the modified optimization rule derived here when both the compliance and the administrative costs of taxation are present and endogenous. The optimal level of revenue $R^*$ should satisfy this equation in order to maximize the representative consumer’s utility. Comparison of the modified Samuelson rule derived here which is given by equation (23) with the one derived by Keen and Lockwood (2010) given by equation (24), show that equation (23) has an additional term of marginal compliance cost (MCC) in the numerator and an additional term of marginal administrative cost (MAC) in the denominator. The result in equation (23) shows that at the margin, we need to account for all the types of taxation costs in order to gauge the net impact of a change in the tax instrument used by the government on the optimal level of revenue $R^*$.

Since, $TMC = MCC + MDL$ and $TMC > 0$ as $t_R > 0$ and $Y_R < 0$

We can rewrite equation (23) as the following:

$$\frac{U_G}{U_C} = \frac{(1 + TMC)}{(1 - MAC)}$$

(25)

Impact of a change in V on the optimal revenue level $R^*$

We now discuss the impact of a change in V on the optimal level of tax revenue R using equation (25). A change in V, changes two things simultaneously for every given level of R. These are TMC and MAC. Let’s start at a point where equation (25) holds and the economy is in the equilibrium. Now V changes as a result of which TMC and MAC may both change and lead to a change in optimal $R^*$. Let’s consider all the possibilities and their net impact on the optimal revenue.
**Scenario III.B1:** With a change in $V$, TMC decreases and MAC does not change. Note that TMC could decrease because of a decrease in MCC or MDL or both of its components. This is because $TMC = MCC + MDL$.

If $TMC \downarrow$ and $\Delta MAC = 0$, then $\frac{U_g}{U_c} > 1 + \frac{TMC}{1 - MAC}$ and the optimal $R^*$ will increase with a change in $V$.

**Scenario III.B2:** With a change in $V$, TMC decreases and MAC also decreases.

If $TMC \downarrow$ and $MAC \downarrow$, then $\frac{U_g}{U_c} > 1 + \frac{TMC}{1 - MAC}$ and the optimal $R^*$ will increase with a change in $V$.

*Intuition:* At the margin, when some or all the endogenous costs are decreasing then higher consumption of the public good will increase the consumer’s total utility which will increase $R^*$.

**Scenario III.B3:** With a change in $V$, TMC increases and MAC does not change. Again, note that TMC could increase because of the increase in MCC or MDL or both of its components.

If $TMC \uparrow$ and $\Delta MAC = 0$, then $\frac{U_g}{U_c} < 1 + \frac{TMC}{1 - MAC}$ and optimal $R^*$ will decrease with a change in $V$.

**Scenario III.B4:** With a change in $V$, TMC increases and MAC also increases.

If $TMC \uparrow$ and $MAC \uparrow$, then $\frac{U_g}{U_c} < 1 + \frac{TMC}{1 - MAC}$ and the optimal $R^*$ will decrease with a change in $V$.

*Intuition:* At the margin, when some or all the endogenous costs are increasing then lower consumption of the public good will increase the consumer’s total utility which will decrease $R^*$.

**Scenario III.B5:** With a change in $V$, TMC increases and MAC decreases.
(i) If $TMC \uparrow > MAC \downarrow$, then $\frac{U_G}{U_C} < 1 + \frac{TMC}{1 - MAC}$ and the optimal $R^*$ will decrease with a change in $V$.

(ii) If $TMC \uparrow < MAC \downarrow$, then $\frac{U_G}{U_C} > 1 + \frac{TMC}{1 - MAC}$ and the optimal $R^*$ will increase with a change in $V$.

**Scenario III.B5:** With a change in $V$, TMC decreases and MAC increases.

(i) If $TMC \downarrow > MAC \uparrow$, then $\frac{U_G}{U_C} > 1 + \frac{TMC}{1 - MAC}$ and the optimal $R^*$ will increase with a change in $V$.

(ii) If $TMC \downarrow < MAC \uparrow$, then $\frac{U_G}{U_C} < 1 + \frac{TMC}{1 - MAC}$ and the optimal $R^*$ will decrease with a change in $V$.

*Intuition:* At the margin, if all the endogenous costs are changing simultaneously then a net decrease / increase in the marginal costs will lead to an unambiguous increase/decrease in $R^*$ respectively. The impact of a change in $V$ on the optimal revenue $R^*$ in all of the scenarios described above can be *summarized by two important points.*

*First,* exogenous and endogenous administrative costs have a differential impact on $R^*$. In presence of an exogenous increase in the government’s administrative costs, the net change in $R^*$ is not straightforward. For example, $R^*$ may increase even when the exogenous administrative costs and other endogenous costs are rising. When all the three types of taxation costs considered
here are endogenous in the model, things are simpler. Equation (25) is valid when this is the case and it shows that as long as the net endogenous costs of taxation are falling at the margin, it will always be welfare improving to increase the consumption of the public good which implies that $R^*$ will increase. Hence it is important to distinguish between exogenous and endogenous tax administration costs.

Second, it is important to consider the change in direction and the magnitude of all the costs incurred from taxation when analyzing the impact of a change in the type of the tax instrument used by the government and there is more than one type of taxation cost. A final change in the optimal level of $R^*$ will be determined by the net change in all the types of taxation costs\(^2\).

5 DATA AND THE EMPIRICAL RESULTS

The main empirical question of interest is the following: has the tax innovation in the form of the replacement of the turnover sales tax by the VAT improved the revenue efficiency at the state level? According to the theoretical model explained above the impact of the transition to the VAT is ambiguous in the short-run when the administrative costs are more likely to be independent of the level of revenue. Recall from the model that a change of an indirect tax instrument used by the government is likely to cause a one-time positive exogenous shock in the government’s administrative costs. This positive shock in the costs is independent of the revenue and in its presence the impact of the VAT on the optimal level of revenue $R^*$ is ambiguous. In this case, in order to pin down the exact change in $R^*$, a complete knowledge of the direction and the magnitude of the changes in all the costs is required. But, fortunately this exogenous shock is

\(^{21}\) This model does not incorporate two other important forms of taxation costs which are costs of tax evasion and tax avoidance.
temporary and over a longer period of time the administrative costs tend to be revenue-varying. When this is the case, the optimal revenue $R^*$ or the revenue efficiency will increase if and only if there is a net fall in the deadweight loss (or distortionary costs), compliance costs and the administrative costs at the margin.

The empirical analyses presented in this paper uses data for the years 1990 to 2010. Twenty-two out of 29 states had adopted the VAT by the year 2005, and 5 more states put it in place in the following year. Therefore for these 27 states (which represent more than 93% of the total number of states) we are able to capture the impact of the VAT on the revenue efficiency over a 4 to 5 year period. Considering a 4 to 5 year period to be a reasonably long period of time, all the costs of taxation are expected to be endogenous. Therefore, from the model, we infer that if we observe an increase in the optimal level of revenue $R^*$ in our empirical results, this increase is a result of a net decrease in the marginal costs of taxation and vice versa. If the VAT led tax reform is found to reduce the taxation costs, then this efficiency gain will show up as an increase in $R^*$ and we will be able to conclude that the VAT reform in India has proved to be efficiency improving at the state level.

We use the state’s tax revenue per capita to measure $R^*$ (or revenue efficiency). Two different measures of the revenue are used; one is the state’s own revenue from all the types of indirect taxes (ITR) and the other is the state’s own revenue from the sales taxes component. As explained before, these sales taxes are levied by the state governments on goods and it is the main form of indirect tax for the states (Its importance is best illustrated by Table 1). Also 28% of the state’s total tax revenue comes from the state’s sales tax component. States essentially replaced this tax instrument by the VAT. The measure of the state’s own revenue from all the indirect taxes takes into account the surcharge taxes which used to be levied on top of the sales
taxes before the presence of the VAT. The states got rid of these inefficient forms of taxes at the time of the transition to the VAT. Therefore this revenue measure could be thought of as a broader measure or an aggregate measure of the revenue efficiency. Also, Keen and Lockwood (2010) point to the fact that the performance of the VAT needs to be evaluated with respect to the total revenue collected from all the types of indirect taxes. This argument makes it useful to capture the change in revenue efficiency of both of the revenue measures explained above from the use of the VAT as a type of sales tax instrument.

5.1 DATA

We use the state level data for the years 1990 to 2010 for 29 states of India including the national capital territory of Delhi\textsuperscript{22}. Union territories are excluded from the analyses because they do not have autonomous state governments except for Puducherry. Union territories together represent only about 7% of India’s population. All data used in the following empirical analyses is obtained from RBI publications, Ministry of Statistics and Programme Implementation (MOSPI), National Sample Survey Office (NSSO) at MOSPI, Ministry of Labour and Employment, Labour Bureau, Government of India and Indiastat. Details on the state level VAT are obtained from the website of Empowered Committee of State Finance Ministers.

5.2 SUMMARY STATISTICS AND THE TRENDS IN THE DATA

Summary statistics of the covariates used in the empirical analyses to explain the overtime trends in the revenue measures are presented in Table 2. Table 2 reports the summary statistics of the key covariates for all the states and also separately for the 11 special category states and the 18 non-special category states. A lower average of GSDP per capita (GSDP pc) and a higher percentage share of agriculture sector in GSDP for the special states compared to

\textsuperscript{22} Three states of India split into two states each, in the year 2000. For the years prior to 2000, we generate value of variables in the data for the split states using their actual figures in years 2000 and 2001.
the non-special states illustrates a lower level of development in the special category of states. Education expenditure is the amount spent by the respective state governments on education as a part of the development expense. Education expenditure per capita is used as a proxy of the literacy level in any given state. In addition to the agricultural sector, the unregistered manufacturing sector is also difficult to tax and it hides within the shadow economy of a country. The size of this unregistered manufacturing sector in the states of India is non-trivial and therefore it is used as one of the explanatory variables in our analyses.

Table 2 shows that its average size across the non-special states is about 7% of GSDP; however it is only 2% of GSDP in the special category states. The central government provides numerous tax concessions to the manufacturing industry in the special states which could explain the modest size of the unregistered manufacturing in these states as compared to the non-special states.

The Central government’s grants to all the states had increased temporarily for 3 to 4 years during the time period when the states were transitioning to the VAT. The state governments were mainly concerned about the initial revenue loss from the transition to the VAT and the central government agreed to compensate them for any such losses up to a certain percentage through temporary grants. To account for this special form of assistance to the states from the center on the state’s revenue effort, we use the non-plan grants from the center to the states as one of the covariates in the analyses. The average value of such grants made to the special states was higher than the grants made to the other 18 states.

Total interest payments paid by the states annually including their interest on loans, internal debt and market loans is used as a proxy for the fiscal crisis the states of India were
grappling with in the second half of the 1990s\textsuperscript{23}. NEC (North Eastern Council) grants are a special form of grants prominently given by the federal government for the development purposes to 8 states of India which are located in the north eastern region. All these states fall into the special category. We control for these grants also in our analyses. All other covariates reported in Table 2 are popularly used by the previous tax effort literature to explain the tax revenue ratio or the revenue productivity. For example the level of urbanization is shown to have a positive and significant effect on the revenue performance in the previous literature. The mining sector is usually dominated by a few large sized firms and hence it could generate large tax surpluses for the government. Therefore we include the share of the mining sector as an explanatory variable.

Table 2 also reports four different measures of tax revenue per capita (pc). The broadest measure among them is the state’s total tax revenue (TTR) pc. It includes the state’s own revenue from the direct and the indirect taxes and also the state’s revenue share in the direct and the indirect central taxes. The second measure is the state’s own tax revenue (OTR) which includes both the indirect and the direct sources of tax revenue. Third measure is the state’s own indirect tax revenue (ITR) which is a subset of the above two measures and the last and the narrowest measure is the state’s revenue from the sales tax / VAT which is a subset of the ITR measure. The state’s revenue from the sales tax instrument came from the turnover type sales tax before the transition to the VAT and from the VAT after the VAT was implemented. All the four revenue measures are consistently lower in value for the special states as compared to the non-special states which explains the lower revenue productivity in these states.

Figure 5 shows the average trend in OTR, ITR and the sales tax/VAT revenue measure as a percentage of TTR for all the states. Dotted vertical lines mark the years when one or more

\textsuperscript{23} Details of this crisis are discussed in section 3 of the paper.
states adopt the VAT. The two ratios OTR to TTR and ITR to TTR follow very similar trends overtime. These two ratios reach their respective peaks in the year 2002 and then they start descending in 2003. They begin trending up after 2007. For the majority of the VAT adoption period from 2005 to 2007, these ratios are falling. A slightly different trend is followed by the sales tax / VAT revenue measure. The fall in it after 2002 quickly vanishes and it manages to stabilize at 30% of TTR for the coming years up until it starts to rise upwards after 2007. The consistent drops in all the three revenue ratios after the year 2003 are perhaps coming from a sharp deterioration in the state’s fiscal conditions in the year 2003-04.

Figure 6 unfolds the growth trend in ITR to TTR separately for the special and the non-special states. Again vertical lines in the graph mark the years of the adoption of the VAT by one or more states. We observe that the growth rate has been marginally trending downwards for the non-special states starting from 2002 and it starts to increase post 2007 although this increase is not sustained in the later years. On the other hand, the special states experienced dramatic fluctuations in the growth rate over the entire time period and no systematic trend emerges. Same is true for the trends in the growth of the sales tax / VAT revenue measure as a percentage of TTR which is shown in Figure 7. It is hard to tell from these pictures if the VAT’s implementation changed revenue productivity in either category of the states.

We also look at Table 3 in an attempt to expose some trends in the revenue performance before and after the VAT. This table presents the average annual growth rates in ITR as a percentage of TTR and sales tax / VAT revenue as a percentage of TTR for the pre and the post VAT periods. We now look at these growth rates individually in each of the 18 non-special states. For majority of these states, annual growth rates improved in the post VAT period as compared to the pre VAT, although the improvements are modest. The state of Chattisgarh
shows the most dramatic improvement in the growth rate of the sales tax / VAT revenue component from a negative 10.5% in the pre VAT to a positive 11.8% in the post VAT period. These growth rates declined sharply in the special category states in the post VAT period.

5.3 \textbf{REGRESSION ANALYSES}

We first estimate equation (26) using fixed effects methodology.

\begin{equation}
\begin{aligned}
r_{it} &= \alpha v_{it} + \beta' X_{it} + \mu_i + \varepsilon_{it} \\
\end{aligned}
\end{equation}

Where,

\begin{align*}
i &= \text{index which represents state } (i = 1, \ldots, 29) \\
t &= \text{index which represents time } (t = 1990, \ldots, 2010) \\
r_{it} &= \log \text{ITR per capita or log sales tax / VAT revenue per capita of a state } i \text{ at a time } t. \text{ It is a (NT X 1) vector of N states and T years.} \\
v_{it} &= \text{takes a value 1 if a state } i \text{ has a VAT in a year } t, \text{ and takes a value zero otherwise} \\
X_{it} &= \text{denotes a column vector of other observable time varying covariates and it also includes a time trend variable.} \\
\mu_i &= \text{denotes a state specific error} \\
\varepsilon_{it} &= \text{denotes an idiosyncratic error}
\end{align*}

The estimators of the parameters $\alpha$ and $\beta$ in equation (26) are shown in Tables 4 and 5 using a fixed effects (FE) model. The only difference between the results in Tables 4 and 5 is that in Table 4 the dependent variable is the state’s own indirect tax revenue per capita (ITR pc) and in Table 5 the dependent variable is the sales tax / VAT revenue pc. The sales tax / VAT revenue pc measures the state’s sales tax revenue pc from the turnover tax in the period prior to the VAT, and it measures the state’s sales tax revenue pc from the VAT in the post VAT period.
The ITR pc measure of the state’s revenue captures the revenue efficiency of the entire indirect tax system whereas the sales tax / VAT revenue measure captures the revenue efficiency of only the sales tax component of the entire indirect tax system. $D_{\text{VAT}}$ in all the tables is the dummy variable indicating the presence of the VAT. The coefficient of interest to us is the coefficient of $D_{\text{VAT}}$ which is $\alpha$ in equation (26). The FE estimates are shown for all the states and then separately for the special and the non-special states in Tables 4 and 5. We also control for time trend in all the above specifications. We observe a significantly positive effect of GSDP per capita in all the specifications of Table 4 and Table 5. This effect is well established in the previous tax effort literature and it is popularly known as Wagner’s law. We also observe a positive and a significant impact of the presence of the VAT on the outcome variable for non-special states in these tables. The estimate in Table 4 shows that in the presence of the VAT, state’s ITR pc increases by 3.4%. The time trend is significant in all columns of Table 4 but it becomes insignificant in Table 5. Table 5 shows that the presence of the VAT has a bigger significant effect on the revenue efficiency of the sales tax component. From Table 5 we see that, with the use of a consumption type VAT by the state governments instead of the turnover tax, the sales tax / VAT revenue per capita increased by 8.46%.

We cluster the standard errors over the states for all the FE estimates. This produces robust standard error estimates that allow heteroskedasticity within the states. The reason to suspect heteroskedasticity is that error $\epsilon_{it}$ is expected to be correlated over time for a given state\textsuperscript{24}. To solve for the problem of autocorrelation in the dependent variable (which is a common problem of a dynamic model and also of tax effort regression specification), we use the first order of the lagged dependent variable as one of the regressors. Its coefficient is significant.

\textsuperscript{24} Note that the specification used still does not allow for the correlation of errors across the states.
and positive in Tables 4 and 5. We use Wooldridge (2002) test of serial correlation in the presence of the fixed effects. The statistics of this test are also reported in Tables 4 and 5 which reveal the presence of serial correlation. The inclusion of the lagged term of the dependent variable in the specification perhaps does not completely solve the underlying problem. It is commonly the case that the errors are serially correlated when the dynamic model is misspecified.

If the correlation in errors follows AR (1) \( u_{it} = \rho u_{i,t-1} + \varepsilon_{it} \), we can obtain more efficient estimates in its presence by using the FE estimator which explicitly allows AR(1) errors. The results of this model are shown in Table 6 for all the states and the non-special states. Columns (1) and (2) of Table 6 present results using ITR pc as the dependent variable and (3) and (4) use the sales tax/ VAT revenue pc as the dependent variable. The significant effect of the VAT on ITR pc vanishes with the use of the FE model of AR (1) errors. However, the impact of the VAT is still significantly positive on the sales tax / VAT revenue pc for the non-special states. The size of the effect is 6.67% which is close in magnitude to the results reported in Table 5.

Cameron and Trivedi (2009) note that the within estimator (or the FE estimator) is inconsistent once lagged regressors are introduced because the first lagged term of the dependent variable for a given state i can be shown to be correlated with the error terms of this state i. Nonetheless, consistent parameter estimates can be obtained from the IV estimators of first-difference (FD) model by instrumenting the first lagged term of the dependent variable with its own lagged term of the higher order. Anderson and Hsiao (1981) estimator uses this model.

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25 Interaction terms of the VAT dummy variable with GSDP and other variables are excluded from of the results presented in the paper because they were consistently found to be insignificant.

26 See Wooldridge, Introductory Econometrics, 4th ed, Chapter 12.

27 Results for special category states are not presented in the table because coefficient of VAT dummy variable is insignificant.
Table 7 presents the results using this estimator. The VAT’s presence is found to be significantly positive on the sales tax / VAT revenue pc for the non-special states and the size of this effect is 6.5% in Table 7. The magnitude of this effect was 8.6% from using the FE estimator as discussed above. Even though the VAT does not seem to improve efficiency of the aggregate indirect tax system of the states, it does seem to improve efficiency of the sales tax component of the indirect tax system which it had essentially replaced.

Tables 5, 6 and 7 report a consistent increase in the long–run28 revenue efficiency of the sales tax instrument used by the state governments from the substitution of a consumption type VAT for a turnover type sales tax. Our theoretical model implies that the observed increase in the revenue efficiency of the sales tax component is a result of a net decrease in the marginal costs of taxation associated with the sales tax instrument. Similarly a no change in the revenue efficiency of the aggregate indirect tax system can be inferred a result of no net change in the marginal distortionary, compliance and administrative costs. Note that here we are talking about a net change in all the costs of taxation. So when the net change in the total marginal costs is zero, it could mean that some costs increased and other costs decreased in such a way that the net effect is zero.

As explained above, our findings provide some evidence of a net decrease in the marginal taxation costs from the use of a VAT as an indirect tax instrument at the state-level. However we are not able to pin-point which type of taxation costs fall more/less than the others. We believe this is a question which can be addressed by future research work. It will be worthwhile to identify which taxation costs changed the most and in which direction among the compliance costs, distortionary costs and the administrative costs.

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28 We consider time period of 4 to 5 years as a long-run time period. This is discussed in detail in paragraph 2 on page 29 of this paper.
6 CONCLUSION

The theoretical model in this paper establishes that, in the long-run, when all the costs from taxation are endogenous, then a net fall in these costs at the margin, makes it efficient for the government to increase the optimal revenue $R^*$. This increase in the level of revenue therefore reflects an efficiency gain. In our empirical analyses we identify such an efficiency gain in the sales tax component in the developed states of India, over a 4 to 5 year time period, from the use of a consumption type VAT. This makes intuitive sense as a consumption type VAT replaced an administratively complex, non-uniform and a distortionary sales tax. However, this efficiency gain is not robust enough and it does not lead to the efficiency improvement of the aggregate indirect tax system. We observe an insignificant effect of the VAT on the revenue efficiency of the entire indirect tax system. Nonetheless, the estimation results presented in this paper provide evidence of efficiency improvement of the sales tax component in a less developed economy from the use of a VAT at the sub-national level. This is an important finding which shows that a sub-national VAT can prove to be an effective tax instrument in the low and middle income countries also.
7 FIGURES

Figure 2: Average state’s OTR as a percentage of GSDP over the period of 1990 to 2000

Figure 3: Average revenue deficit as a percentage of GSDP
Figure 4: Implementation of the VAT in the states of India by year
Figure 5: Trend in state’s revenue ratios (in percent)

Figure 6: Growth rate in ITR as a percentage of TTR for special and non-special category of states
Figure 7: Growth rate in sales tax / VAT revenue as a percentage of TTR for special and non-special category of states


## Tables

Table 1: Percentage share of ITR to OTR and Sales tax / VAT revenue to ITR

<table>
<thead>
<tr>
<th>All-India average</th>
<th>ITR to OTR (in percent)</th>
<th>Sales tax / VAT revenue to ITR (in percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990 to 1995</td>
<td>87.85%</td>
<td>50.96%</td>
</tr>
<tr>
<td>1996 to 2000</td>
<td>87.6%</td>
<td>52.98%</td>
</tr>
<tr>
<td>2001 to 2005*</td>
<td>87.8%</td>
<td>58.42%</td>
</tr>
<tr>
<td>2006 to 2010</td>
<td>88.5%</td>
<td>64.38%</td>
</tr>
</tbody>
</table>

Notes:
*2005 is a significant year as 21 out of 29 states adopted the VAT in this year. Haryana was the first state to adopt a VAT in the year 2003.

ITR = State’s own indirect tax revenue

OTR = State’s own tax revenue

Sales tax/ VAT revenue = Revenue collected by states by charging indirect taxes on goods.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSDPpc</td>
<td>All states</td>
<td>609</td>
<td>25547.13</td>
<td>24065.72</td>
<td>2582.67</td>
</tr>
<tr>
<td></td>
<td>Special</td>
<td>231</td>
<td>22398.96</td>
<td>17912.22</td>
<td>3818.52</td>
</tr>
<tr>
<td></td>
<td>Non- special</td>
<td>378</td>
<td>27471.01</td>
<td>26990.76</td>
<td>7.96</td>
</tr>
<tr>
<td>Agri. GSDP share (in %)</td>
<td>All states</td>
<td>606</td>
<td>44.61</td>
<td>172.77</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>Special</td>
<td>228</td>
<td>77.29</td>
<td>278.64</td>
<td>7.96</td>
</tr>
<tr>
<td></td>
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<td>378</td>
<td>24.89</td>
<td>10.82</td>
<td>0.71</td>
</tr>
<tr>
<td>Unreg. Manuf. GSDP share (in %)</td>
<td>All states</td>
<td>592</td>
<td>5.15</td>
<td>25.52</td>
<td>0.63</td>
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<tr>
<td></td>
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<td>223</td>
<td>2.60</td>
<td>1.42</td>
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<tr>
<td></td>
<td>Non- special</td>
<td>369</td>
<td>6.69</td>
<td>32.22</td>
<td>1.23</td>
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<tr>
<td>Mining sector GSDP share (in %)</td>
<td>All states</td>
<td>587</td>
<td>2.46</td>
<td>3.48</td>
<td>0.00</td>
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<tr>
<td></td>
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<td>1.85</td>
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<td></td>
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<td>372</td>
<td>2.82</td>
<td>3.80</td>
<td>0.00</td>
</tr>
<tr>
<td>Urban Pop (in %)</td>
<td>All states</td>
<td>602</td>
<td>29.05</td>
<td>16.61</td>
<td>7.00</td>
</tr>
<tr>
<td></td>
<td>Special</td>
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<td>22.13</td>
<td>10.94</td>
<td>8.00</td>
</tr>
<tr>
<td></td>
<td>Non- special</td>
<td>374</td>
<td>33.15</td>
<td>18.00</td>
<td>7.00</td>
</tr>
<tr>
<td>Education expenditure per capita</td>
<td>All states</td>
<td>605</td>
<td>946.84</td>
<td>892.24</td>
<td>50.54</td>
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<tr>
<td></td>
<td>Special</td>
<td>231</td>
<td>1345.26</td>
<td>1127.41</td>
<td>200.00</td>
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<tr>
<td></td>
<td>Non- special</td>
<td>374</td>
<td>700.76</td>
<td>588.49</td>
<td>50.54</td>
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<tr>
<td>Non plan grants from Centre per capita</td>
<td>All states</td>
<td>595</td>
<td>716.90</td>
<td>1380.98</td>
<td>0.00</td>
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<tr>
<td></td>
<td>Special</td>
<td>228</td>
<td>1677.92</td>
<td>1857.49</td>
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<tr>
<td></td>
<td>Non- special</td>
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<td>119.87</td>
<td>149.86</td>
<td>0.00</td>
</tr>
<tr>
<td>NEC grants per capita</td>
<td>All states</td>
<td>604</td>
<td>37.54</td>
<td>115.59</td>
<td>0.00</td>
</tr>
<tr>
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<td>Special</td>
<td>230</td>
<td>98.02</td>
<td>171.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Non- special</td>
<td>374</td>
<td>0.35</td>
<td>2.70</td>
<td>0.00</td>
</tr>
<tr>
<td>Interest payments per capita</td>
<td>All states</td>
<td>603</td>
<td>728.96</td>
<td>612.12</td>
<td>40.84</td>
</tr>
<tr>
<td></td>
<td>Special</td>
<td>231</td>
<td>889.59</td>
<td>673.64</td>
<td>40.84</td>
</tr>
<tr>
<td></td>
<td>Non- special</td>
<td>372</td>
<td>629.21</td>
<td>548.29</td>
<td>51.34</td>
</tr>
<tr>
<td>TTR pc</td>
<td>All states</td>
<td>605</td>
<td>2440.62</td>
<td>2075.30</td>
<td>285.36</td>
</tr>
<tr>
<td></td>
<td>Special</td>
<td>231</td>
<td>2269.26</td>
<td>1797.99</td>
<td>311.81</td>
</tr>
<tr>
<td></td>
<td>Non- special</td>
<td>374</td>
<td>2546.47</td>
<td>2225.15</td>
<td>285.36</td>
</tr>
<tr>
<td>OTR pc</td>
<td>All states</td>
<td>605</td>
<td>1492.83</td>
<td>1697.65</td>
<td>29.44</td>
</tr>
<tr>
<td></td>
<td>Special</td>
<td>231</td>
<td>814.62</td>
<td>928.00</td>
<td>29.44</td>
</tr>
<tr>
<td></td>
<td>Non- special</td>
<td>374</td>
<td>1911.72</td>
<td>1917.04</td>
<td>95.52</td>
</tr>
<tr>
<td>ITR pc</td>
<td>All states</td>
<td>605</td>
<td>1328.42</td>
<td>1526.90</td>
<td>25.67</td>
</tr>
<tr>
<td></td>
<td>Special</td>
<td>231</td>
<td>729.13</td>
<td>846.77</td>
<td>25.67</td>
</tr>
<tr>
<td></td>
<td>Non- special</td>
<td>374</td>
<td>1698.58</td>
<td>1724.33</td>
<td>81.17</td>
</tr>
<tr>
<td>Sales tax / VAT revenue pc</td>
<td>All states</td>
<td>521</td>
<td>875.11</td>
<td>1062.83</td>
<td>2.80</td>
</tr>
<tr>
<td></td>
<td>Special</td>
<td>214</td>
<td>402.61</td>
<td>484.39</td>
<td>2.80</td>
</tr>
<tr>
<td></td>
<td>Non- special</td>
<td>307</td>
<td>1204.49</td>
<td>1221.18</td>
<td>63.66</td>
</tr>
</tbody>
</table>

Notes:
GSDP = Gross state domestic product of state; TTR = State’s total tax revenue; OTR = State’s own tax revenue; ITR = State’s own indirect tax revenue
Table 3: Average annual growth rates in ITR and sales tax / VAT revenues before and after the VAT

<table>
<thead>
<tr>
<th>States</th>
<th>Average growth rate in ITR to TTR (in per cent per annum)</th>
<th>Average growth rate in Sales tax / VAT rev to TTR (in per cent per annum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Five year period before VAT</td>
<td>Post VAT</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>-0.14</td>
<td>0.37</td>
</tr>
<tr>
<td>Bihar</td>
<td>-3.88</td>
<td>1.65</td>
</tr>
<tr>
<td>Chattisgarh</td>
<td>1.58</td>
<td>-0.39</td>
</tr>
<tr>
<td>Delhi</td>
<td>-0.83</td>
<td>0.22</td>
</tr>
<tr>
<td>Goa</td>
<td>0.40</td>
<td>-1.62</td>
</tr>
<tr>
<td>Gujarat</td>
<td>-1.27</td>
<td>-0.72</td>
</tr>
<tr>
<td>Harayana</td>
<td>2.22</td>
<td>-1.30</td>
</tr>
<tr>
<td>Jharkhand</td>
<td>3.39</td>
<td>-3.19</td>
</tr>
<tr>
<td>Karnataka</td>
<td>-0.24</td>
<td>0.37</td>
</tr>
<tr>
<td>Kerala</td>
<td>-0.22</td>
<td>-0.11</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>1.38</td>
<td>-0.60</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>0.30</td>
<td>-1.25</td>
</tr>
<tr>
<td>Orissa</td>
<td>0.66</td>
<td>0.29</td>
</tr>
<tr>
<td>Punjab</td>
<td>-0.74</td>
<td>-0.70</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>-0.33</td>
<td>-1.17</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>-0.61</td>
<td>0.40</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>-3.42</td>
<td>2.16</td>
</tr>
<tr>
<td>West Bengal</td>
<td>-2.96</td>
<td>0.05</td>
</tr>
<tr>
<td>Special Category states</td>
<td>17.92</td>
<td>-1.22</td>
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</table>
Table 4: Results using the FE estimator with ITR per capita as the dependent variable

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) All States</th>
<th>(2) Non-special states</th>
<th>(3) Special states</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln (ITR per capita lag)</td>
<td>0.58561***</td>
<td>0.59152***</td>
<td>0.46150**</td>
</tr>
<tr>
<td></td>
<td>(0.128)</td>
<td>(0.036)</td>
<td>(0.195)</td>
</tr>
<tr>
<td>DVAT</td>
<td>0.00496</td>
<td>0.03405**</td>
<td>-0.01967</td>
</tr>
<tr>
<td></td>
<td>(0.015)</td>
<td>(0.013)</td>
<td>(0.040)</td>
</tr>
<tr>
<td>Time trend</td>
<td>0.03695**</td>
<td>0.03681***</td>
<td>0.09916**</td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(0.009)</td>
<td>(0.034)</td>
</tr>
<tr>
<td>ln(GSDP_{pc})</td>
<td>0.12473</td>
<td>0.15895***</td>
<td>-0.15080</td>
</tr>
<tr>
<td></td>
<td>(0.078)</td>
<td>(0.045)</td>
<td>(0.160)</td>
</tr>
<tr>
<td>ln(Pop)</td>
<td>-0.15597</td>
<td>-0.23261</td>
<td>-0.57095</td>
</tr>
<tr>
<td></td>
<td>(0.180)</td>
<td>(0.214)</td>
<td>(0.324)</td>
</tr>
<tr>
<td>Np_grants_{pc}</td>
<td>0.00004**</td>
<td>-0.00004</td>
<td>0.00001</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Nec_{pc}</td>
<td>0.00023*</td>
<td>-0.00093*</td>
<td>0.00023</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Interest_{pc}</td>
<td>0.00004</td>
<td>-0.00006*</td>
<td>0.00013</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Agriculture</td>
<td>0.00012**</td>
<td>0.00025</td>
<td>0.00015*</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.003)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Unreg Manufacturing</td>
<td>0.00330</td>
<td>-0.00056</td>
<td>-0.01600</td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td>(0.004)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>Mining</td>
<td>0.00088</td>
<td>-0.00185</td>
<td>0.00442</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.005)</td>
<td>(0.012)</td>
</tr>
<tr>
<td>Urbanization</td>
<td>0.00192</td>
<td>0.00293</td>
<td>0.00642</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.002)</td>
<td>(0.009)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.10515*</td>
<td>1.21565**</td>
<td>2.69698*</td>
</tr>
<tr>
<td></td>
<td>(0.618)</td>
<td>(0.450)</td>
<td>(1.440)</td>
</tr>
<tr>
<td>Observations</td>
<td>535</td>
<td>337</td>
<td>198</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.971</td>
<td>0.983</td>
<td>0.965</td>
</tr>
<tr>
<td>Number of states</td>
<td>29</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>Serial correlation test</td>
<td>F(1,28) = 10.191</td>
<td>F(1,17) = 36.159</td>
<td>F(1,10) = 5.799</td>
</tr>
<tr>
<td></td>
<td>(0.0035)</td>
<td>(0.0000)</td>
<td>(0.0368)</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1
<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln (sales tax/ VAT per capita lag)</td>
<td>0.45996***</td>
<td>0.60711***</td>
<td>0.37000*</td>
</tr>
<tr>
<td></td>
<td>(0.159)</td>
<td>(0.086)</td>
<td>(0.180)</td>
</tr>
<tr>
<td>$D_{\text{VAT}}$</td>
<td>0.00353</td>
<td>0.08456**</td>
<td>-0.12056</td>
</tr>
<tr>
<td></td>
<td>(0.046)</td>
<td>(0.031)</td>
<td>(0.128)</td>
</tr>
<tr>
<td>Time trend</td>
<td>0.01035</td>
<td>0.01536</td>
<td>0.09152</td>
</tr>
<tr>
<td></td>
<td>(0.029)</td>
<td>(0.016)</td>
<td>(0.086)</td>
</tr>
<tr>
<td>ln(GSDP$_{pc}$)</td>
<td>0.41028</td>
<td>0.26883***</td>
<td>-0.13286</td>
</tr>
<tr>
<td></td>
<td>(0.271)</td>
<td>(0.115)</td>
<td>(0.714)</td>
</tr>
<tr>
<td>ln(Pop)</td>
<td>0.20594</td>
<td>0.27536</td>
<td>-1.16388</td>
</tr>
<tr>
<td></td>
<td>(0.475)</td>
<td>(0.465)</td>
<td>(1.054)</td>
</tr>
<tr>
<td>Np_grants$_{pc}$</td>
<td>0.00009</td>
<td>-0.00001</td>
<td>0.00007</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>NEC$_{pc}$</td>
<td>0.00011</td>
<td>0.00166*</td>
<td>0.00008</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.001)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Interest$_{pc}$</td>
<td>0.00010</td>
<td>-0.00002</td>
<td>0.00027</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Agriculture</td>
<td>0.00053**</td>
<td>0.00097</td>
<td>0.00066**</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.003)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Unreg Manufacturing</td>
<td>-0.00582</td>
<td>0.00776</td>
<td>-0.10057*</td>
</tr>
<tr>
<td></td>
<td>(0.017)</td>
<td>(0.009)</td>
<td>(0.052)</td>
</tr>
<tr>
<td>Mining</td>
<td>0.00554</td>
<td>0.00960</td>
<td>-0.03805</td>
</tr>
<tr>
<td></td>
<td>(0.015)</td>
<td>(0.008)</td>
<td>(0.035)</td>
</tr>
<tr>
<td>Urbanization</td>
<td>-0.01718*</td>
<td>-0.00159</td>
<td>-0.04050**</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.006)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.63643</td>
<td>-0.64541</td>
<td>3.01584</td>
</tr>
<tr>
<td></td>
<td>(2.322)</td>
<td>(1.190)</td>
<td>(4.940)</td>
</tr>
<tr>
<td>Observations</td>
<td>454</td>
<td>276</td>
<td>178</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.887</td>
<td>0.965</td>
<td>0.866</td>
</tr>
<tr>
<td>Number of states</td>
<td>29</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>Serial correlation test</td>
<td>F(1,28) = 7.609</td>
<td>F(1,17) = 35.459</td>
<td>F(1,10) = 6.498</td>
</tr>
<tr>
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<td>(0.0101)</td>
<td>(0.0000)</td>
<td>(0.0289)</td>
</tr>
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</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Table 6: Results using the FE estimator with AR (1) errors

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>All states</th>
<th>Non-special states</th>
<th>All states</th>
<th>Non-special states</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln (ITR per capita)</td>
<td>0.00337</td>
<td>0.02046</td>
<td>0.01160</td>
<td>0.06662**</td>
</tr>
<tr>
<td>(0.027)</td>
<td>(0.021)</td>
<td>(0.068)</td>
<td></td>
<td>(0.032)</td>
</tr>
<tr>
<td>Time trend</td>
<td>0.04184***</td>
<td>0.03445***</td>
<td>0.03510*</td>
<td>0.03522**</td>
</tr>
<tr>
<td>(0.008)</td>
<td>(0.010)</td>
<td>(0.019)</td>
<td></td>
<td>(0.014)</td>
</tr>
<tr>
<td>ln(GSDP per capita)</td>
<td>0.35865***</td>
<td>0.23627***</td>
<td>0.39117***</td>
<td>0.24999***</td>
</tr>
<tr>
<td>(0.046)</td>
<td>(0.063)</td>
<td>(0.098)</td>
<td></td>
<td>(0.091)</td>
</tr>
<tr>
<td>ln(Pop)</td>
<td>-0.03340</td>
<td>-0.16182</td>
<td>0.29518</td>
<td>-0.15762</td>
</tr>
<tr>
<td>(0.155)</td>
<td>(0.243)</td>
<td>(0.341)</td>
<td></td>
<td>(0.385)</td>
</tr>
<tr>
<td>Np_grants per capita</td>
<td>0.00005***</td>
<td>-0.00004</td>
<td>0.00011***</td>
<td>-0.00001</td>
</tr>
<tr>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
<td>(0.000)</td>
</tr>
<tr>
<td>Nec_per capita</td>
<td>0.00020**</td>
<td>-0.00085</td>
<td>0.00005</td>
<td>0.00252</td>
</tr>
<tr>
<td>(0.000)</td>
<td>(0.002)</td>
<td>(0.000)</td>
<td></td>
<td>(0.003)</td>
</tr>
<tr>
<td>Interest per capita</td>
<td>0.00006*</td>
<td>-0.00007***</td>
<td>0.00014</td>
<td>-0.00003</td>
</tr>
<tr>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
<td>(0.000)</td>
</tr>
<tr>
<td>Agriculture</td>
<td>0.00020***</td>
<td>0.00061</td>
<td>0.00075***</td>
<td>0.00195</td>
</tr>
<tr>
<td>(0.000)</td>
<td>(0.002)</td>
<td>(0.000)</td>
<td></td>
<td>(0.004)</td>
</tr>
<tr>
<td>Unreg Manufacturing</td>
<td>0.01218</td>
<td>0.00277</td>
<td>-0.00826</td>
<td>0.01008</td>
</tr>
<tr>
<td>(0.009)</td>
<td>(0.006)</td>
<td>(0.024)</td>
<td></td>
<td>(0.010)</td>
</tr>
<tr>
<td>Mining</td>
<td>0.00731</td>
<td>0.00087</td>
<td>-0.00699</td>
<td>0.00045</td>
</tr>
<tr>
<td>(0.008)</td>
<td>(0.006)</td>
<td>(0.020)</td>
<td></td>
<td>(0.009)</td>
</tr>
<tr>
<td>Urbanization</td>
<td>0.00174</td>
<td>0.00266</td>
<td>-0.01513</td>
<td>-0.00287</td>
</tr>
<tr>
<td>(0.004)</td>
<td>(0.002)</td>
<td>(0.010)</td>
<td></td>
<td>(0.005)</td>
</tr>
<tr>
<td>ln (ITR per capita lag)</td>
<td>0.32504***</td>
<td>0.55394***</td>
<td>0.26384***</td>
<td>0.54768***</td>
</tr>
<tr>
<td>(0.043)</td>
<td>(0.050)</td>
<td>(0.047)</td>
<td></td>
<td>(0.051)</td>
</tr>
<tr>
<td>ln (Sales tax per capita lag)</td>
<td>0.18058</td>
<td>0.57794</td>
<td>0.20357</td>
<td>0.30881</td>
</tr>
<tr>
<td>(0.258)</td>
<td>(0.636)</td>
<td>(0.603)</td>
<td></td>
<td>(0.822)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.00174</td>
<td>0.00266</td>
<td>-0.01513</td>
<td>-0.00287</td>
</tr>
<tr>
<td>(0.004)</td>
<td>(0.002)</td>
<td>(0.010)</td>
<td></td>
<td>(0.005)</td>
</tr>
<tr>
<td>Observations</td>
<td>506</td>
<td>319</td>
<td>425</td>
<td>258</td>
</tr>
<tr>
<td>Number of states</td>
<td>29</td>
<td>18</td>
<td>29</td>
<td>18</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Table 7: Results using the IV estimator of the First-difference model

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>All States</th>
<th>Non-special states</th>
<th>All states</th>
<th>Non-special states</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ln (ITR pc)</td>
<td>Ln (ITR pc)</td>
<td>Ln (Sales tax pc)</td>
<td>Ln (Sales tax pc)</td>
</tr>
<tr>
<td>LD.ln (ITR pc)</td>
<td>-0.11055 **</td>
<td>0.57471 **</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.117)</td>
<td>(0.293)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L3D.ln (ITR pc)</td>
<td>0.06398</td>
<td>0.04434</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.041)</td>
<td>(0.065)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D unjust</td>
<td><strong>0.01620</strong></td>
<td>-0.04118</td>
<td>-0.00729</td>
<td>0.06506 *</td>
</tr>
<tr>
<td></td>
<td>(0.029)</td>
<td>(0.034)</td>
<td>(0.079)</td>
<td>(0.035)</td>
</tr>
<tr>
<td>ln(GSDP_pc)</td>
<td>0.11936</td>
<td>-0.06481</td>
<td>0.10444</td>
<td>0.31436 *</td>
</tr>
<tr>
<td></td>
<td>(0.120)</td>
<td>(0.164)</td>
<td>(0.367)</td>
<td>(0.176)</td>
</tr>
<tr>
<td>ln(Pop)</td>
<td>-0.82210 ***</td>
<td>-0.89060</td>
<td>-1.93123 **</td>
<td>0.22455</td>
</tr>
<tr>
<td></td>
<td>(0.311)</td>
<td>(0.797)</td>
<td>(0.890)</td>
<td>(0.853)</td>
</tr>
<tr>
<td>Np_grants_pc</td>
<td>0.00002</td>
<td>0.00004</td>
<td>0.00012 ***</td>
<td>0.00000</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Nec_pc</td>
<td>-0.00013</td>
<td>-0.00325</td>
<td>-0.00010</td>
<td>-0.00102</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.003)</td>
<td>(0.000)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Interest_pc</td>
<td>0.00009 *</td>
<td>0.00000</td>
<td>0.00003</td>
<td>0.00002</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Agriculture</td>
<td>0.00003</td>
<td>0.00725 *</td>
<td>0.00013</td>
<td>0.00124</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.004)</td>
<td>(0.000)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>Unreg Manufacturing</td>
<td>0.00589</td>
<td>0.01881</td>
<td>-0.01353</td>
<td>0.01856</td>
</tr>
<tr>
<td></td>
<td>(0.013)</td>
<td>(0.013)</td>
<td>(0.037)</td>
<td>(0.015)</td>
</tr>
<tr>
<td>Mining</td>
<td>-0.01161</td>
<td>-0.04215 **</td>
<td>-0.05011</td>
<td>-0.00841</td>
</tr>
<tr>
<td></td>
<td>(0.013)</td>
<td>(0.017)</td>
<td>(0.034)</td>
<td>(0.018)</td>
</tr>
<tr>
<td>Urbanization</td>
<td>0.01767 *</td>
<td>0.01124</td>
<td>-0.00992</td>
<td>0.00868</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.011)</td>
<td>(0.029)</td>
<td>(0.014)</td>
</tr>
<tr>
<td>Education_pc</td>
<td>0.00009 ***</td>
<td>0.00026 ***</td>
<td>0.00002</td>
<td>0.00014 *</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>LD.ln (Sales tax pc)</td>
<td>-0.12659 ***</td>
<td>0.06000 *</td>
<td>0.16202 ***</td>
<td>0.08118 *</td>
</tr>
<tr>
<td></td>
<td>(0.023)</td>
<td>(0.033)</td>
<td>(0.060)</td>
<td>(0.048)</td>
</tr>
<tr>
<td>L3D.ln (Sales tax pc)</td>
<td>-0.08885</td>
<td>0.03467</td>
<td>0.129</td>
<td>0.3471</td>
</tr>
<tr>
<td></td>
<td>(0.129)</td>
<td>(0.347)</td>
<td>(0.49)</td>
<td>(0.59)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.00281</td>
<td>-0.03246</td>
<td>0.000281</td>
<td>-0.03246</td>
</tr>
<tr>
<td></td>
<td>(0.049)</td>
<td>(0.059)</td>
<td>(0.049)</td>
<td>(0.059)</td>
</tr>
<tr>
<td>Observations</td>
<td>457</td>
<td>286</td>
<td>357</td>
<td>214</td>
</tr>
<tr>
<td>Number of states</td>
<td>29</td>
<td>18</td>
<td>29</td>
<td>18</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
CHAPTER TWO - DID INDIA’S SUB-NATIONAL VAT IMPROVE ECONOMIC EFFICIENCY?

1 ABSTRACT

We investigate the efficiency of a recently implemented sub-national value-added tax (VAT) in India between the years 2003 and 2008. A system of state-level VATs in India was expected to eliminate the cascading tax burden associated with a long-dominate turnover tax on commodities by solving the problem of double taxation which had considerably impaired the efficiency of the sales tax system of the states before the introduction of the VAT. We believe if cascading tax burden is wiped out with the replacement of a turnover type sales tax with a consumption-type VAT, then the price growth across commodities must decrease due to a fall in the real tax burden. This in turn would lead to a simultaneous increase in the real private consumption of commodities. We analyze the impact of the VAT on the prices and consumption of multiple commodity groups in rural and urban areas using time series data of household level consumption expenditure surveys collected by a federal government organization. As expected, we find the biggest impact of the VAT on consumption and prices of the durable goods indicating the biggest efficiency gain in these goods.

2 INTRODUCTION

Value added tax (VAT) is a multistage sales tax and is collected on the ‘value added’ at every production-distribution stage of a good or a service. The retail value of a good is equal to the sum of the added values at each stage of production. Therefore a consumption–type VAT and a retail sales tax (RST) must raise equivalent tax revenues if applied at the same rate on the same
goods and services. However, in practice, a VAT is considered superior to a RST as a RST is more vulnerable to tax evasion and avoidance. With a RST, unlike VAT, the tax revenue is lost completely if the tax is evaded at the final point of sale. A VAT is also considered compliance incentivizing because under a VAT regime, wholesalers and retailers have to ensure that the traders they deal with pay the tax in order to be eligible for input tax credit. So a VAT is self-policing and is better at exposing forged accounts and an informal economy as compared to a RST (Bird (2005) and Agha et. al (1996)). For the same reason, a VAT is generally regarded as a more promising consumption tax for developing countries where the size of the informal sector is bigger. For the reasons discussed above, at the national level, a VAT has been widely accepted by tax policy experts\(^{29}\) as one of the most efficient forms of indirect taxation. However its performance at the sub-national level remains far from clear. Researchers question the efficiency of a sub-national VAT for various reasons including high efficiency and administrative costs associated with the taxation of cross border trade\(^{30}\) and the non-uniformity of the VAT rates across the states or regions within a country\(^{31}\). Moreover it is hard to empirically evaluate the performance of a sub-national VAT simply because it is not very commonly found in practice.

India is among the only three countries in the world which has embraced a sub-national VAT. The other two countries to ever have adopted a sub-national VAT are Canada and Brazil. Canada’s success with VAT is largely attributed to its exceptionally high tax administrative


\(^{30}\) The application of a VAT on the interstate trade is often pointed out, by tax policy experts, as the most serious practical issue with the use of a sub-national VAT (Bird et. al (1998)). There is no general consensus on the best way to apply a destination-based VAT to the interstate trade. (McLure (2005) explains why a sales tax with a destination principle is more desirable). Bird (1993) points out other problems related to a sub-national VAT. These include coordination of federal and regional taxes, loss of macroeconomic control and high administrative and compliance costs.

\(^{31}\) McLure (2000) emphasizes the desirability of allowing state governments to charge their own VAT rates. The logical reasoning behind the existence of the non-uniform rates is to preserve the regional government’s autonomy.
quality. Since few countries have tax administrations of comparable quality, it is widely believed that Canada’s success cannot be replicated in other countries, particularly in low- and middle-income countries with inadequately developed tax administration systems. Therefore, empirically examining India’s experience with a sub-national VAT will not only help to better understand the impact of an important tax policy reform in India but will also inform important tax policy decision-making at the sub-national level in other developing countries.

The adoption of the VAT was primarily expected to improve economic efficiency through the reduction in the level of tax cascading. The Government of India believed that the VAT will rationalize the overall tax burden and bring down the general level of prices. The turnover type sales tax which existed prior to the VAT created severe problems of double taxation on the final consumption goods. The forbidding distortionary costs stemming from the double taxation were expected to fall substantially following the adoption of the VAT. Therefore it is meaningful to investigate if the VAT of India, in its existing form, managed to reduce the cascading tax burden on commodities.

The main research question at hand is whether the state-level VATs improved the efficiency of India’s indirect tax-system by reducing the level of tax cascading. We are able to gauge this in the following manner. If the VAT managed to weed-out or diminish the cascading tax burden, we would observe a fall in the real price level of commodities in the years following its adoption. With the reduction in the level of tax cascading, the real value of sales taxes collected on commodities, in the form of the VAT, must fall causing a fall in the price growth. In addition, this fall in the prices would trigger a subsequent increase in the overall economic activity and

\[\text{Refer to Bird et. al (2001).}\]

\[\text{The states of India can levy tax only on the final consumption goods only. Most of the services have always been taxed by the federal government in India. Only very few services are taxed by the state governments and there exist separate taxes on them such as entertainment tax and luxury tax.}\]
higher growth in the real private consumption. In this paper, we not only capture the change in real prices of commodities from VAT, we also capture the VAT driven growth in the real private consumption, if any, by using the state-level household surveys conducted in India. The important question is, even if the prices fell with the adoption of VAT, was the fall in prices sufficient enough to improve the economic efficiency of the tax system and the welfare of the consumers. By tracking the real private consumption at the micro-level, we are able to address this question. We conduct a micro-level analysis of the trends in real prices and consumption across multiple commodities for urban and rural regions. The details of the price and consumption analyses are explained in detail below in the results section. As far as we know, no previous research work has analyzed the impact of India’s VAT on its level of tax cascading.

The paper proceeds as follows. Section 3 broadly reviews the state-level sales tax system of India before VAT and outlines the salient features of the existing state-level VATs, Section 4 outlines the theoretical model, Section 5 explains the data and the methodology and Section 6 presents the results and concludes.

3 BACKGROUND

In India, the state governments collect sales taxes only on commodities and not on services. The type of commodity sales tax which existed in the states of India before VAT was highly distortionary because of multiple reasons. One of the biggest problems was that it resulted in a cascading tax burden. This was mainly because the tax instrument used was a turnover type sales tax and it taxed both the input and the final consumption goods. This cascading effect was further pronounced due to the presence of additional taxes collected by the states on the same
commodities such as surcharge on sales tax, additional surcharge and entry tax\textsuperscript{34}. Other primary source of inefficiency in the old sales tax system was the multiplicity of rates across commodities within a state. This led to heterogeneous tax rates not only across states but also across commodities within the states. Under the old system, it was not uncommon for states to have 17 to 20 categories of commodity tax rates ranging from as low as zero percent to as high as seventy percent\textsuperscript{35}. Since the taxes cascaded, the effective tax rates were much higher than the applicable rates. Such a distorted taxation system was bound to impose high deadweight loss and administrative and compliance costs.

A much awaited tax reform made its way through the introduction of the state-level VATs. The use of VATs simplified the old system, removed the multiplicity of rates and made the overall tax rates uniform across commodities and states. With the adoption of the VAT, states also got rid of their additional unnecessary taxes such as the surcharge on sales tax\textsuperscript{36}. Finance Minister of India in his budget speech of 1993 / 94 stated that a broad agreement would have to be reached between the central and the various state governments regarding the uniform design of the state –level VATs. In May 1994, a committee of the state finance ministers was formed to outline a uniform design of the VAT across states. On 17 January 2005, the Committee released a White Paper\textsuperscript{37} which revealed the salient features of the sub-national VAT. It laid down the foundation of a common model based on which each state was expected to develop its own VAT legislation. This way the states got to choose the specific features in the design under the basic rules set by the central government, for example the states could choose the specific list of the exempted goods. The Committee specified three basic rates under the VAT system. These

\textsuperscript{34} See Purohit (2001) and Bagchi (2005)
\textsuperscript{35} See Purohit (2001), Sthanumoorthy (2006). Tax rates as high as 70\% were charged on beer, wine and other types of alcohol.
\textsuperscript{36} Few states continue to hold onto the entry taxes they used to charge before moving towards VAT.
\textsuperscript{37} White paper on state level value added tax (Jan 2005)
included a standard rate of 12.5% and a reduced rate of 4%. The reduced rate was applicable to most of the items of basic necessities.\(^{38}\) The third rate of 1% rate was applicable on gold and silver ornaments. All the states of India uniformly adopted the three VAT rates. These rates exist in addition to a specific category of exempted goods\(^ {39}\).

The state of Haryana introduced a VAT on its own initiative in 2003 and became the first state to adopt it. According to the White Paper, all the other states agreed to bring in the VAT on April 1, 2005 but later seven states backed out. Five of these seven states adopted the VAT in the following year. By the year 2008 all the 29 states (including the national capital territory) had replaced their turnover type sales taxes on goods with the VAT. The political factors brought in the timing variation in the adoption of the VAT by the states.

4 **THEORETICAL MODEL**

The theoretical model presented in this section shows how prices and tax revenues behave under a retail sales tax and a turnover tax. A turnover tax or a multi-stage sales tax is collected on every stage of production whereas a single-stage sales tax is imposed at only one stage of production. A RST is a single-stage sales tax which is imposed on a retailer. However, other variants of a single-stage tax include scenarios where a sales tax is collected from a producer or a wholesaler instead of a retailer. Our theoretical model first compares the per unit price of a good and the total tax revenue collected on that good when a single-stage sales tax is levied at

---

\(^{38}\) These include goods such as medicines, agricultural and industrial inputs, capital goods etc. This category includes 270 goods approximately on average.

\(^{39}\) The states have the discretion to decide which goods to exempt from VAT. Although the White paper stated that the exempted goods would include 46 commodities including natural and unprocessed goods in the unorganized sector. The states were allowed to choose 10 items of these goods. However, the states do not strictly follow the number of exemption goods restriction specified by the central government.
different points of production. Following are the notations we will use in the model presented below:

Let P stand for producer, W stand for wholesaler, and R stand for retailer.

If $a =$ price markup

$b =$ marginal costs (MC)

$t =$ per unit tax charged on a good

$T =$ total tax revenue

$X =$ units of good produced, then Table 8 below illustrates the level of tax inclusive price per unit and tax revenue under different scenarios.

Table 8 shown below illustrates that the maximum tax revenue is collected under scenario C when the single-stage sales tax is collected from the retailer. It also shows that the tax inclusive price per unit would be the same under each scenario in the special case where $t_p = t_w = t_r$

<table>
<thead>
<tr>
<th>Point of collection of a single-stage sales tax</th>
<th>Tax inclusive price per unit of a good</th>
<th>Total tax revenue collected on the good</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario A: When the sales tax is imposed on the producer</td>
<td>$P = b (1 + t_p)(1 + a_w)(1 + a_r)$</td>
<td>$T_p = t_p b X$</td>
</tr>
<tr>
<td>Scenario B: When the sales tax is imposed on the wholesaler</td>
<td>$P = b (1 + a_w)(1 + t_w)(1 + a_r)$</td>
<td>$T_w = t_w b (1 + a_w) X$</td>
</tr>
<tr>
<td>Scenario C: When the sales tax is imposed on the retailer</td>
<td>$P = b (1 + a_w)(1 + a_r)(1 + t_r)$</td>
<td>$T_r = t_r b (1 + a_w)(1 + a_r) X$</td>
</tr>
</tbody>
</table>

Notes:
1. $t_p$ is the per unit tax imposed on the producer, $t_w$ is the per unit tax imposed on the wholesaler and so on.
2. $T_p$ is the total tax revenue collected on a good by imposing a tax on the producer. Similarly, $T_w$ is the total tax revenue collected on a good by imposing a tax on the wholesaler and so on.
Next, we move on to derive the tax inclusive price per unit of good and total tax revenue collected on it under a turnover tax. As explained above, a turnover tax is collected on every production stage. As a result, it inefficiently inflates the per unit price of a good and generates a higher level of tax revenue. Under the turnover tax, let $t_c$ denote the per unit tax charged on every production stage of a good and let $T_c$ denote the total revenue collected under this tax system.

Given this, tax inclusive per unit price of a good is shown by the following expression:

\[
\text{Price inclusive of tax} = b (1 + t_c)(1 + a_w)(1 + t_c)(1 + a_r)(1 + t_c)
\]

\[
\text{Price inclusive of tax} = b (1 + a_w)(1 + a_r)(1 + t_c)^3 \tag{1}
\]

Similarly we can estimate the tax revenue under a turnover tax which is given by the following equation:

\[
T = t_c bX + t_c bX (1 + t_c)(1 + a_w) + t_c bX (1 + t_c)^2(1 + a_w)(1 + a_r) \tag{2}
\]

The price equation under scenario C (which is a RST) in Table 8 above illustrates the per unit price of the good when it is taxed once. On the other hand, equation (1) above illustrates the price of a good when the good is taxed multiple times under a turnover tax. Equation (1) shows the tax cascading phenomena on the price from the use of a turnover tax. As demonstrated by this equation, charging a tax at every stage of production results in a tax on a tax and inflates prices. This simple theoretical model confirms our economic intuition that a cascading tax burden considerably magnifies the general price growth. In addition, the model illustrates that the exact number of times the price of a good is taxed under a multi-stage sales tax depends on the number of production stages. The intuition derived from this simple model is that the greater the number of production steps, the greater will be the level of price inflation. Therefore the
cascading effect of a turnover tax magnifies with the number of production stages. We will delve into this intuition to better understand the price and the consumption results presented in section 6 of this paper.

5 DATA AND METHODOLOGY

5.1 DATA

We are using three waves of the large sample rounds of the state- and household-level consumer expenditure survey (CES) conducted by the National Sample Survey organization (NSSO). NSSO, an organization of the central government, conducts these large sample rounds of the surveys once in every five years. The three waves used in our data belong to the years 1999, 2004 and 2009. Consequently, the first two years identify the price and consumption trends in the period before the adoption of the VAT\(^{40}\) and the third year identifies the price and consumption trends in the period after the adoption of the VAT.

The CES collects information on the consumption expenditures of the sample households for a variety of goods and services at the state level, separately for the rural and urban regions. In addition, the surveys also record the level of quantity consumed for some of these goods and services. More specifically, the survey records consumption on 142 food related goods and services, 19 addictive substances including tobacco, alcohol and illicit drugs, 15 types of fuel and energy generating goods and services and 79 types of durables goods. The surveys also record expenditures on medical and education related goods and services. To analyze the impact of the VAT on real consumption we use the household-level consumption expenditures per capita recorded in the surveys and adjust these estimates for inflation. To gauge the responsiveness of

\(^{40}\text{One of the 29 states in India adopted VAT in the year 2003.}\)
the commodity prices to the VAT, we use the state- and the household-level prices of individual commodities. The commodity prices used in our analyses are estimated from within the survey data. Since these surveys record the quantity consumed by the households of certain goods, we are able to estimate the prices of these goods by dividing the household expenditures by quantity consumed. Further details on the identification strategy are presented in the results section below.

We adjust the nominal consumption expenditures of households for inflation by using the CPI numbers estimated by the Ministry of Labour, Government of India. The state-level CPI data includes a general CPI index which summarizes price trend of all the goods and services commonly consumed. In addition, the state-level CPI data provides separate estimates for the urban and the rural areas and also for different groups of goods and services. For example, the nominal food consumption expenditure for a given state in the urban sector is adjusted for inflation by using the CPI food estimate for the urban area of that state.

5.2 Real Consumption Expenditure Analysis

First, we take a look at the impact of the VAT on the real consumption of households. We estimate our regression equation (3) shown below, separately for the rural and the urban areas across 18 commodity groups. The dependent variable, \( C_{ist}^\alpha \), is the log of real consumption expenditure per capita for household \( i \) in state \( s \) and year \( t \). A household \( i \) belongs to a sector \( \alpha \) (urban or rural) in a given state. We analyze \( C_{ist}^\alpha \) across 18 broad groups of commodities. The variable of interest is the coefficient of \( v_{st} \). \( v_{st} \) is a dummy variable and it takes a value one if state \( s \) has VAT in year \( t \). We include log of gross state domestic product (GSDP) per capita as an explanatory variable in our regressions. This GSDP variable is specific to a sector \( \alpha \) and therefore it is equal to GSDP generated from agriculture and other rural activities in the analysis.
of the rural sector. The urban sector GSDP is estimated by subtracting the rural sector GSDP from the overall GSDP of the state. The vector $\theta$ in equation (3) includes the explanatory variables we use to control for the income effect of households. We also include the state and year fixed effects in our regression specifications to control for any state specific and time trends.

$$C_{ist}^\alpha = \beta v_{st} + \rho GSDP_pe_{st}^\alpha + \tau \theta_{ist}^\alpha + \mu_s + \gamma_t + \epsilon_{ist}^\alpha$$  (3)

The dependent variable, real consumption expenditure per capita identifies the consumption expenditure on various goods over the last 30 days, except the long-term durable goods. The expenditure on the long-term durable goods is recorded over the last 365 days.

5.3 Real Price Analysis

Next, we look at the impact of the VAT on the real prices. We generate the state- and household-level prices of individual commodities from within the survey data to conduct this analysis.

We estimate the price regressions shown by equation (4) below, separately for the rural and the urban areas for the 18 more developed states of India. The dependent variable, $P_{ist}^\alpha$, is the log of per unit price paid for a commodity by household $i$ in state $s$ and year $t$. A household $i$ belongs to a sector $\alpha$ (urban or rural) in a given state $s$. We analyze $P_{ist}^\alpha$ across 32 individual commodities in the rural and the urban areas. These 32 individual commodities represent the most popularly consumed goods in the 18 broad commodity categories used to analyze the consumption

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41 Previous literature using NSSO data uses monthly per capita expenditure as a proxy for household income (Kumar et al (2011)). We use this and additional variables to control for the income of households. The additional variables control for the type of employment of the household members, land ownership and the primary cooking and lighting sources used by a household. We believe all these variables indicate the level of a household’s wealth.

42 Some of the selected commodities differ across the rural and urban areas depending on their popularity of consumption.
expenditure results. Again, the variable of interest is the coefficient of \( v_{st} \) where \( v_{st} \) is a dummy variable and takes a value one if state \( s \) has moved to the VAT in year \( t \). To control for inflationary trends in overall prices, we include the average lending rate offered by banks to meet the short- and medium-term financing needs of the private sector as an explanatory variable in the price regressions. The vector \( \theta \) in equation (3) includes the explanatory variables used to control for the income effect of households. We also include the state and year fixed effects\(^{43}\) in our regression specifications.

\[
P_{ist}^\alpha = \beta v_{st} + \rho \text{Interest Rate}_{t} + \tau \theta_{ist}^\alpha + \mu_{s}^\alpha + \gamma_{t}^\alpha + \epsilon_{ist}^\alpha \tag{4}
\]

6 RESULTS AND CONCLUSION

6.1 RESULTS

The tables 11 to 16 report the consumption results using equation (3) for the urban areas in the 18\(^{44}\) more developed states of India. These 18 states include the national capital territory of Delhi and the population in these states together represents 90% of India’s population. In India these states are known as the ‘non-special’ category states and the remaining 11 states are addressed as the ‘special category’ states. We exclude the special category states from our estimation because these states are very different from the other 18 states. They are very sparsely populated, have very limited tax revenue generating capacity of their own and relatively few households are sampled from these states in the NSSO survey rounds.

Tables 9 and 10 show the samples means of the real consumption per capita (for all the commodity groups) in all the 18 states, before and after the adoption of the VAT. These

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\(^{43}\) We believe that we are able to control for any changes in the quality through the inclusion of state and year fixed effects.

\(^{44}\) Three of these 18 states split into two each, in the year 2000. Since our time series data uses years before and after the split, we continue to treat the split states as one for our analysis.
summary statistics tables show that, in general, the real consumption expenditure per capita is high for the urban areas as compared to the rural areas. The commodity groups with high consumption include food, medical goods and services and long-term durable goods (including household appliances and jewelry). For long-term durable goods such as recreation goods, furniture and jewelry we have data for the year 2004 (before VAT) and 2009 (after VAT) only. Data for year 1999 is not available on these goods. Table 10 shows that the real expenditure on some long-term durable goods category namely furniture and recreation decreases in the year after VAT is adopted. Tables 17 to 22 present the consumption results for equation (3) for the rural areas in the 18 more developed states of India. The last row of the columns in the tables indicate whether state / year fixed effects are included in the specification. Tables 23 and 24 present the price results for equation (4) for the urban and the rural areas respectively.

Before we discuss the significance and the magnitude of the VAT coefficients, here is a quick reminder of the relationship we expect between the real consumption and prices of commodities and the VAT. In general, we suspect a positive (negative) impact of the VAT on real consumption (real prices) of those commodities which were brought under the system of VAT rates and/ or whose production is characterized by multiple production steps. We expect that the efficiency of the sales tax system should improve with the use of a VAT not only because of the reduction in the level of tax cascading, but also because of the elimination of multiple tax rates which existed under the previous sales tax system. The introduction of a state-level VAT in India brought down the number of sales tax rates used by the states from as large as 20 to 3 basic rates for most of the goods. As mentioned before these 3 basic rates of the VAT were uniformly adopted by all the states. However, the states were given some freedom to determine the list of commodities to be included in the tax-exempted category (Bagchi (2005)).
With the introduction of VAT, the central government specified a floor rate of 20% on a special list of goods which include alcohol, petrol, diesel and other fuels. The states were given the discretion to determine the actual rate on each of these commodities. Most of the states taxed these goods at rates ranging from 20% to 35%. Before the VAT, the tax rates on these goods ranged from 20% to 80%. Although, the tax rates reduced on some of these goods in some states with adoption of the VAT, tax policies on these goods are still complicated and therefore it is hard to derive inferences on the behavior of their prices and consumption under the VAT. The list of commodities included under tax-exempted category and other VAT rates can be found in the documents released by each individual state at the time of the introduction of the VAT. These documents are called VAT ACTS.

Using the intuition from the theoretical model presented in section 4, we know that the level of tax cascading is higher among those goods which involve multiple production steps. Therefore, we predict that our results should capture a bigger reduction in the cascading effect (in the form of an increase in real consumption and a decrease in real prices) among commodities involving large number of production stages. Under the India’s VAT system, the registration of individual dealers/ manufacturers was voluntary if their annual sales turnover was equal to or below Rs 5 million. This implies that the impact of the VAT on the price and consumption of a good is also tied to the size of the dealers involved in its production since the size will determine if a given dealer will enter the VAT system or not. Consequently, we predict a greater increase (decrease) in the real consumption (price) of the goods which are manufactured by large-sized dealers.

45 For example, tax on beer and wine decreased in some states from 70 - 80% to 30-35%.
46 Also the state VAT does not allow for input tax deductions on petrol, natural gas and other fuels as these are not treated as inputs by the state governments.
47 Refer to the following link to the states’ VAT ACTS: http://empcom.gov.in/index.aspx
dealers and also involve multiple production steps. The goods which best fit these descriptions are the long-term durable goods.

Now we derive some intuition on the comparison of the results of the urban areas with those of the rural areas. In general, we expect a greater presence of the small-sized manufacturers/dealers in the rural areas, who fall below the threshold limit of Rs 5 million, as compared to the urban areas. Since India’s VAT fails to bring these producers into its formal system, they would cause multiple breaks in the VAT chain. Such breaks in the VAT chain can cast serious doubts on its performance. Therefore, it is reasonable to assume that the VAT on goods in the urban areas would work more efficiently than the VAT on the same goods in the rural areas. As a result, we are more likely to capture a bigger increase (decrease) in real consumption (price) of commodities produced and sold in the urban areas.

Given the prediction of the results outlined above, we now take our attention to the VAT coefficients in the result tables. The results in Table 11 show that the VAT significantly increases the food consumption expenditure in urban areas by 7.7%. *Food* identifies the expenditure on the unprocessed and the processed food. It includes the consumption of staple food such as rice, lentils and cereals and it also includes the consumption of nutritive and expensive food such as green vegetables, fruits, dairy products, meat and fish, bakery goods like cakes and pastries and dried fruits and nuts such as almonds. In majority of the states, the unprocessed food items were exempted from the VAT and the processed food was taxed at 4% VAT rate. With the adoption of VAT the effective rates on all food items reduced as compared to those before VAT and hence we find evidence of a reduction in tax cascading. VAT also significantly reduces the real prices of majority of the food items in the urban and the rural areas as shown in Tables 23 and 24. VAT has the biggest significant decrease on the urban prices of onion, clear butter, milk, cooking oil
and groundout (which is a type of dry fruit). For instance, the adoption of VAT significantly reduces the price of milk per litre by 5.7%. Note that the impact of VAT is more pronounced on the nutritive and the more processed food items like milk and groundnut. This finding is consistent with our hypothesis that we should observe a greater efficiency on the more processed goods due to a bigger drop in the level of tax cascading on these goods.

The urban prices of eggs, potato, suji and Indian spices (turmeric) are falling with VAT also but their coefficients are not precisely estimated. There is an exception of one or two food items whose prices are not falling but rising with VAT. For example, urban price of salt is significantly increasing with VAT. This makes sense because the sales tax system which existed before VAT did not tax processed salt. However the VAT taxes it at the 4% rate in majority of the states. Same is true for processed rice. We do not capture an equally significant impact of the VAT on the overall food consumption in the rural areas (Table 17), although the sign of the coefficient is as expected. The impact of the VAT on rural prices is less significant as compared to urban prices as shown in Tables 23 and 24. These findings are also consistent with our hypothesis that we would find smaller efficiency gains in the rural areas because of the higher probability of multiple breaks in the VAT chain.

The results capture a significant and a positive effect of the VAT on the consumption of addictive substances in the urban areas. This coefficient becomes insignificant for rural areas as seen from Table 17. \textit{Addictive Substances} identify the consumption of tobacco in various forms, alcohol and drugs. India’s tobacco consumption is heavily dominated by non-cigarette tobacco in the form of bidis, chewing tobacco, paan masala and gutka. (Deshpande et. al (2010)).

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48 A type of commonly used flour.
49 Bidis are made by rolling a dried, rectangular piece of temburni or tendu leaf (diospyros melanoxylon) with an average of 0.33 g of sun-dried, flaked tobacco into a cone secured with thread (Deshpande et. al (2010)).
50 Paan masala is a betel-quid ingredient that may or may not contain tobacco (Deshpande et. al (2010)).
Taxation of these popular tobacco products in India is very complex and both the state and the central governments levy taxes on them. The actual tax rates charged by the central government vary across different types of tobacco products\textsuperscript{52}. In the first year of the introduction of the VAT, states governments were not allowed to tax tobacco in any form. After the first year, states could tax cigarettes and other finished tobacco products\textsuperscript{53}. However, majority of the states’ VAT ACTS include raw tobacco and betel leaves\textsuperscript{54} in the list of exempted goods. These exemptions, along with much lower taxes on alcohol\textsuperscript{55} (beer and wine) after the introduction of the VAT, can explain a significant increase in the consumption of the addictive substances under VAT in the urban areas. In the rural areas we expect that the local and the small-sized tobacco and alcohol producers would not be affected considerably by the VAT as these producers are more likely to be a part of the informal sector of the economy.

The price results give a more detailed picture of individual items. We observe that the price of pan (for which major ingredient is betel leaves) falls significantly with VAT (in both urban (Table 23) and rural (Table 24) sectors) but the price of locally produced alcohol and tobacco products in the form of bidi and chewing tobacco increases. As mentioned before, alcohol is not taxed under the 3 basic rates of VAT so trends in its prices are hard to interpret. Since the adoption of the VAT, states are continuing to increase their tax rates on local tobacco products every year through VAT and other type of tax instruments such as luxury and/or entry tax. This could explain the observed increase in prices of tobacco products.

\textsuperscript{51} Gutka is a preparation of crushed betel nut, tobacco, catechu, lime and sweet or savory flavorings (Deshpande et. al (2010)).

\textsuperscript{52} Bidis (locally produced cigarettes) are taxed the lowest by the central government (Kumar et. al (2011)) and chewing tobacco is taxed the highest at 86%.

\textsuperscript{53} Most of the states levied 12.5\% rate on the finished tobacco products.

\textsuperscript{54} It is used as an important ingredient in the preparation of a commonly used addictive substance in India called paan masala.

\textsuperscript{55} With the introduction of VAT, the state-level taxes on different kinds of alcohol fell substantially from as high as 80\% to 20\%.
Our results in Table 11 show a significant reduction in the consumption of energy related goods from VAT in the urban regions. **Energy** includes the consumption of all types of fuel commonly used by households for cooking and lighting. This category includes the consumption of electricity which is the most commonly used source of energy in the urban areas. However, electricity is not taxed under the VAT system. State governments charge a separate excise duty on electricity consumption. Perhaps the relative price of electricity is going up with VAT and some households decrease its consumption. We do observe an increase in the real price of electricity in the presence of VAT and this is shown in Table 23. The second most commonly used good in this category in the urban areas is LPG (a cooking fuel) which is produced from natural gas. India’s VAT does not allow input tax deductions on the use of natural gas. Since the VAT on LPG continues to cascade, we would expect a negative effect of VAT on its consumption. However, Table 23 shows that the price of LPG decreases significantly with the VAT. Some states tax final consumption of LPG at 4% whereas others tax it at 12.5%. Perhaps our price regressions are picking up the VAT’s effect on those states which tax LPG at lower rates. The price of fuels commonly used in rural areas decrease with the VAT and this finding is consistent with the observed significant increase in the consumption of energy in the rural areas as shown in Table 17.

The next consumption category is Clothing, bedding. **Clothing, bedding** category (shown in Tables 12 and 18) identifies the expenses\(^{56}\) incurred on clothing, footwear, bedspreads, and home accessories such as rugs and curtains. This is a broadly defined category which represents consumption on a variety of clothing, bedding and footwear goods. Therefore it is hard to predict the impact of VAT on its overall consumption. Some of the clothing and bedding goods included in this category are usually produced by small-sized manufacturers in both the rural and

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\(^{56}\) Expenses in this category are recorded over the last 365 days.
the urban areas. The results presented in Tables 12 and 18 show that the VAT negatively impacts the overall consumption in this category. Perhaps multiple breaks in the VAT chain of the goods produced by the small-sized manufacturers create inefficiencies which more than offset the benefits of the VAT on other goods. This could explain why we capture a negative impact on the overall consumption. The price results in Tables 23 and 24 shed light on the efficiency of some individual goods included in this category. The impact of the VAT is significant and negative on the price of garments, hosiery, bed sheets (both urban and rural areas), bed accessories, blankets, rubber footwear, slippers and upholstery. This shows that the VAT manages to improve efficiency of all of these individual goods. In addition, as expected the VAT coefficients of these goods are bigger and more significant in urban areas than in rural areas. However this efficiency improvement, as reflected by the fall in prices of the individual goods, is not carried over to the overall consumption of clothing bedding and footwear commodity group.

*Education* records mostly the expenses on education services\(^{57}\) including tuition and fees. A smaller portion is contributed by the expenses on goods purchased for the purpose of education. *Medical care In-patient*\(^{58}\) and *Out-patient* categories record expenditures incurred as in-patient and out-patient at the private and the government hospitals, nursing homes etc, respectively. We do not identify any significant impact of the VAT on the consumption of education services or medical in-patient expenses (shown in Tables 12 and 18) when both state and the year fixed effects are included. This is not surprising because none of these expenses are taxed under the VAT system. However, we capture a significant and a positive impact of the VAT on the medical out-patient consumption in the urban areas. This is shown in Table 13. All expenses on medicines are recorded in this category and hence the above finding makes sense because drugs

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\(^{57}\) Expenses in this category are recorded over the last 365 days.

\(^{58}\) Medical care in-patient expenses are recorded over the last 365 days.
and medicines in most states are taxed at the 4% rate under the VAT. We do not have information on the quantity consumed on any individual goods within these categories. Therefore we cannot run a parallel price analysis on these groups.

We also identify a positive impact of the VAT on the entertainment category in Table 13 in the urban areas. **Entertainment** includes the expenses incurred by households on entertainment goods and services. This group represents the expenses on short-term durable goods used for entertainment and includes items such as movie theatre ticket expenses, expenses on movie and music CDs/DVDs, toys and sports goods. The significant increase in its urban consumption with the use of VAT is also intuitive because the VAT was applied on all the entertainment goods included in this category and these goods are much more widely consumed in the urban areas than in the rural areas. **Personal Care** records expenses on minor durable goods of personal use such as spectacles, umbrella and cigarette lighter. We do not observe a significant effect of VAT on this category in the urban areas. In the rural areas, the efficiency of these goods appears to have decreased with VAT\(^{59}\) as shown in Table 19.

**Rent** determines rental expenses and includes house, garage and land rent and hotel lodging expenses. A luxury tax is charged by the states on the hotel services and accommodation. Multiple taxes are levied by the central and the state governments on the rental income although the rental expense is out of scope of the state-level VAT. Nevertheless, we find a significant and a negative impact of the VAT on the rental expenditure in the urban sector (Table 14). Perhaps, with a use of a more efficient tax on goods in the form of the state-level VAT, the economic activity is going up in general as we suspect. If this is the case then it would become cheaper to buy a house and therefore people will purchase their own homes and move out of the rental

\(^{59}\) This may be justified on the basis that the breaks in the VAT chain due to the small-sized manufacturers create inefficiencies which more than offset the benefits of VAT.
properties. **Services** category tracks expenditure on all consumer services (except travel services). In our results in Tables 14 and 20, we obtain a significantly positive coefficient of VAT on the consumption of services in the urban and the rural areas. Services are not directly taxed under VAT, but this result makes sense because the cost of services are based on the real cost of goods used in the provision of services. Therefore this result is also providing an evidence of a reduction in tax cascading on commodities. Additionally, the NSSO survey data description explains that payment for some services is made in the form of goods such as food, clothing and footwear. In such instances, the value of these goods is recorded as payments for the services. In the data, there is no way to identify what percentage of the service consumption is paid in the form of goods. If majority of the consumption of services are paid in the form of goods such as clothing and footwear then the fall in the prices of these goods because of the VAT would lead to a positive impact of the VAT on the services category.

We pick-up a significantly negative impact of the VAT on consumption of travel services and transport related goods in the rural sector (as shown in Tables 20 and 21). The related coefficients in the urban areas are negative but not significant. **Travel** category tracks all expenses related to travel services such as airfare, bus fare and fuel for vehicle. Most of the travel services are taxed by the central government so these won’t be affected by the VAT. However, as the price of other goods decrease with the VAT as shown by the price results in Tables 23 and 24, these services would become relatively expensive and consumers might want to cut-back their consumption of this category. Moreover, travel services also include the consumption of motor vehicle fuel (petrol and diesel) and other vehicle fuels which are taxed at the high rates of 20% and above and no input tax credits are available on them. So there is no reason to believe that the efficiency would improve in this category.
**Transport** is the expenditure on long-term durable goods used for personal transport such as bicycle, tyres, cars etc. Motor vehicles are one of the few goods (like petrol and diesel) for which input tax deductions are not allowed by majority of the states under the current VAT system. This explains a continued tax cascading on the transport goods as compared to other durable goods. As a result, under the VAT system, the price of these goods is expected to be relatively higher than other durable goods. This discourages their consumption significantly in rural areas. Therefore we obtain a negative impact of the VAT on transport category in the rural areas. Since these are expensive goods and the budget constraints are expected to be higher in rural than in urban areas, the substitution effect on these goods is more evident in the rural consumption.

Other long-term durable goods include the following categories. **Recreation** includes expenditure on long-term durable goods used for recreation such as television, camera and photography equipment. **Furniture** category characterizes expenses on all sorts of domestic furniture and their repairs. **Jewelry** records expenses incurred on gold, silver and other ornaments. **Appliances** category determine expenses borne on all sorts of household appliances including washing machine, sewing machine, refrigerator etc. As explained in the introduction of the results section, we anticipate the greatest efficiency gain in the long-term durable goods because these goods are produced by large-sized manufacturers and involve multiple production steps. This intuition is confirmed in our findings. We capture a positive, significant and an economically substantive impact of the VAT on the consumption of recreation goods in the urban areas (Table 15). Recreation goods are luxury goods and are sparsely consumed in the rural areas, so its consumption trend in the rural area is not as meaningful. Tables 15, 16, 21 and 22 demonstrate a significantly positive increase in the consumption of furniture and appliances.
from the VAT in both rural and the urban areas and coefficients in urban areas are more significant.

On the other hand, the impact of the VAT on jewelry consumption is significant and negative. This negative effect is coming from the 1% tax rate charged on all gold and silver ornaments. Before VAT these ornaments were tax free in most of the states. Lastly, we look at the final category of goods which we name ‘All Durables’. This category records consumption of all the long-term durables goods included in the survey. Note that Recreation, Transport, Furniture, Jewelry and Appliances are sub-categories of ‘All Durables’. When we analyze the impact of the VAT on the consumption trends of all long-term durable goods together, the VAT coefficient for the urban region becomes insignificant. However, it becomes negative and significant for the rural areas. This implies that for some categories of long-term durable goods, the adoption of VAT fails to sufficiently improve the efficiency of the tax system in the rural areas as evident in the transport category explained above.

6.2 CONCLUSION

We identify the biggest efficiency improvements from the adoption of the sub-national VAT in India in certain long-term durable goods in both rural and the urban sectors. These improvements arise from the decrease in the level of tax cascading which reduces the real tax burden and the prices on these goods. This reduction in the real prices consequently leads to an increase in the real consumption of these goods. We identify such an increase in the real consumption of long-term durables goods used for recreation in the urban areas. This increase in real consumption is not only statistically significant at the convention levels but also economically substantive. We observe a similar increase in the real consumption of furniture goods and household-appliances in both the rural and the urban areas. As a result we conclude
that there is evidence of reduction in tax-cascading with the introduction of an important tax policy reform in India which took place in the form of a sub-national VAT.
### Table 9: Sample means of real consumption expenditure per capita by commodity groups

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Rural Before VAT¹</th>
<th>Rural After VAT²</th>
<th>Urban Before VAT</th>
<th>Urban After VAT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Food</strong></td>
<td>331.626</td>
<td>343.574</td>
<td>447</td>
<td>439.825</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>186.113</td>
<td>182.523</td>
<td>456.48</td>
<td>270.83</td>
</tr>
<tr>
<td>Sample Size</td>
<td>139,344</td>
<td>56,943</td>
<td>80,529</td>
<td>36,693</td>
</tr>
<tr>
<td><strong>Addictive Substance</strong></td>
<td>22.817</td>
<td>22.125</td>
<td>35.161</td>
<td>43.414</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>37.246</td>
<td>40.341</td>
<td>66.926</td>
<td>88.448</td>
</tr>
<tr>
<td>Sample Size</td>
<td>99,264</td>
<td>38,032</td>
<td>41,246</td>
<td>17,268</td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td>48.412</td>
<td>55.938</td>
<td>70.135</td>
<td>83.052</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>33.26</td>
<td>33.9</td>
<td>729.29</td>
<td>62.732</td>
</tr>
<tr>
<td>Sample Size</td>
<td>139,143</td>
<td>56,905</td>
<td>79,787</td>
<td>36,534</td>
</tr>
<tr>
<td><strong>Clothing, Bedding and Footwear</strong></td>
<td>307.098</td>
<td>692.759</td>
<td>421.372</td>
<td>768.531</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>396.89</td>
<td>554.977</td>
<td>613.416</td>
<td>769.04</td>
</tr>
<tr>
<td>Sample Size</td>
<td>139,042</td>
<td>56,910</td>
<td>80,365</td>
<td>36,649</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td>219.239</td>
<td>578.578</td>
<td>463.12</td>
<td>1330.223</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>849.442</td>
<td>1822.592</td>
<td>1,705</td>
<td>3,742</td>
</tr>
<tr>
<td>Sample Size</td>
<td>83,984</td>
<td>38,425</td>
<td>55,397</td>
<td>26,811</td>
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<tr>
<td><strong>Medical In-Patient</strong></td>
<td>471.672</td>
<td>1255.402</td>
<td>604.588</td>
<td>1894.252</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>2278.61</td>
<td>4911.358</td>
<td>3411.09</td>
<td>5342.506</td>
</tr>
<tr>
<td>Sample Size</td>
<td>20,379</td>
<td>8,211</td>
<td>11,823</td>
<td>5,091</td>
</tr>
<tr>
<td><strong>Medical Out-Patient</strong></td>
<td>42.579</td>
<td>46.666</td>
<td>59.39</td>
<td>72.275</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>101.676</td>
<td>127.291</td>
<td>190.408</td>
<td>172.126</td>
</tr>
<tr>
<td>Sample Size</td>
<td>87,368</td>
<td>39,719</td>
<td>50,294</td>
<td>24,966</td>
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<tr>
<td><strong>Entertainment</strong></td>
<td>14.417</td>
<td>18.504</td>
<td>28.796</td>
<td>28.882</td>
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<tr>
<td>Std. Dev.</td>
<td>28.886</td>
<td>33.759</td>
<td>42</td>
<td>33</td>
</tr>
<tr>
<td>Sample Size</td>
<td>31,371</td>
<td>23,186</td>
<td>36,867</td>
<td>24,143</td>
</tr>
<tr>
<td><strong>Personal Care</strong></td>
<td>9.913</td>
<td>11.365</td>
<td>15.449</td>
<td>20.771</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>19.416</td>
<td>42.884</td>
<td>32</td>
<td>38</td>
</tr>
<tr>
<td>Sample Size</td>
<td>22,458</td>
<td>11,281</td>
<td>13,864</td>
<td>5,810</td>
</tr>
</tbody>
</table>

Notes:

¹Before VAT includes years 1999 and 2004
²After VAT includes year 2009
<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Before VAT</th>
<th>After VAT</th>
<th>Before VAT</th>
<th>After VAT</th>
</tr>
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<tbody>
<tr>
<td>Services</td>
<td>22.376</td>
<td>39.335</td>
<td>56.771</td>
<td>74.12</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>47.374</td>
<td>67.955</td>
<td>113.016</td>
<td>120.765</td>
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<tr>
<td>Sample Size</td>
<td>131,917</td>
<td>55,765</td>
<td>78,123</td>
<td>36,138</td>
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<tr>
<td>Rent</td>
<td>50.235</td>
<td>63.986</td>
<td>148.156</td>
<td>263.685</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>98.621</td>
<td>178.307</td>
<td>208.944</td>
<td>448.414</td>
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<tr>
<td>Sample Size</td>
<td>7,889</td>
<td>3,974</td>
<td>26,624</td>
<td>11,334</td>
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<tr>
<td>Rent</td>
<td>30.841</td>
<td>44.174</td>
<td>65.066</td>
<td>84.617</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>62.189</td>
<td>101.1</td>
<td>130.814</td>
<td>170.485</td>
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<tr>
<td>Sample Size</td>
<td>104,864</td>
<td>48,598</td>
<td>62,645</td>
<td>31,155</td>
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<tr>
<td>Recreation goods</td>
<td>248.513</td>
<td>140.463</td>
<td>408.389</td>
<td>186.002</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>678.726</td>
<td>466.966</td>
<td>975.282</td>
<td>745.752</td>
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<tr>
<td>Sample Size</td>
<td>5,673</td>
<td>6,282</td>
<td>3,798</td>
<td>5,175</td>
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<tr>
<td>Transport</td>
<td>227.987</td>
<td>320.214</td>
<td>318.912</td>
<td>405.957</td>
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<tr>
<td>Std. Dev.</td>
<td>3030.652</td>
<td>423.195</td>
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<td>Sample Size</td>
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<td>32,697</td>
<td>19,087</td>
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<td>Furniture</td>
<td>162.324</td>
<td>142.628</td>
<td>290.916</td>
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<td>Std. Dev.</td>
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<td>8,015</td>
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<td>Household Appliances</td>
<td>104.624</td>
<td>95.74</td>
<td>164.209</td>
<td>164.326</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>462.219</td>
<td>394.407</td>
<td>623.148</td>
<td>557.988</td>
</tr>
<tr>
<td>Sample Size</td>
<td>7,902</td>
<td>11,487</td>
<td>7,205</td>
<td>10,546</td>
</tr>
<tr>
<td>Jewelry</td>
<td>532.321</td>
<td>770.62</td>
<td>765.203</td>
<td>945.988</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>3804.955</td>
<td>6085.153</td>
<td>4122.74</td>
<td>3268.678</td>
</tr>
<tr>
<td>Sample Size</td>
<td>9,324</td>
<td>7,966</td>
<td>3,782</td>
<td>4,423</td>
</tr>
<tr>
<td>All Durable Goods</td>
<td>448.688</td>
<td>617.416</td>
<td>689.312</td>
<td>763.071</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>3194.712</td>
<td>4648.998</td>
<td>3326.383</td>
<td>3749.062</td>
</tr>
<tr>
<td>Sample Size</td>
<td>57,704</td>
<td>47,825</td>
<td>28,861</td>
<td>29,522</td>
</tr>
</tbody>
</table>

Notes:
All the long-term durable goods categories include recreation, transport, furniture, appliance and all durable goods. For these groups ‘Before VAT’ observations come from year 2004 only. Data for year 1999 is not available for these categories.
**Table 11:** Consumption expenditure results for urban sector and developed states

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Food</td>
<td>Food</td>
<td>Addictive Substance</td>
<td>Addictive Substance</td>
<td>Energy</td>
<td>Energy</td>
</tr>
<tr>
<td>LN(GSDPpc)</td>
<td>-0.201***</td>
<td>-0.168***</td>
<td>-0.327***</td>
<td>-0.046</td>
<td>-0.008</td>
<td>1.661**</td>
</tr>
<tr>
<td></td>
<td>(0.032)</td>
<td>(0.046)</td>
<td>(0.100)</td>
<td>(0.285)</td>
<td>(0.190)</td>
<td>(0.722)</td>
</tr>
<tr>
<td>VAT</td>
<td>0.010</td>
<td>0.077***</td>
<td>0.330***</td>
<td>0.243***</td>
<td>0.100</td>
<td>-0.143**</td>
</tr>
<tr>
<td></td>
<td>(0.029)</td>
<td>(0.015)</td>
<td>(0.088)</td>
<td>(0.050)</td>
<td>(0.105)</td>
<td>(0.060)</td>
</tr>
<tr>
<td>Observations</td>
<td>109,403</td>
<td>109,403</td>
<td>53,641</td>
<td>53,641</td>
<td>108,618</td>
<td>108,618</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.805</td>
<td>0.805</td>
<td>0.270</td>
<td>0.271</td>
<td>0.518</td>
<td>0.546</td>
</tr>
<tr>
<td>State FE</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Year FE</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Table 12:** Consumption expenditure results for urban sector and developed states

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clothing</td>
<td>Clothing</td>
<td>Education</td>
<td>Education</td>
<td>Medical</td>
<td>Medical</td>
</tr>
<tr>
<td></td>
<td>Bedding</td>
<td>Bedding</td>
<td></td>
<td></td>
<td>In-patient</td>
<td>In-patient</td>
</tr>
<tr>
<td>LN(GSDPpc)</td>
<td>5.938***</td>
<td>-0.068</td>
<td>6.612***</td>
<td>0.370</td>
<td>7.507***</td>
<td>0.219</td>
</tr>
<tr>
<td></td>
<td>(0.557)</td>
<td>(0.199)</td>
<td>(0.627)</td>
<td>(0.332)</td>
<td>(0.640)</td>
<td>(0.489)</td>
</tr>
<tr>
<td>VAT</td>
<td>-2.426***</td>
<td>-0.112***</td>
<td>-2.481***</td>
<td>0.101</td>
<td>-2.655***</td>
<td>0.030</td>
</tr>
<tr>
<td></td>
<td>(0.265)</td>
<td>(0.020)</td>
<td>(0.301)</td>
<td>(0.072)</td>
<td>(0.346)</td>
<td>(0.091)</td>
</tr>
<tr>
<td>Observations</td>
<td>109,207</td>
<td>109,207</td>
<td>76,444</td>
<td>76,444</td>
<td>15,988</td>
<td>15,988</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.765</td>
<td>0.880</td>
<td>0.586</td>
<td>0.647</td>
<td>0.659</td>
<td>0.722</td>
</tr>
<tr>
<td>State FE</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Year FE</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
### Table 13: Consumption expenditure results for urban sector and developed states

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Medical Out-patient</td>
<td>Medical Out-patient</td>
<td>Entertainment</td>
<td>Entertainment</td>
<td>Personal Care</td>
<td>Personal Care</td>
</tr>
<tr>
<td>LN(GSDPpc)</td>
<td>0.037</td>
<td>0.176</td>
<td>0.460*</td>
<td>0.681</td>
<td>0.145</td>
<td>-0.920</td>
</tr>
<tr>
<td></td>
<td>(0.121)</td>
<td>(0.269)</td>
<td>(0.248)</td>
<td>(0.388)</td>
<td>(0.282)</td>
<td>(0.533)</td>
</tr>
<tr>
<td>VAT</td>
<td>0.020</td>
<td>0.264***</td>
<td>-0.239</td>
<td>0.324***</td>
<td>0.237*</td>
<td>0.111</td>
</tr>
<tr>
<td></td>
<td>(0.097)</td>
<td>(0.052)</td>
<td>(0.210)</td>
<td>(0.107)</td>
<td>(0.128)</td>
<td>(0.078)</td>
</tr>
<tr>
<td>Observations</td>
<td>69,932</td>
<td>69,932</td>
<td>57,018</td>
<td>57,018</td>
<td>17,635</td>
<td>17,635</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.313</td>
<td>0.314</td>
<td>0.470</td>
<td>0.473</td>
<td>0.328</td>
<td>0.331</td>
</tr>
<tr>
<td>State FE</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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<tr>
<td>Year FE</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

### Table 14: Consumption expenditure results for urban sector and developed states

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Services</td>
<td>Services</td>
<td>Rent</td>
<td>Rent</td>
<td>Travel</td>
<td>Travel</td>
</tr>
<tr>
<td>LN(GSDPpc)</td>
<td>0.801***</td>
<td>0.299</td>
<td>0.160</td>
<td>-1.220</td>
<td>-0.287***</td>
<td>-0.056</td>
</tr>
<tr>
<td></td>
<td>(0.115)</td>
<td>(0.204)</td>
<td>(0.288)</td>
<td>(0.911)</td>
<td>(0.090)</td>
<td>(0.138)</td>
</tr>
<tr>
<td>VAT</td>
<td>-0.191**</td>
<td>0.276***</td>
<td>0.189</td>
<td>-0.474***</td>
<td>0.279***</td>
<td>-0.055</td>
</tr>
<tr>
<td></td>
<td>(0.083)</td>
<td>(0.042)</td>
<td>(0.209)</td>
<td>(0.099)</td>
<td>(0.080)</td>
<td>(0.044)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.637</td>
<td>0.639</td>
<td>0.451</td>
<td>0.455</td>
<td>0.577</td>
<td>0.578</td>
</tr>
<tr>
<td>State FE</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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<tr>
<td>Year FE</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
### Table 15: Consumption expenditure results for urban sector and developed states

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Recreation</th>
<th>Recreation</th>
<th>Transport</th>
<th>Transport</th>
<th>Furniture</th>
<th>Furniture</th>
</tr>
</thead>
<tbody>
<tr>
<td>LN(GSDPpc)</td>
<td>-0.675</td>
<td>2.686</td>
<td>0.507***</td>
<td>0.559</td>
<td>-0.644</td>
<td>0.181</td>
</tr>
<tr>
<td></td>
<td>(1.328)</td>
<td>(1.604)</td>
<td>(0.159)</td>
<td>(0.634)</td>
<td>(0.368)</td>
<td>(1.210)</td>
</tr>
<tr>
<td>VAT</td>
<td>-0.470</td>
<td>0.648***</td>
<td>0.025</td>
<td>0.039</td>
<td>0.053</td>
<td>0.271**</td>
</tr>
<tr>
<td></td>
<td>(0.616)</td>
<td>(0.086)</td>
<td>(0.091)</td>
<td>(0.077)</td>
<td>(0.165)</td>
<td>(0.118)</td>
</tr>
<tr>
<td>Observations</td>
<td>8,130</td>
<td>8,130</td>
<td>37,590</td>
<td>37,590</td>
<td>6,561</td>
<td>6,561</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.267</td>
<td>0.272</td>
<td>0.501</td>
<td>0.501</td>
<td>0.424</td>
<td>0.425</td>
</tr>
<tr>
<td>State FE</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Year FE</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: The above results for the durable goods are estimated using data for years 2004 and 2009

### Table 16: Consumption expenditure results for urban sector and developed states

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Jewelry</th>
<th>Jewelry</th>
<th>Appliances</th>
<th>Appliances</th>
<th>All Durables</th>
<th>All Durables</th>
</tr>
</thead>
<tbody>
<tr>
<td>LN(GSDPpc)</td>
<td>0.291</td>
<td>-0.094</td>
<td>-0.718**</td>
<td>-0.291</td>
<td>0.540</td>
<td>1.592</td>
</tr>
<tr>
<td></td>
<td>(0.614)</td>
<td>(1.395)</td>
<td>(0.313)</td>
<td>(1.056)</td>
<td>(0.415)</td>
<td>(0.995)</td>
</tr>
<tr>
<td>VAT</td>
<td>-0.169</td>
<td>-0.339***</td>
<td>0.107</td>
<td>0.237*</td>
<td>-0.305</td>
<td>0.008</td>
</tr>
<tr>
<td></td>
<td>(0.312)</td>
<td>(0.078)</td>
<td>(0.158)</td>
<td>(0.115)</td>
<td>(0.211)</td>
<td>(0.087)</td>
</tr>
<tr>
<td>Observations</td>
<td>7,153</td>
<td>7,153</td>
<td>16,332</td>
<td>16,332</td>
<td>53,932</td>
<td>53,932</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.511</td>
<td>0.511</td>
<td>0.330</td>
<td>0.330</td>
<td>0.431</td>
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<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Year FE</td>
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<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: The above results for the durable goods are estimated using data for years 2004 and 2009
### Table 17: Consumption expenditure results for rural sector and developed states

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LN(GSDPpc)</td>
<td>-0.097*</td>
<td>0.008</td>
<td>-0.363**</td>
<td>-0.127</td>
<td>0.082</td>
<td>-0.136</td>
</tr>
<tr>
<td>VAT</td>
<td>-0.106***</td>
<td>-0.008</td>
<td>-0.147***</td>
<td>0.030</td>
<td>-0.032</td>
<td>0.099***</td>
</tr>
<tr>
<td>Observations</td>
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<td>162,001</td>
<td>109,515</td>
<td>109,515</td>
<td>161,800</td>
<td>161,800</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.800</td>
<td>0.803</td>
<td>0.267</td>
<td>0.269</td>
<td>0.471</td>
<td>0.486</td>
</tr>
<tr>
<td>State FE</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Year FE</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

---

### Table 18. Consumption expenditure results for rural sector and developed states

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LN(GSDPpc)</td>
<td>3.697*</td>
<td>0.234**</td>
<td>3.841*</td>
<td>0.080</td>
<td>4.104*</td>
<td>0.042</td>
</tr>
<tr>
<td>VAT</td>
<td>0.440</td>
<td>-0.024</td>
<td>0.495</td>
<td>-0.001</td>
<td>0.799</td>
<td>-0.010</td>
</tr>
<tr>
<td>Observations</td>
<td>161,739</td>
<td>161,739</td>
<td>98,231</td>
<td>98,231</td>
<td>22,831</td>
<td>22,831</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.425</td>
<td>0.899</td>
<td>0.388</td>
<td>0.677</td>
<td>0.477</td>
<td>0.747</td>
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<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Year FE</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

---

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### Table 19. Consumption expenditure results for rural sector and developed states

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Medical Outpatient</th>
<th>(2) Medical Outpatient</th>
<th>(3) Entertainment</th>
<th>(4) Entertainment</th>
<th>(5) Personal Care</th>
<th>(6) Personal Care</th>
</tr>
</thead>
<tbody>
<tr>
<td>LN(GSDPpc)</td>
<td>-0.128</td>
<td>0.008</td>
<td>0.265</td>
<td>0.249</td>
<td>0.564</td>
<td>0.411</td>
</tr>
<tr>
<td></td>
<td>(0.300)</td>
<td>(0.282)</td>
<td>(0.190)</td>
<td>(0.176)</td>
<td>(0.360)</td>
<td>(0.367)</td>
</tr>
<tr>
<td>VAT</td>
<td>-0.112</td>
<td>0.079</td>
<td>0.092</td>
<td>0.069</td>
<td>0.057</td>
<td>-0.200**</td>
</tr>
<tr>
<td></td>
<td>(0.070)</td>
<td>(0.048)</td>
<td>(0.057)</td>
<td>(0.042)</td>
<td>(0.097)</td>
<td>(0.077)</td>
</tr>
<tr>
<td>Observations</td>
<td>106,029</td>
<td>106,029</td>
<td>45,311</td>
<td>45,311</td>
<td>25,141</td>
<td>25,141</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.298</td>
<td>0.298</td>
<td>0.429</td>
<td>0.429</td>
<td>0.240</td>
<td>0.240</td>
</tr>
<tr>
<td>State FE</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Year FE</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

### Table 20. Consumption expenditure results for rural sector and developed states

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Services</th>
<th>(2) Services</th>
<th>(3) Rent</th>
<th>(4) Rent</th>
<th>(5) Travel</th>
<th>(6) Travel</th>
</tr>
</thead>
<tbody>
<tr>
<td>LN(GSDPpc)</td>
<td>0.395**</td>
<td>0.153</td>
<td>0.847</td>
<td>-0.132</td>
<td>0.128</td>
<td>-0.043</td>
</tr>
<tr>
<td></td>
<td>(0.167)</td>
<td>(0.154)</td>
<td>(0.752)</td>
<td>(0.661)</td>
<td>(0.142)</td>
<td>(0.113)</td>
</tr>
<tr>
<td>VAT</td>
<td>0.345***</td>
<td>0.178***</td>
<td>0.070</td>
<td>-0.053</td>
<td>0.073*</td>
<td>-0.139***</td>
</tr>
<tr>
<td></td>
<td>(0.045)</td>
<td>(0.036)</td>
<td>(0.241)</td>
<td>(0.109)</td>
<td>(0.040)</td>
<td>(0.024)</td>
</tr>
<tr>
<td>Observations</td>
<td>156,303</td>
<td>156,303</td>
<td>8,243</td>
<td>8,243</td>
<td>123,714</td>
<td>123,714</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.532</td>
<td>0.535</td>
<td>0.744</td>
<td>0.752</td>
<td>0.507</td>
<td>0.509</td>
</tr>
<tr>
<td>State FE</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Year FE</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
### Table 21. Consumption expenditure results for rural sector and developed states

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Recreation (1)</th>
<th>Recreation (2)</th>
<th>Transport (3)</th>
<th>Transport (4)</th>
<th>Furniture (5)</th>
<th>Furniture (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LN(GSDPpc)</td>
<td>-1.252***</td>
<td>-1.437***</td>
<td>-0.553</td>
<td>-0.677*</td>
<td>-0.715*</td>
<td>-0.557</td>
</tr>
<tr>
<td></td>
<td>(0.273)</td>
<td>(0.259)</td>
<td>(0.320)</td>
<td>(0.373)</td>
<td>(0.385)</td>
<td>(0.464)</td>
</tr>
<tr>
<td>VAT</td>
<td>-0.207***</td>
<td>-0.512***</td>
<td>0.159*</td>
<td>-0.151***</td>
<td>0.025</td>
<td>0.154**</td>
</tr>
<tr>
<td></td>
<td>(0.068)</td>
<td>(0.054)</td>
<td>(0.082)</td>
<td>(0.043)</td>
<td>(0.096)</td>
<td>(0.055)</td>
</tr>
<tr>
<td>Observations</td>
<td>9,636</td>
<td>9,636</td>
<td>59,989</td>
<td>59,989</td>
<td>12,920</td>
<td>12,920</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.298</td>
<td>0.298</td>
<td>0.399</td>
<td>0.399</td>
<td>0.385</td>
<td>0.385</td>
</tr>
<tr>
<td>State FE</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Year FE</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: The above results for the durable goods are estimated using data for years 2004 and 2009

### Table 22. Consumption expenditure results for rural sector and developed states

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Jewelry (1)</th>
<th>Jewelry (2)</th>
<th>Appliances (3)</th>
<th>Appliances (4)</th>
<th>All Durables (5)</th>
<th>All Durables (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LN(GSDPpc)</td>
<td>0.475</td>
<td>0.467</td>
<td>-1.253**</td>
<td>-1.239*</td>
<td>-0.202</td>
<td>-0.328</td>
</tr>
<tr>
<td></td>
<td>(0.483)</td>
<td>(0.508)</td>
<td>(0.471)</td>
<td>(0.587)</td>
<td>(0.332)</td>
<td>(0.348)</td>
</tr>
<tr>
<td>VAT</td>
<td>-0.085</td>
<td>-0.132</td>
<td>0.119</td>
<td>0.132**</td>
<td>0.092</td>
<td>-0.252***</td>
</tr>
<tr>
<td></td>
<td>(0.148)</td>
<td>(0.088)</td>
<td>(0.113)</td>
<td>(0.059)</td>
<td>(0.103)</td>
<td>(0.043)</td>
</tr>
<tr>
<td>Observations</td>
<td>12,479</td>
<td>12,479</td>
<td>15,431</td>
<td>15,431</td>
<td>87,147</td>
<td>87,147</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.534</td>
<td>0.534</td>
<td>0.327</td>
<td>0.327</td>
<td>0.379</td>
<td>0.380</td>
</tr>
<tr>
<td>State FE</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Year FE</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: The above results for the durable goods are estimated using data for years 2004 and 2009
Table 23. Price Results for urban areas and developed states including state and year fixed effects

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VAT</td>
<td>0.034***</td>
<td>-0.047***</td>
<td>-0.057***</td>
<td>-0.051**</td>
<td>-0.056***</td>
<td>-0.002</td>
<td>-0.053***</td>
<td>0.119***</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.009)</td>
<td>(0.012)</td>
<td>(0.021)</td>
<td>(0.006)</td>
<td>(0.010)</td>
<td>(0.015)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>Sample Size</td>
<td>97,860</td>
<td>82,984</td>
<td>92,253</td>
<td>24,823</td>
<td>39,045</td>
<td>42,432</td>
<td>26,523</td>
<td>28,243</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Price of Onion</th>
<th>Price of Potato</th>
<th>Price of Groundnut</th>
<th>Price of Sugar</th>
<th>Price of Salt</th>
<th>Price of Turmeric&lt;sup&gt;60&lt;/sup&gt;</th>
<th>Price of Chilli powder&lt;sup&gt;61&lt;/sup&gt;</th>
<th>Price of Suji&lt;sup&gt;62&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAT</td>
<td>-0.072***</td>
<td>-0.003</td>
<td>-0.049***</td>
<td>-0.013**</td>
<td>0.064***</td>
<td>-0.022</td>
<td>-0.009</td>
<td>-0.007</td>
</tr>
<tr>
<td></td>
<td>(0.012)</td>
<td>(0.016)</td>
<td>(0.013)</td>
<td>(0.006)</td>
<td>(0.018)</td>
<td>(0.027)</td>
<td>(0.017)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>Sample Size</td>
<td>101,769</td>
<td>99,658</td>
<td>29,063</td>
<td>92,779</td>
<td>104,517</td>
<td>101,202</td>
<td>97,408</td>
<td>40,048</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Price of Yellow Lentil</th>
<th>Price of Banana</th>
<th>Price of Tea Leaves</th>
<th>Price of Pan&lt;sup&gt;63&lt;/sup&gt;</th>
<th>Price of Bidi&lt;sup&gt;64&lt;/sup&gt;</th>
<th>Price of Cigarette (Foreign)</th>
<th>Price of Alcohol (Local)</th>
<th>Price of Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAT</td>
<td>-0.020</td>
<td>-0.003</td>
<td>-0.070***</td>
<td>-0.059***</td>
<td>0.112***</td>
<td>0.100***</td>
<td>0.286***</td>
<td>0.038</td>
</tr>
<tr>
<td></td>
<td>(0.021)</td>
<td>(0.012)</td>
<td>(0.011)</td>
<td>(0.019)</td>
<td>(0.012)</td>
<td>(0.024)</td>
<td>(0.058)</td>
<td>(0.036)</td>
</tr>
<tr>
<td>Sample Size</td>
<td>77,112</td>
<td>70,703</td>
<td>93,692</td>
<td>9,297</td>
<td>18,730</td>
<td>9,279</td>
<td>5,597</td>
<td>95,988</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Price of LPG&lt;sup&gt;65&lt;/sup&gt;</th>
<th>Price of Hosiery Goods</th>
<th>Price of Garments</th>
<th>Price of Bedsheet</th>
<th>Price of Other Bedding</th>
<th>Price of Rubber Footwear</th>
<th>Price of Slippers</th>
<th>Price of Upholstery</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAT</td>
<td>-0.050**</td>
<td>-0.001</td>
<td>-0.069**</td>
<td>-0.184***</td>
<td>-0.175**</td>
<td>-0.047**</td>
<td>-0.094***</td>
<td>-0.339***</td>
</tr>
<tr>
<td></td>
<td>(0.021)</td>
<td>(0.014)</td>
<td>(0.025)</td>
<td>(0.016)</td>
<td>(0.059)</td>
<td>(0.018)</td>
<td>(0.013)</td>
<td>(0.048)</td>
</tr>
<tr>
<td>Sample Size</td>
<td>59,663</td>
<td>98,951</td>
<td>88,484</td>
<td>45,602</td>
<td>10,733</td>
<td>87,903</td>
<td>54,065</td>
<td>3,375</td>
</tr>
</tbody>
</table>

Notes: Values in parentheses are the estimated robust standard errors

*** p<0.01, ** p<0.05, * p<0.1

<sup>60</sup> It is one of the most commonly used spices in India.

<sup>61</sup> It is one of the most commonly used spices in India.

<sup>62</sup> It is commonly used flour used to make bread and sweets.

<sup>63</sup> It is an addictive substance popularly consumed in India. Betel leaves is the most important ingredient in it.

<sup>64</sup> It is a locally made cigarette. It is one of the most commonly consumed forms of tobacco.

<sup>65</sup> It is made from natural gas and is used as a cooking fuel.
Table 24. Price Results for rural areas and developed states including state and year fixed effects

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VAT</td>
<td>0.105***</td>
<td>-</td>
<td>-0.029**</td>
<td>-0.009</td>
<td>-0.021**</td>
<td>-0.024**</td>
<td>-0.026**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.007)</td>
<td>(0.008)</td>
<td>(0.013)</td>
<td>(0.022)</td>
<td>(0.006)</td>
<td>(0.009)</td>
<td>(0.010)</td>
<td>(0.011)</td>
</tr>
<tr>
<td>Sample Size</td>
<td>140,963</td>
<td>105,077</td>
<td>121,441</td>
<td>15,655</td>
<td>76,667</td>
<td>50,979</td>
<td>30,739</td>
<td>34,283</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Price of Onion</th>
<th>Price of Potato</th>
<th>Price of Groundnut</th>
<th>Price of Sugar</th>
<th>Price of Salt</th>
<th>Price of Turmeric</th>
<th>Price of Chilli powder</th>
<th>Price of Suji</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAT</td>
<td>-0.035**</td>
<td>-0.006</td>
<td>-0.095***</td>
<td>-0.013***</td>
<td>0.088***</td>
<td>0.025</td>
<td>0.063***</td>
<td>0.002**</td>
</tr>
<tr>
<td></td>
<td>(0.013)</td>
<td>(0.016)</td>
<td>(0.014)</td>
<td>(0.004)</td>
<td>(0.024)</td>
<td>(0.025)</td>
<td>(0.014)</td>
<td>(0.015)</td>
</tr>
<tr>
<td>Sample Size</td>
<td>156,126</td>
<td>150,471</td>
<td>34,218</td>
<td>133,609</td>
<td>160,510</td>
<td>155,681</td>
<td>149,654</td>
<td>38,912</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Price of Yellow Lentil</th>
<th>Price of Banana</th>
<th>Price of Tea Leaves</th>
<th>Price of Pan69</th>
<th>Price of Bidi70</th>
<th>Price of Chewing Tobacco</th>
<th>Price of Alcohol (Local)</th>
<th>Price of Firewood71</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAT</td>
<td>-0.002</td>
<td>-0.068***</td>
<td>-0.128**</td>
<td>0.103***</td>
<td>0.652***</td>
<td>0.173***</td>
<td>-0.009</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.025)</td>
<td>(0.012)</td>
<td>(0.011)</td>
<td>(0.055)</td>
<td>(0.014)</td>
<td>(0.063)</td>
<td>(0.055)</td>
<td>(0.033)</td>
</tr>
<tr>
<td>Sample Size</td>
<td>94,721</td>
<td>80,561</td>
<td>130,836</td>
<td>14,346</td>
<td>49,312</td>
<td>31,029</td>
<td>15,230</td>
<td>139,389</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VAT</td>
<td>-0.000</td>
<td>-0.051***</td>
<td>-0.103*</td>
<td>-0.241***</td>
<td>-0.013</td>
<td>-0.036</td>
<td>-0.013</td>
<td>-0.036</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.008)</td>
<td>(0.014)</td>
<td>(0.054)</td>
<td>(0.013)</td>
<td>(0.026)</td>
<td>(0.015)</td>
<td>(0.085)</td>
</tr>
<tr>
<td>Sample Size</td>
<td>121,706</td>
<td>144,368</td>
<td>123,009</td>
<td>135,808</td>
<td>54,088</td>
<td>17,013</td>
<td>135,534</td>
<td>2,009</td>
</tr>
</tbody>
</table>

Notes: Values in parentheses are the estimated robust standard errors

*** p<0.01, ** p<0.05, * p<0.1

66 It is one of the most commonly used spices in India.
67 It is one of the most commonly used spices in India.
68 It is commonly used flour used to make bread and sweets.
69 It is an addictive substance popularly consumed in India. Betel leaves is the most important ingredient in it.
70 It is a locally made cigarette. It is one of the most commonly consumed forms of tobacco.
71 It is an important source of energy in the rural areas.
72 A type of fuel commonly used for cooking and lighting in the rural areas.
CHAPTER THREE - TAX INCIDENCE: DO INSTITUTES MATTER? AN EXPERIMENTAL STUDY

1 ABSTRACT

There is perhaps no more important question in public finance than who ultimately bears the burden of a tax. According to tax incidence theory, the long-run incidence of a unit tax is independent of the assignment of the liability to pay tax. However, the theory is silent on the possible effects of market institutions on tax incidence. We report data from an experiment designed to address two questions. Is tax incidence independent of the assignment of the liability to pay tax in experimental markets? Is tax incidence independent of the market institution in experimental markets? We conduct laboratory experiments, using double auction and posted offer markets. Based on the results of Kolmogorov-Smirnov tests of experimental market prices, we conclude that the answer to both questions is an emphatic “no.” We report evidence that the observed differences from the theoretical values are statistically significant and economically meaningful.

2 INTRODUCTION

To understand the distributional effects of a tax, it is necessary to know who ultimately bears the tax burden. The theory of tax incidence concerns itself with answering this very question, and there may be no more important question in the field of public finance. According to the liability side equivalence (LSE) hypothesis, the incidence of a tax in long-run competitive equilibrium has nothing to do with the statutory assignment of the liability to pay tax. Rather, it
depends on the relative elasticity’s of supply and demand; the more inelastic of the two ultimately bears the greater tax burden.

The economic intuition for this conclusion is straightforward. Suppose, for example, that a firm is liable to pay tax on every unit sold. The firm can try to shift the tax forward onto the consumer through higher prices. The ability of the firm to do so, however, is limited by the own-price elasticity of demand for the good. If demand is sufficiently inelastic relative to supply, the change in quantity demanded will be small in response to a given increase in the price. In this case, the firm will find it profitable to shift much of the tax burden onto consumers. If, on the other hand, demand is elastic relative to supply, increasing the price to shift the tax onto consumers will lead to a large decrease in the quantity demanded. In this case, the firm will not find it profitable to shift as much of the tax onto the consumer as in the inelastic case. From this perspective, nothing changes if the consumer is assigned the liability to pay the tax rather than the seller.\(^73\)

Since governments seldom change the statutory assignment of the liability to pay tax, there are seldom opportunities to test the LSE hypothesis using observational data. An exception is Saez et al. (2012) who test the LSE hypothesis using evidence from a natural experiment created by a change in the assignment of the liability to pay the payroll tax in Greece. They report evidence that contradicts the LSE hypothesis. Furthermore, there is a growing literature indicating that informational, behavioral, and institutional factors influence tax incidence.\(^74\)

Indeed, markets need institutions to function. These institutions specify how buyers and sellers

---

73 Of course, the firm has not exhausted all of its options; it could also attempt to shift the tax backward onto the suppliers of factors of production. Again, according to the LSE hypothesis, the firm’s ability to do so depends on the relative price elasticities of factor supplies and demands.

74 Using a laboratory experiment, Sausgruber and Tyran (2005) test the “Mill hypothesis” that the burden of an indirect tax may differ from that of a direct tax because the latter is more visible or salient. In a related study using a field experiment and observational data on gasoline and liquor sales, Chetty et al. (2009) examine the impact of tax salience on tax incidence. In a related study, Finkelstein (2009) reports evidence that salience influences the elasticity of demand for tolled roads.
interact to determine prices and quantities. Different market institutions are known to have different price formation and quantity determination properties, and these properties may affect the incidence and excess burden of taxes. Yet, the theoretical literature on tax incidence does not account for the potential influence of market institutions on tax incidence. In this study, we use laboratory experiments to see if two important market institutions – double auction and posted offer markets – produce results that are consistent with the LSE hypothesis.

Perfect competition is a theoretical construct of an idealized market structure. In everyday life, however, we deal with market institutions rather than idealized market structures. There is no discussion in the theoretical literature on the impact of market institutions on tax incidence. Consider the following example as a case in point. Perfectly competitive markets assume price-taking behavior by buyers and sellers. In the case of retail markets, sellers obviously set or post prices, and buyers purchase as many units as they wish to at the posted price. Furthermore, in contrast to the assumption of complete information in perfectly competitive markets, buyers and sellers do not have perfect information about prices of comparable goods on offer at other stores as assumed by the theory of perfect competition absent a costly search for such information.

In laboratory experiments, the market institutions that are the focus of this study exhibit the price convergence property predicted by the theory of perfectly competitive markets. Strictly speaking, we do not claim to be testing the theory of long-run tax incidence for perfectly competitive markets. Rather we are testing whether the data generated in laboratory experiments with two important market institutions are consistent with the LSE hypothesis. In this way we are

---

75 See, for examples: Williams (1973), Plott and Smith (1978), Hong and Plott (1982), Smith (1982b), and Ketcham et al. (1984).
attempting to add an important dimension to our understanding of the potential influence of market institutions on tax incidence.

We are not the first to propose testing the LSE hypothesis in a laboratory setting. Kachelmeier et al. (1994), Kerschbamer and Kirchsteiger (2000), Borck et al. (2002), Riedl et al. (2005), and Ruffle (2005) test the LSE hypothesis in laboratory settings using a variety of tax types and market institutions. Kerschbamer and Kirchsteiger (2000) test the LSE hypothesis by imposing a tax on either the proposer or the responder in a one-stage ultimatum bargaining game. They contend that the LSE hypothesis should hold in the tax version of the ultimatum game as long as the fairness norm threshold below which offers are rejected remains unaffected by a change in the statutory assignment of the liability to pay the tax. Based on the results of their experiments, they reject the LSE hypothesis at conventional levels of significance. To explain this finding, they hypothesize that the assignment of the liability to pay tax may lead those with the legal responsibility for remitting the tax to the government to feel a moral duty to bear the tax economically. There is no market institution in this experiment.

Riedl and Tyran (2005) test the LSE hypothesis, using a gift-exchange game. They contend that LSE should hold in gift-exchange games when gross wages adjust to changes in taxes and market participants are exclusively concerned with net-of-tax profits and wages. They test the LSE hypothesis in a gift-exchange game where social norms may cause LSE to breakdown. In contrast to Kerschbamer and Kirschsteiger, Riedl and Tyran cannot reject the LSE hypothesis at conventional levels of significance. However, there is no market institution in the Riedl and Tyran experiment.

Kachelmeier et al. (1994) use an elaborate experimental design to test the LSE hypothesis. Their design involves two interrelated, double auction markets, three agents
(customers, retailers, and wholesalers), and three different tax instruments (an ad valorem tax levied on customers, a turnover tax levied on retailers, and a value-added tax levied on wholesalers and retailers). In their experimental design, there are 10 periods without a tax; then, there are 10 periods with one of the tax instruments described above. They conduct 10 market sessions. They cannot reject the LSE hypothesis at conventional levels of significance. Borck et al. (2002) test the LSE hypothesis in posted offer markets, using a unit excise tax. In their experimental design, there is no tax in the first 12 periods; then they introduce a unit tax in periods 13 through 24. They conduct 10 market sessions. They also conduct two market sessions using a double auction market design. They cannot reject the LSE hypothesis for either market institution. However, they do not report whether tax incidence differs between the two market institutions.\textsuperscript{76}

Ruffle (2005) tests the LSE hypothesis for taxes and subsidies. They use a pit market where at least eight pairs of buyers and sellers participate in all experiments.\textsuperscript{77} All sessions consist of 19 three-minute trading periods. During the first eight periods, subjects participate in an ordinary pit market, with no tax or subsidy. Beginning in period 9, a single change is introduced, namely a 10-unit tax (subsidy) on either the buyers or the sellers. They find strong support for the LSE hypothesis for both subsidies and taxes.

\textsuperscript{76} Although sellers are in a position to behave strategically, posted offers are typically discussed in experimental studies as deviations from or convergent to the perfectly competitive price. Holt and Solis-Soberon describe a Nash equilibrium pricing strategy involving randomization in laboratory posted offer markets that may differ from the competitive equilibrium. Borck et al. (2002) point out that the Nash equilibrium described by Holt and Solis-Soberon assumes non-strategic behavior by buyers which may limit the applicability of this equilibrium. Furthermore, Borck et al. do not find empirical support for the Nash equilibrium pricing strategy in their posted offer markets. We return this issue below.

\textsuperscript{77} A pit market closely resembles a double auction market. The two institutions differ in the way bids and asks are organized. In a pit market, traders negotiate directly with whomever they choose from the other side of the market, with participants freely exchanging bids and asks between them until a transaction price is agreed upon. In the double auction market, bids and asks are publicly recorded. In a double auction market, actual trade occurs when a seller accepts the most attractive bid price, or a buyer accepts the most attractive offer price among the outstanding bid and offer prices.
In each of the experimental designs with market institutions described above, the experiment begins with a no-tax treatment in the initial trading periods; then, a tax is introduced and trading proceeds for an equal number of periods as in the initial no-tax treatment. In these experiments, there is a striking difference in the speed of price convergence in the initial, no-tax trading periods and in the subsequent trading periods with a tax. In the initial no-tax trading periods, the trading prices are rather noisy, and it takes a few trading periods for prices to begin to converge to an equilibrium. In contrast, the initial rounds of the tax treatment converge almost immediately to an equilibrium. For example, Borck et al., report the mean and variance of the prices by trading period in their Table 1. We use these data to compute the coefficient of variation in the initial three periods and the last period with no tax and with a tax on the seller. The coefficients of variation in the initial three periods and the last period without a tax are 41.2, 28.7, 16.5, and 8.0, respectively, and with a tax on the seller, they are 17.9, 9.7, 8.2, and 4.6, respectively. When the tax is on the buyer, the coefficients of variation by period exhibit the same pattern. This raises the question of whether the LSE hypothesis is robust to alternative experimental treatments. More specifically, we ask and attempt to answer whether the findings reported above depend on the initial trading periods without a tax. The reason for pursuing this question is concern about cross-treatment contamination. We are also interested to compare the incidence of a tax, holding the liability to pay tax the same, for two different market institutions.

Our experimental design differs from the existing literature in a number of important ways. We introduce a unit tax in the first trading period and maintain that tax throughout all 30 trading periods. In addition to testing the LSE hypothesis for two market institutions, we also test

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78 Introducing a tax in the 13th trading period changes the scale of the price series; therefore, the variances for the two price series with and without a tax are not comparable. We use the coefficient of variation to compare the variation in the two price series, which is defined as follows: \((\sigma / \mu) \times 100\), where \(\sigma\) is the standard deviation and \(\mu\) is the mean. The coefficient of variation accounts for the change in the scale of the two series by dividing the standard deviation by the mean.
whether the incidence of a unit tax is the same in both market institutions holding the liability to pay tax the same. We also calculate the excess burden due to the unit tax for each of the four treatments that result from our 2×2 design. Our underlying research question therefore is whether two prominent features of a controlled experimental economy – the assignment of the liability to pay tax and the type of market institution – influence the incidence of a tax using two important market institutions observed in the field.

More specifically, we conduct laboratory experiments comparing computerized double auction (DA) and posted-offer (PO) markets to investigate whether tax incidence is independent of the assignment of the liability to pay tax and the type of market institution. The rules of the computerized DA market in our experiments are essentially the same as those that govern trading on the New York Stock Exchange and on many organized futures markets. An experimental DA market is open for a specified interval of time; buyers are free to announce at any instant a bid price for the commodity they wish to buy; and sellers are free to announce an offer price for the commodity they wish to sell. In the simplified DA markets used in many experiments, including ours, each bid, offer, or contract is for a single unit. Actual trade occurs when a seller accepts the most attractive bid price, or a buyer accepts the most attractive offer price among the outstanding bid and offer prices.

The rules of the computerized PO market in our experiments are similar to those that govern most of the consumer goods markets in developed countries. Think, for example, of a supermarket or department store. The seller posts a sales price for a commodity and may also limit the quantity they are willing to sell at that price. Buyers may compare prices available to them from different sellers and make the decision to buy or not to buy a given commodity from a
The choice of DA and PO markets are particularly well suited to the research questions at hand. Smith (1976b), Smith et al. (1982), Williams (1980), and Smith and Williams (1983) report the robust result that DA markets converge rapidly to a competitive equilibrium thus exhausting the potential gains from trade. In other words, DA markets achieve the Pareto efficient resource allocation of competitive market theory. It would seem that DA markets give the LSE hypothesis very good chances for success. In contrast, Plott and Smith (1978), Williams (1980), Hong and Plott (1982), Smith (1982b), and Ketcham et al. (1984) report evidence that PO markets produce prices that converge to the competitive equilibrium price from above and more slowly than in DA markets. PO markets also yield less efficient allocations than DA markets. Consequently, the LSE hypothesis may not apply to PO markets. However, PO exchange is the most common retail market institution in advanced market economies; thus, it is important to investigate the effect of this market institution on tax incidence.

Our experimental design includes four treatments that use the same induced, stationary supply and demand schedules: (1) a double auction market with a unit tax on the buyer (DATB); (2) a double auction market with a unit tax on the seller (DATS); (3) a posted offer market with a unit tax on the buyer (POTB); and (4) a posted offer market with a unit tax on the seller (POTS). Tax incidence theory is silent about the role market institutions play in determining who ultimately bears the burden of a tax. However, according to the LSE hypothesis, the incidence and excess burden of a unit excise tax are independent of the assignment of the liability to pay tax. This hypothesis is robust to many market structures.
To test the LSE hypothesis, we conduct Kolmogorov-Smirnov (K-S) two independent sample tests using pairwise comparisons of the empirical cumulative distributions of the buyer prices produced by the four experimental treatments. In contrast to the predictions of the LSE hypothesis, the K-S tests reject the LSE hypothesis at conventional levels of significance. The K-S tests also reject the hypothesis at conventional levels of significance that the type of market institution has no effect on the distribution of buyer prices. In short, we report evidence that the assignment of the liability to pay tax and the type of market institution have statistically significant and economically meaningful effects on tax incidence in the two market institutions that are the focus of this study.

The remainder of this paper is organized as follows. The next section describes our experimental design in greater detail, and the subsequent section explains the results. We conclude in the final section.

3 EXPERIMENTAL DESIGN AND PROTOCOL

Our experimental design tests the ability of a widely accepted economic theory to predict the influence of changes in the type of market institution and in the assignment of the liability to pay tax on tax incidence. Following Smith (1976a, 1982a), we induce stationary demand and supply functions for a fictitious commodity. We use a balanced design in which tax incidence theory predicts that the economic burden of a unit tax on a homogeneous good will be equally shared between buyers and sellers, independently of the assignment of the liability to pay tax.79

As previously noted, the theory makes no prediction regarding the influence of a change in the type of market institution on the incidence of a tax. To gauge the impact of the market

79 A “balanced design” is the discrete-variables analogue of a continuous-variables model in which: (a) the slope of the linear market demand function is the negative of the slope of the linear market supply function; and (b) consumers’ surplus equals sellers’ surplus at the theoretical competitive equilibrium price and quantity.
institution, we change the market institution from a DA to a PO market, keeping the assignment of the liability to pay tax the same. Similarly, we change the assignment of the liability to pay tax from the seller to the buyer, keeping the market institution the same, in order to gauge the impact of this change on the incidence of a tax. The result is a 2×2 design with a total of four treatments. This illustrates the advantage of laboratory experiments. They are performed in well-defined, controlled environments, where one variable at a time is changed to measure its impact on the outcome of interest. We proceed below by describing our basic experimental design.

We conduct a total of four sessions, where each session is devoted to one of the four treatments. The subject’s role as a buyer or a seller in the experimental market is randomly assigned by a computer at the beginning of each session and remains the same throughout the session. In each session, four independent markets, consisting of five buyers and five sellers in each market, are simultaneously trading. Each buyer and seller is given five (no-tax) infra-marginal units to sell or buy at the beginning of each trading period, and there are 30 trading periods in each of the four markets in a given session. In short, the experiment uses a between subjects design, with 40 subjects randomly assigned to the role of buyer or seller in equal numbers in each of the four treatments, resulting in a total of 160 subjects.

Table 25 below shows an individual seller’s marginal costs and an individual buyer’s marginal values per unit. The table shows the five (no-tax) infra-marginal costs and values and the marginal cost and value for a sixth, extra-marginal unit. Each buyer in all four treatments is assigned a value of 50 experimental dollars (ED) for unit 1 of the fictitious commodity, 47 ED for unit 2, 44 ED for unit 3, 41 ED for unit 4, 38 ED for unit 5, and 35 ED for unit 6. These marginal values represent the induced individual demand schedules used in the experiment. Similarly each seller in all four treatments is assigned a cost of 23 ED for unit 1, 26 ED for unit
2, 29 ED for unit 3, 32 ED for unit 4, 35 ED for unit 5, and 38 ED for unit 6. These marginal costs identify the induced individual supply schedules used in the experiment. Costs and values are private information. Throughout each session, the subjects are seated in a manner that protects the privacy of this information. The amount of the unit tax (12 ED) and the assignment of the liability to pay tax are announced to the subjects at the beginning of each session. The costs, values, and tax per unit remain the same throughout each session.

In the absence of a tax, the unique competitive equilibrium quantity is 25 units, consisting of 5 units traded by each buyer and seller. After we impose a unit tax of 12 ED, the unique equilibrium quantity predicted by the theory is 15 units, consisting of 3 units traded by each buyer and seller. The predicted excess burden of this tax is 60 ED \[= 5 \times (38 - 35) + 5 \times (41 - 32)]\. 

At the beginning of each experimental session, subjects read through detailed instructions appearing on their computer screens on how to interact with the computer to trade in the market. The instructions for buyers and sellers for all four treatments are available at the following URL: http://expecon.gsu.edu/jccox/subjects.html. These instructions are also available to the reader in the appendix of this paper. After the subjects read through the instructions, summary instructions are projected on a screen and read to the subjects to increase understanding of the market participation process. The scripts of the oral summary instructions are available at the URL given above. Subjects are permitted to ask questions of the experimenter, either publically or privately. Before actual trading periods begin, there are five practice trading periods to ensure the subjects are comfortable with the software. These practice periods acquaint the subjects with the software and help them to understand the decision-making process. The practice periods are followed by 30 actual trading periods in each session (treatment). The total number of trading periods is not announced to the subjects.
The subjects are mostly undergraduate students at a large urban university in the United States. Table 26 provides information on the demographic profile of the subjects. They are nearly equally divided among class ranks, with 25 percent freshmen, 31 percent sophomores, 20 percent juniors, and 22 percent seniors. Masters students make up two percent of the sample. Approximately 75 percent of the sample has previous experience in an experiment; 59 percent are female; 51 percent are African-American; 20 percent are white; 15 percent are foreign born; and the remaining 14 percent are either Asian-American, Hispanic-American, or mixed race. The average age in our sample is 20 years old; the minimum age is 18; and the maximum age is 24. Approximately 34 percent of the sample is either a business major (accounting, finance, or management) or an economics major. The modal (39 percent) grade point average (GPA) is between 3.25 and 3.74; 9 percent have a GPA between 1.25 and 2.74; 29 percent between 2.75 and 3.24, and 19 percent between 3.75 and 4.0. A small percentage of the sample (4 percent) has yet to receive a final grade in a college course. Although there is some variation in the demographic profiles among the four treatments, the percentages are similar across treatments suggesting that the randomization was successful.

2.1 Induced value information given to subjects

Subjects are given the same information about induced marginal costs and values in every experimental session with either market institution. A seller’s trading screen shows “cost per unit” in one column and the “cost plus tax per unit” in an adjacent column. If, however, the

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80 For both the double auction and posted offer market treatments, we include separate columns for “cost per unit” and “cost plus tax per unit” in the seller’s trading screen and “value per unit” and “value minus tax per unit” in the buyer’s trading screen in order to make the tax salient. Chetty et al. (2009) defines tax salience as the price of a good calculated at the gross-of-tax price. He reports evidence of the impact of tax salience on behavioral responses to taxes from a field experiment and regression analysis using observational data. When taxes are less salient, agents do not optimize relative to the true tax-inclusive prices, and so demand becomes less sensitive to a tax. In other words, a less salient tax makes the own-price elasticity of demand more inelastic relative to a more salient tax, making consumers bear more of the tax burden. Furthermore, Finkelstein (2009) shows that less salient tolls result in more inelastic demand.
buyer is assigned the liability to pay tax, the figures in these two columns are identical, because the unit tax on the seller is equal to zero. Similarly, a buyer’s trading screen shows “value per unit” in one column and the “value minus tax per unit” in an adjacent column. If, however, the seller is assigned the liability to pay tax, the figures in these two columns are identical, because the unit tax on the buyer is equal to zero. For further details on the exact layout of the buyer and seller trading screens, the interested reader may see the screen shots in the subject instructions which are available at the URL given above.

2.2 Computerized double auction markets

Two treatments are conducted with DA markets. In one treatment, the liability to pay tax is assigned to the seller in the market and, in the other treatment, to the buyer in the market. The assignment of the liability to pay tax is the only difference in the two DA treatments. The unit tax in both treatments is the same and equal to 12 ED. In both treatments sellers and buyers are given two and a half minutes to complete their transactions in each trading period. The time remaining in the trading period, the subject’s own number of units available to buy or sell, own cumulative earnings, own profit or loss from each traded unit, outstanding bid and ask prices in the market, tax charged per unit, and the market transaction prices are displayed on the trading screens of the buyers and sellers at all times. The bid, ask, and transaction price information provided is a characteristic of the DA market institution.

2.3 Computerized posted offer markets

The remaining two treatments are PO markets. In this market institution, sellers make the first move by posting an offer price and the number of units they are willing to sell at that offer price. Buyers then enter the market in a random queue, one by one, and accept the sellers’ offers if they find them attractive. If an offer is accepted, then trade occurs. In one posted-offer
treatment, the liability to pay a unit tax on each traded unit of a fictitious commodity is assigned to the seller. In the other treatment, the liability to pay a unit tax on each traded unit of the commodity is assigned to the buyer. Again, the assignment of the liability to pay tax is the only difference between these two treatments. In both treatments, sellers have two and a half minutes to post offers to the market in each trading period. Each buyer has an equal amount of time (30 seconds) to accept the available offers in the market. The time remaining to make decisions, own number of units available to buy or sell, own cumulative earnings, own profit or loss from each traded unit, and the unit tax are displayed on the sellers’ and buyers’ trading screens. A seller’s trading screen also lists the offers posted by oneself. Sellers are not able to see the offers posted by other sellers in the market. We believe that this feature of the treatment best reflects the field institution that we are trying to replicate in the laboratory. In the field, knowledge of the prices offered by other sellers in the market can only be obtained through costly surveillance; this information is not provided without cost by the PO market institution.

A buyer’s trading screen lists the number of units available for sale and the offer price corresponding to each of these units as posted by the sellers. For further details on the trading screen’s presentation of information and layout, please refer to the screenshots provided in the subject instructions which are available at the URL given above.

2.4 Questionnaire and subject payments

At the end of each session, the subjects are asked to complete a short survey, and then they are paid their cumulative earnings for all 30 trading periods, according to the conversion rate (1 ED = $0.07) announced at the beginning of the session. Table 27 reports the minimum, average, and maximum earnings for each of the 4 treatments. In the DATS treatment, the minimum earnings are $14.25, the average earnings $26.99, and the maximum earnings $38.75.
Turning to the DATB treatment, the minimum, average, and maximum earnings are $16.75, $27.66, and $35.25, respectively. In the POTS (POTB) treatment, the minimum earnings are $9.25 ($6.75), the average earnings $20.12 ($20.79), and the maximum earnings $40.75 ($38.50). A session takes approximately 2 hours to complete; thus average earnings exceed $10.00 per hour, which is a favorable hourly earnings rate for student subjects. A copy the questionnaire is available in the appendix of the paper.

4 DATA FROM THE EXPERIMENT

We investigate two questions in this study. Is tax incidence independent of the assignment of the liability to pay tax for a given market institution? Is tax incidence independent of the type of market institution? We proceed below by making pairwise comparisons of the average buyer prices from the four treatments. Then, we test the statistical significance of these pairwise comparisons, using the Kolmogorov-Smirnov (K-S) test for two independent samples.

We begin by making pairwise comparisons of the average buyer prices from the four treatments. According to the LSE hypothesis, there should be no difference between the average buyer prices in the two DA treatments and no difference in the two PO treatments.81

Figure 8 shows the percentage differences in pairwise comparisons of average buyer prices from the four treatments. The average buyer price from the DATS treatment is 1.46 percent greater than that from the DATB treatment. Similarly, the average buyer price in the POTS markets is 1.82 percent greater than the average buyer price in the POTB markets. A comparison of prices between market institutions reveals that the average buyer price is 5.40

81 The choice of buyer or seller prices has no bearing on the inferences drawn from the data. The buyer price is the amount paid by a buyer for a unit of the fictitious commodity. The difference between the buyer price and the seller price is always equal to the unit tax or 12 ED. The comparisons among prices across the four treatments would be the same if the analysis were conducted in terms of seller prices.
percent higher in the POTS than in the DATS markets and 5.14 percent higher in the POTB than in the DATB markets. Clearly, the differences in average buyer prices are greater for the comparisons between market institutions, holding the assignment of the liability to pay tax the same, than for the comparisons between the assignments of the liability to pay tax, holding the market institution the same. These differences may appear to be rather modest; however, as discussed in greater detail below, relatively small differences in buyer prices lead to much larger differences in excess burdens.

To test the LSE hypothesis, we use the K-S test for two independent samples. The K-S test has several advantages over alternative statistical procedures. Since the K-S test is based on the empirical cumulative distributive functions (CDFs) of the price series, it uses all the moments of the data. Furthermore, the K-S test is robust to alternative distributional properties of the data, non-normal distributions, and heteroskedasticity. In contrast, the Student’s t-test only uses the first moment of the data and is sensitive to significant departures from normality and homoscedasticity.

There is a lot of “noise” in the prices in the initial trading periods, which undoubtedly reflects the price discovery process. This noise appears to fade away by the 15th trading period. Prices stabilize more rapidly in the DA markets than in the PO markets, which is consistent with previous findings reported in the literature for experimental markets without taxes. Since the K-S test assumes the observations are independent draws from a given distribution, we conduct a runs test for serial randomness of the price data for the last 15 trading periods of each treatment. The runs tests fail to reject the null hypothesis of serial independence at conventional levels of

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82 The intuition behind this test is as follows. If two independent samples are drawn from the same population, the two cumulative frequency distributions would be expected to be reasonably similar. The protocol for the K-S test of two independent samples is based on the principle that if there is a significant difference at any point along the two cumulative frequency distributions, the researcher can conclude there is a high likelihood the samples come from two different populations. For further details, see Daniel (1990) and Smirnov (1936).
significance for each treatment.\textsuperscript{83} More specifically, the runs test is equal to -1.26 (p-value = 0.21) for the DATB buyer price series; to 1.07 (p-value = 0.29) for the DATS price series; to -0.59 (p-value = 0.55) for the POTB price series; and to -0.01 (p-value = 1.00) for the POTS price series.\textsuperscript{84} This provides statistical support for our conclusion based on merely looking at the price series that they have converged by the 15\textsuperscript{th} trading period. Consequently, we feel justified in using the data from the last 15 trading periods to conduct the K-S test for two independent samples.

Figures 9 through 12 provide pairwise comparisons of the CDFs of buyer prices from pairwise comparisons of the four treatments. Beneath each figure, we report the maximum difference between the two CDFs and the associated p-value of the K-S test statistic.

We begin by examining whether the incidence of a tax is independent of the assignment of the liability to pay tax for the two market institutions that are the focus of this study. Figure 9 compares the CDFs of the average buyer prices from the DATB and DATS treatments. The maximum difference between the two CDFs is 0.2023 (p-value = 0.000), which is statistically different from zero at conventional levels of significance. Thus, we can reject the null hypothesis that the two price series come from identical probability distributions. This finding for the DA treatments is inconsistent with the prediction of the LSE hypothesis that the incidence of a tax is independent of the assignment of the liability to pay tax.

Figure 10 makes a similar comparison for the two CDFs of the buyer prices from the PO treatments. The distributions appear to be quite different. The maximum difference between the two CDFs is 0.3030 (p-value = 0.000), which is statistically significantly different from zero at conventional levels of significance. Again, this leads us to reject the hypothesis that the

\textsuperscript{83} See Zar (1999) for further details on the runs test of serial randomness.

\textsuperscript{84} The p-value is the probability of obtaining a test statistic at least as extreme as the one that is actually observed, assuming that the null hypothesis is true that the two samples are drawn from the same probability distribution.
incidence of a tax is independent of the assignment of the liability to pay tax in the PO treatments, too.

Now we turn to our second question: Is the incidence of a tax independent of the type of market institution, holding the assignment of the liability to pay tax the same. Figure 11 compares the two CDFs of the buyer prices from the DATB and POTB treatments. Again the two distributions appear to be quite different, and, indeed, the maximum difference between the two CDFs is 0.7022 (p-value = 0.000), which is statistically significantly different from zero at conventional levels of significance. Finally, Figure 12 compares the two CDFs of the buyer prices from the DATS and POTS treatments. The maximum difference between these two CDFs is 0.7253 (p-value = 0.000), which is also statistically significantly different from zero at conventional levels of significance.

Although these differences are highly statistically significant, it is also important to gauge whether these differences are economically meaningful. We use several measures of economic significance. We compare the proportions of the total tax revenue paid by buyers and sellers in the four treatments. We also compare the excess burdens created by the tax in each of the four treatments.

Table 28 reports average buyer prices, total tax revenue, and the incidence of the tax as a percent of total revenue for the last 15 periods of each of the four treatments. Since we use a balanced design, the theory of tax incidence predicts that the burden of the tax will be equally shared between buyers and sellers. This is what we observe in the DATB treatment, where approximately 50 percent of the tax burden is borne by buyers and 50 percent by sellers, as shown in the first row of Table 28. Consequently, we use these results to gauge the incidence of the tax in the other three treatments. In the DATS treatment, 55.1 percent of the tax revenue of
180.4 ED is borne by buyers and 44.9 percent by sellers. In contrast, 67.9 percent of the tax revenue of 133.6 ED is borne by buyers and 32.1 percent by sellers in the POTB treatment. The burden of the tax is even further shifted onto buyers in the POTS treatment; here 74.5 percent of the tax revenue of 124.8 ED is borne by buyers and 25.5 percent by sellers. Clearly, these differences in tax incidence among the four treatments are economically meaningful.

Now, we turn to the analysis of excess burdens. Table 29 shows the average quantity, average excess burden, average excess burden as a percentage of tax revenue, and average excess burden as a percentage of participant earnings for the last 15 periods of each treatment. The average quantities shown in Table 29 are consistent with the observed differences in tax shifting documented in Table 28. The equilibrium quantity in the DATB treatment is approximately equal to 15 units, which is the post-tax equilibrium quantity predicted by the theory. As a result, the excess burden in the DATB treatment is approximately equal to 60 ED which is the value predicted by the theory. In the DATS treatment, the average quantity is 15.03, and the excess burden is 63.85 ED. In contrast, the average quantities are clearly lower and excess burdens strikingly greater in the POTB and POTS treatments. The average quantities (excess burdens) are 11.13 (134.7 ED) and 10.40 (147.4 ED) in the POTB and POTS treatments, respectively. Table 29 also shows that there are stark differences in excess burdens as a share of tax revenue and as a share of participant earnings among the four treatments.

In short, the data generated by the DATB treatment are consistent with the theory of long-run tax incidence in competitive markets. Using this treatment as the benchmark, we find substantial differences in the average prices and quantities as well as the excess burdens as a share of participant earnings among the other three treatments. Contrary to the predictions of the
LSE hypothesis, tax incidence is not independent of the assignment of the liability to pay tax. Incidence also depends on the type of market institution in our laboratory experiments.

Despite the similarities in research question, our conclusions dramatically differ from those of Borck et al. (2002) who fail to reject the LSE hypothesis in posted offer and double auction markets. Therefore, it may be worthwhile to discuss what may be giving rise to these discrepant conclusions. There are two plausible explanations: differences in our experimental and statistical procedures.

Beginning with the differences in the experimental procedures, Borck et al have the traders begin with 12 trading periods without a tax. In the 13th trading period, they introduce a unit tax and allow trade to continue for an additional 12 periods. The induced supply and demand schedules are the same in all 24 trading periods. Our experimental protocols differ from theirs in that we introduce a tax in the first trading period. This difference in our experimental designs may account for the discrepancy in our conclusions. In this case, we believe that both sets of findings are interesting and raise potentially interesting questions for further research.

There are also important differences in our statistical procedures that may explain the discrepancies in our conclusions. We use a non-parametric K-S test of independent samples to test the LSE hypothesis. As previously noted the K-S test has a number of attractive statistical properties. Furthermore, we use a runs test to verify that the data satisfy the independence assumption of the K-S test. In contrast, they estimate a random effects model. The reason they give for doing so is to account for potential serial correlation in the data. An alternative would be to estimate a first or second order autoregressive model with random effects. We use our data to estimate both types of models (a random effects model using an identical specification as theirs
and an AR(1) model with random effects). Both econometric specifications reject the LSE hypothesis in all four cases at conventional levels of significance.

It is well known that significant deviations from normality, homoskedasticity, and independence can substantially affect the performance of statistical inferences in regression models. When estimating regression models with small samples, therefore, good statistical practice should include diagnostic tests of the residuals to verify that they are well behaved. Borck et al. do not report the results of such diagnostic tests. This is not unusual in econometric studies. However, when we use our data to estimate these regression models, a Jarque-Bera (1987) test rejects the null hypothesis that the residuals from these models are normally distributed. In other words, the statistical procedures that they employ to make inferences with their data would not be valid using our data.\textsuperscript{85}

In sum, the discrepancies in the conclusions between these two studies may reflect differences in our experimental and statistical procedures. In the case of the former, we believe that the conclusions of the two studies address slightly different but still important questions and raise potentially interesting questions for further research.

5 CONCLUSIONS

We analyze data from an experiment designed to examine two important questions regarding tax incidence in two important field markets. Is tax incidence independent of: (a) the assignment of the liability to pay tax; and/or (b) the market institution that exists in the taxed market? We use the Kolmogorov-Smirnov (K-S) test for two independent samples to examine

\textsuperscript{85} We asked the authors to share their data with us, and they kindly shared the data that they were able to locate. Unfortunately, the data were not complete which is certainly understandable given the length of time that has passed since they collected those data. Therefore, we could not assess whether the residuals from their regressions satisfied the statistical properties required for valid inferences.
the statistical significance of differences in pairwise comparisons of the CDFs of buyer prices generated by the four experimental treatments in a 2×2 design that crosses selection of buyer or seller tax liability with a double auction or posted-offer market institution.

In contrast to the predictions of the LSE hypothesis, we find that the assignment of the liability to pay tax has a statistically significant and economically meaningful effect on the long-run incidence of a tax in the two market institutions examined in this study. We also find that a change in the market institution has a greater impact on tax incidence than a change in the assignment of the liability to pay tax. Interestingly, we find evidence of greater tax shifting in the case of the POTS (posted-offer institution with a tax on the sellers) treatment, which is consistent with the econometric evidence of unusual tax-shifting in the analogous field institution. Our results additionally show more tax shifting onto consumers when the assignment of the liability to pay tax is on the seller in both market institutions examined here. Finally, the excess burden created by a unit tax in the DATB (double auction institution and tax on buyers) treatment is consistent with that predicted by the theory of long-run tax incidence in competitive markets.

Given the prominence of the LSE hypothesis in the public finance canon and the practical importance of tax incidence to tax policy design, we believe that the potential influence of market institutions on tax incidence merits further study.
6 Tables

Table 25: Individual marginal costs and values per unit

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Marginal cost</th>
<th>Marginal value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23</td>
<td>50</td>
</tr>
<tr>
<td>1</td>
<td>26</td>
<td>47</td>
</tr>
<tr>
<td>1</td>
<td>29</td>
<td>44</td>
</tr>
<tr>
<td>1</td>
<td>32</td>
<td>41</td>
</tr>
<tr>
<td>1</td>
<td>35</td>
<td>38</td>
</tr>
<tr>
<td>1</td>
<td>38</td>
<td>35</td>
</tr>
</tbody>
</table>
Table 26: Demographic characteristics of the full sample and by treatment

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sample</th>
<th>Full</th>
<th>Double Auction</th>
<th>Posted Offer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Tax on seller</td>
<td>Tax on buyer</td>
<td>Tax on seller</td>
</tr>
<tr>
<td>Percent buyers</td>
<td></td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Percent freshmen</td>
<td></td>
<td>25</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Percent sophomore</td>
<td></td>
<td>31</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Percent juniors</td>
<td></td>
<td>20</td>
<td>28</td>
<td>10</td>
</tr>
<tr>
<td>Percent seniors</td>
<td></td>
<td>22</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>Percent Masters students</td>
<td></td>
<td>2</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Percent with experience in experiments</td>
<td></td>
<td>76</td>
<td>78</td>
<td>78</td>
</tr>
<tr>
<td>Percent female</td>
<td></td>
<td>59</td>
<td>55</td>
<td>68</td>
</tr>
<tr>
<td>Percent African-American</td>
<td></td>
<td>51</td>
<td>48</td>
<td>43</td>
</tr>
<tr>
<td>Percent Asian-American</td>
<td></td>
<td>4</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Percent Hispanic-American</td>
<td></td>
<td>2</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Percent mixed race</td>
<td></td>
<td>8</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Percent white</td>
<td></td>
<td>20</td>
<td>23</td>
<td>25</td>
</tr>
<tr>
<td>Percent foreign born</td>
<td></td>
<td>15</td>
<td>13</td>
<td>23</td>
</tr>
<tr>
<td>Average age</td>
<td></td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Standard deviation of age</td>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Minimum age</td>
<td></td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Maximum age</td>
<td></td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Percent business administration majors</td>
<td></td>
<td>28</td>
<td>25</td>
<td>28</td>
</tr>
<tr>
<td>Percent economics majors</td>
<td></td>
<td>6</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Percent other majors</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Percent with at least 1 economics course</td>
<td></td>
<td>55</td>
<td>53</td>
<td>58</td>
</tr>
<tr>
<td>GPA between 1.25 and 2.74 (percent)</td>
<td></td>
<td>9</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>GPA between 2.75 and 3.24 (percent)</td>
<td></td>
<td>29</td>
<td>48</td>
<td>28</td>
</tr>
<tr>
<td>GPA between 3.25 and 3.74 (percent)</td>
<td></td>
<td>39</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>GPA between 3.75 and 4.0 (percent)</td>
<td></td>
<td>19</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Not taken courses with grades (percent)</td>
<td></td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Number of experimental subjects</td>
<td></td>
<td>160</td>
<td>40</td>
<td>40</td>
</tr>
</tbody>
</table>
### Table 27: Earnings in U.S. dollars, by treatment

<table>
<thead>
<tr>
<th>Earnings</th>
<th>Sample</th>
<th>Double auction</th>
<th>Posted offer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>tax on seller</td>
<td>on buyer</td>
</tr>
<tr>
<td>Minimum Earnings</td>
<td>$6.75</td>
<td>$14.25</td>
<td>$16.75</td>
</tr>
<tr>
<td>Average Earnings</td>
<td>$23.89</td>
<td>$26.99</td>
<td>$27.66</td>
</tr>
<tr>
<td>Maximum Earnings</td>
<td>$40.75</td>
<td>$38.75</td>
<td>$35.25</td>
</tr>
</tbody>
</table>

### Table 28: Equilibrium buyer prices (ED) and tax burden as a percent of tax revenue, by treatment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Equilibrium buyer price (ED)</th>
<th>Total tax revenue (ED)</th>
<th>Proportion of the tax revenue paid by the buyer (percent)</th>
<th>Proportion of the tax revenue paid by the seller (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double auction, tax on buyer</td>
<td>41.8</td>
<td>181.2</td>
<td>50.0</td>
<td>50.0</td>
</tr>
<tr>
<td>Double auction, tax on seller</td>
<td>42.4</td>
<td>180.4</td>
<td>55.1</td>
<td>44.9</td>
</tr>
<tr>
<td>Posted offer, tax on buyer</td>
<td>43.9</td>
<td>133.6</td>
<td>67.9</td>
<td>32.1</td>
</tr>
<tr>
<td>Posted offer, tax on seller</td>
<td>44.7</td>
<td>124.8</td>
<td>74.5</td>
<td>25.5</td>
</tr>
</tbody>
</table>

Notes: The estimates reported above are based on the data from the last 15 trading periods of each treatment. The average buyer and seller prices from the DATB treatment are used as the baseline to calculate the incidence of the other three treatments. Figures reported in the table are rounded to first decimal place.
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Equilibrium quantity (Units)</th>
<th>Excess burden (ED)</th>
<th>Excess burden as a percent of tax revenue</th>
<th>Excess burden as a percent of participant earnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double auction, tax on buyer</td>
<td>15.10</td>
<td>60.60</td>
<td>33.44</td>
<td>21.91</td>
</tr>
<tr>
<td>Double auction, tax on seller</td>
<td>15.03</td>
<td>63.85</td>
<td>35.39</td>
<td>23.65</td>
</tr>
<tr>
<td>Posted offer, tax on buyer</td>
<td>11.13</td>
<td>134.70</td>
<td>100.82</td>
<td>64.78</td>
</tr>
<tr>
<td>Posted offer, tax on seller</td>
<td>10.40</td>
<td>147.40</td>
<td>118.11</td>
<td>73.26</td>
</tr>
</tbody>
</table>
7 FIGURES

Figure 8: Percentage differences in pair-wise comparisons of average buyer prices

Notes: DATB = double auction market with tax on buyer; DATS = double auction market with tax on seller; POTB = posted offer market with tax on buyer; and POTS = posted offer market with tax on seller.
Figure 9: Cumulative distribution functions of the buyer prices for the two double auction market treatments.

Notes: DATB = double auction market with the tax on the buyer. DATS = double auction market with the tax on the seller.

Kolmogorov–Smirnov test of the maximum difference between the cumulative distribution functions of the buyer prices of the two double auction market treatments, using the last 15 trading periods. Maximum difference between the two cumulative distribution functions = 0.2023 (p-value = 0.000).
Figure 10: Cumulative distribution functions of the buyer prices, using the last 15 trading periods of each market session, for the two posted offer market treatments.

Notes: POTB = posted offer market with the tax on the buyer.
POTS = posted offer market with the tax on the seller.

Kolmogorov-Smirnov test of the maximum difference between the cumulative distribution functions of the average buyer prices from the two posted offer market treatments, using the last 15 trading periods. Maximum difference between the two cumulative distribution functions = 0.3030 (p-value = 0.000).
Figure 11: Cumulative distribution functions of the buyer prices from the double auction and posted offer market treatments with the tax on the buyer.

Notes:  
DATB = double auction market with the tax on the buyer.  
POTB = posted offer market with the tax on the buyer.

Kolmogorov-Smirnov test of the maximum difference between the cumulative distributions of the average buyer prices, using the last 15 trading periods, from the double auction and posted offer markets with the tax on the buyers. Maximum difference between the two cumulative distribution functions = 0.7022 (p-value = 0.000).
Figure 12: Cumulative distribution functions of the buyer prices for the double auction and posted offer market treatments with the tax on the sellers.

Notes: DATS = double auction market with tax on seller.
POTS = posted offer market with tax on seller.

Kolmogorov-Smirnov test of the maximum difference between the cumulative distribution functions of the buyer prices from double auction and posted offer markets with tax on the sellers, using the last 15 trading periods. Maximum difference between the two cumulative distribution functions = 0.7253 (p-value = 0.000).
Appendix for the paper “Tax Incidence: Do Institutions Matter?
An Experimental Study”

Experimental Instructions

Appendix Index

Appendix 1: This appendix presents the experiment instructions to the participants for all the four treatments of the study.

Appendix 1.1. This section presents the experimental instructions when market institution is posted offer and the seller is liable to pay a per unit tax.

Appendix 1.2. This section presents the experimental instructions when market institution is posted offer and the buyer is liable to pay a per unit tax.

Appendix 1.3. This section presents the experimental instructions when market institution is double auction and the seller is liable to pay a per unit tax.

Appendix 1.4. This section presents the experimental instructions when market institution is double auction and the buyer is liable to pay a per unit tax.

Appendix 2: This appendix presents the questionnaire given out to the participants as a short survey at the end of the study.
APPENDIX 1.1

Treatment 1

The market institution is a posted offer market; the Seller is liable to pay a tax on each unit sold.

Today’s experiment:

This is an experiment in the economics of decision making in markets.

Your earnings will be determined by your own decisions and the decisions of others as described in the following instructions. SO IT IS IMPORTANT THAT YOU READ THESE INSTRUCTIONS CAREFULLY. This experiment is structured so that only you know your earnings. All of the money that you earn will be paid to you privately IN CASH immediately following the end of today’s experiment.

Scenario

You will be randomly assigned to the role of a Buyer or a Seller. As such, you will decide the number of units of a fictitious commodity that you would like to buy or sell. You will keep the same role for the entire experiment.

Anonymity

Your role and the role of others will be kept private. You will not know anyone’s role other than your own.

Trading screens

Sellers post offers to sell and Buyers accept offers through a series of action screens. We explain below how Sellers interact with these screens to post Offers to sell in the market.

Seller’s instructions:

You are a Seller. Sellers in the market can post Offers to sell units of a fictitious commodity to Buyers in the market. During each round of today’s experiment, you are given an opportunity to
Offer one or more units of a fictitious commodity to the market. You are also given an opportunity to set the price at which you are willing to sell the specified number of units.

A tax per unit is collected from the Sellers in the market. The amount of the unit tax is $12.00.

There will be several Sellers and Buyers in the market.

**How does a Seller like yourself make money in today’s experiment?**

Sellers make money in today’s experiment by selling units at prices greater than their costs plus tax per unit. The Seller’s cost per unit is provided on a screen, as described below. A Seller’s unit cost information is private and will be revealed only to the Seller. A Seller’s profit from trading a unit is computed by subtracting the Seller’s cost for that unit and the unit tax from the purchase price.

**How does a Buyer make money in today’s experiment?**

Buyers make money in today’s experiment by buying units at prices lower than the Buyer’s values per unit. A Buyer’s profit from buying a unit is computed by subtracting the purchase price from the Buyer’s value for that unit.

**How does a Seller like yourself trade in the market?**

Below we explain how a Seller interacts with the trading screen to post an Offer to the market. The Sellers post their Offers to the market simultaneously, and this period of the experiment is called the posting period. The posting period lasts two and one-half minutes. There will be many rounds of the experiment and thus many opportunities to post Offers to the market. The numbers used in the example below are for instructional purposes only and may not be the same numbers you will see during the experiment.
**Time Remaining to Post an Offer**

During each round of today’s experiment, Sellers are given an opportunity to post Offers to the market. Sellers are given two and one-half minutes to complete this task. The highlighted area of the trading screen in Figure 1 above displays the status of the experiment and **the time remaining for the Sellers to complete their decisions.**
Selling in the market

The highlighted area of the screen in Figure 2 above provides information on the Seller’s costs and tax per unit. A Seller should consider this information before posting an Offer to the market. An Offer consists of a price and quantity, or, in other words, the number of units that a Seller is willing and able to sell at a given price of the Seller’s choosing.

In deciding what price and quantity to post to the market, you should always check the cost to you of selling the last unit that you post to sell. The cost to you of each unit is given by the numbers in the Cost Plus Tax column.
The Seller may Offer to sell as many units as they have available to sell. The column labeled “Qty” in the highlighted area of the screen indicates that the Seller may Offer to sell up to five units.

**Seller’s Figure 3**

---

**Submitting an Offer to the market**

A Seller posts Offers to the market in the highlighted area of the screen in Figure 3 above. The Offer price is entered in the box labeled “Price” in dollars and cents. For example, 77.32 indicates an Offer price of 77 dollars and 32 cents.
A Seller can post any price greater than $0 but less than $100.

The quantity is entered in the box labeled “Qty” and must be a whole number. For example, 3 indicates an Offer to sell 3 units. The posted quantity is the maximum number of units the Seller is willing to sell at the posted offer price. As previously explained, the Seller may offer to sell as many units as they have available to sell.

The Seller posts an Offer to the market by clicking on the “Post Offer” button on the trading screen. Be aware that once the Offer is posted to the market, it cannot be retrieved or recalled. Consider your decisions carefully before clicking on the “Post Offer” button. Note that in this example there is a 5.00 dollar tax per unit which is collected from the Seller.
Market Information: Knowing where you stand in the market

Once all Sellers have submitted their offers, Buyers will take turns accepting offers. The screen in Figure 4 above shows the sort of information that will be provided to you while buyers are making their decisions. **Note that a buyer bought one unit of your offer. You made profit of 14.32 dollars, and you still have an offer to sell two additional units at a price of $77.32 in the market.**

A. The progress bar in the highlighted area of the trading screen labeled A in Figure 4 above displays the amount of time remaining for Buyers to buy in this period.

B. The highlighted area labeled B displays your own Offer which is labeled *You*. 
C. The highlighted area labeled C displays your profit on each unit sold as well as the total period profit.

D. The highlighted area labeled D displays your total period profit for the period or round just completed.

**Questionnaire and payment**

After you have finished all of your decisions in today’s experiment, you will complete a brief online questionnaire. We will convert your total earnings in experimental dollars into U.S. dollars at the exchange rate announced at the beginning of today’s experiment. The more experimental dollars you earn, the more U.S. dollars you will be paid at the end of today’s experiment. You will receive payment of your earnings, and the experiment is over.
Today’s experiment:

This is an experiment in the economics of decision making in markets.

Your earnings will be determined by your own decisions and the decisions of others as described in the following instructions. SO IT IS IMPORTANT THAT YOU READ THESE INSTRUCTIONS CAREFULLY. This experiment is structured so that only you know your earnings. All of the money that you earn will be paid to you privately IN CASH immediately following the end of today’s experiment.

Scenario

You will be randomly assigned to the role of a Buyer or a Seller. As such, you will decide the number of units of a fictitious commodity that you would like to buy or sell. You will keep the same role for the entire experiment.

Anonymity

Your role and the role of others will be kept private. You will not know anyone’s role other than your own.

Trading screens

Sellers post offers to sell and Buyers accept offers through a series of action screens. We explain below how Buyers interact with these screens to accept Offers posted to the market by Sellers.
Buyer’s instructions:

You are a Buyer. Buyers are given an opportunity to purchase units of a fictitious commodity from Sellers in the market, by accepting Offers posted by Sellers.

A tax per unit is collected from the Sellers in the market. The amount of the unit tax is $12.00.

There will be several Buyers and several Sellers in the market.

How does a Buyer like yourself make money in today’s experiment?

Buyers make money in today’s experiment by purchasing units at prices lower than the Buyer’s values per unit. The Buyer’s values for units are provided on a trading screen, as described below. A Buyer’s unit value information is private and will be revealed only to the Buyer. A Buyer’s profit from buying a unit is computed by subtracting the purchase price from the Buyer’s value for the unit.

How does a Seller make money in today’s experiment?

Sellers make money in today’s experiment by selling units at prices greater than their costs plus tax per unit. A Seller’s profit from selling a unit is computed by subtracting the Seller’s cost for that unit and the unit tax from the purchase price.

How does a Buyer like yourself trade in the market?

Below we explain how a Buyer interacts with the trading screen to accept Offers from the market. The Buyers take turns accepting offers from the market, and this phase of the experiment is called the accepting phase. There will be many rounds of the experiment and thus many opportunities to accept Offers from the market.

The numbers used in the example below are for instructional purposes only and may not be the same numbers you will see during the experiment.
Buyer’s Figure 1

*Time Remaining to Accept Offers:*

During each round of today’s experiment, Buyers are given an opportunity to accept offers available in the market. Each Buyer enters the market in a randomly assigned sequence. When a Buyer’s turn arrives, the Buyer, and only that Buyer, may accept Offers in the market. Each Buyer is given the same amount of time to complete their decisions. The highlighted area of the trading screen in Figure 1 above displays the status of the experiment. The pink area graphically represents when it is your turn and the time remaining for you to accept offers. Once the progress bar reaches the pink area, it is your turn to accept offers. In this example, some other Buyer has 30 seconds remaining to complete her (his) decisions.
Buying in the market BY ACCEPTING AN OFFER

The highlighted area of the screen in Figure 2 above is the Buyer’s action screen. The highlighted area shows the number of units available for sale and the Offer price of each Seller in the market.

When it is your turn to accept offers, you can accept a Seller’s Offer by clicking the “Buy” button next to the respective Seller’s quantity and price information. You will buy 1 unit each time you click the Buy button, as long as the respective Seller still has units available to sell.

Note that in this example, you bought one unit at a price of 59.12 dollars and made a profit of 12.88 dollars.
Making money in this experiment

The highlighted area of the trading screen in Figure 3 above provides information on the Buyer’s values per unit. A Buyer should consider this information before accepting an Offer in the market.

In deciding whether to accept an Offer available in the market, you should always check the Value to you of the next unit. The Value to you is given by the number in the Value column in the first row that does NOT contain an entry for Trade Profit.

The rightmost column is the “Trade Profit” column that shows the profit or loss that you made on each unit that you buy in the market.
When you have completed your decisions, you may click on the “I’m Done” button at the bottom of the screen.
Market Information: Knowing where you stand in the market

The highlighted area of the trading screen in Figure 4 above indicates the total period profit (loss).
Questionnaire and payment

After you have finished all of your decisions in today’s experiment, you will complete a brief on-line questionnaire. We will convert your total earnings in experimental dollars into U.S. dollars at the exchange rate announced at the beginning of today’s experiment. The more experimental dollars you earn, the more U.S. dollars you will be paid at the end of today’s experiment. You will receive payment of your earnings, and the experiment is over.
APPENDIX 1.2

Treatment 2

The market institution is a posted offer market; the Buyer is liable to pay a tax on each unit sold.

Today’s experiment:

This is an experiment in the economics of decision making in markets.

Your earnings will be determined by your own decisions and the decisions of others as described in the following instructions. SO IT IS IMPORTANT THAT YOU READ THESE INSTRUCTIONS CAREFULLY. This experiment is structured so that only you know your earnings. All of the money that you earn will be paid to you privately IN CASH immediately following the end of today’s experiment.

Scenario

You will be randomly assigned to the role of a Buyer or a Seller. As such, you will decide the number of units of a fictitious commodity that you would like to buy or sell. You will keep the same role for the entire experiment.

Anonymity

Your role and the role of others will be kept private. You will not know anyone’s role other than your own.

Trading screens

Sellers post offers to sell and Buyers accept offers through a series of action screens. We explain below how Sellers interact with these screens to post Offers to sell in the market.

Seller’s instructions:

You are a Seller. Sellers in the market can post Offers to sell units of a fictitious commodity to Buyers in the market. During each round of today’s experiment, you are given an opportunity to
Offer one or more units of a fictitious commodity to the market. You are also given an opportunity to set the price at which you are willing to sell the specified number of units.

A tax per unit is collected from the Buyers in the market. The amount of the unit tax is $12.00.

There will be several Sellers and Buyers in the market.

**How does a Seller like yourself make money in today’s experiment?**

Sellers make money in today’s experiment by selling units at prices greater than their costs per unit. The Seller’s cost per unit is provided on a screen, as described below. A Seller’s unit cost information is private and will be revealed only to the Seller. A Seller’s profit from trading a unit is computed by subtracting the Seller’s cost for the unit from the purchase price.

**How does a Buyer make money in today’s experiment?**

Buyers make money in today’s experiment by buying units at prices lower than the Buyer’s values minus tax per unit. A Buyer’s profit from buying a unit is computed by subtracting the purchase price and the tax per unit from the Buyer’s value for that unit.

**How does a Seller like yourself trade in the market?**

Below we explain how a Seller interacts with the trading screen to post an Offer to the market. The Sellers post their Offers to the market simultaneously, and this period of the experiment is called the posting period. The posting period lasts two and one-half minutes. There will be many rounds of the experiment and thus many opportunities to post Offers to the market.

The numbers used in the example below are for instructional purposes only and may not be the same numbers you will see during the experiment.
**Time Remaining to Post an Offer**

During each round of today’s experiment, Sellers are given an opportunity to post Offers to the market. Sellers are given two and one-half minutes to complete this task. The highlighted area of the trading screen in Figure 1 above displays the status of the experiment and the time remaining for the Sellers to complete their decisions.
Selling in the market

The highlighted area of the screen in Figure 2 above provides information on the Seller’s costs per unit. A Seller should consider this information before posting an Offer to the market. An Offer consists of a price and quantity or, in other words, the number of units that a Seller is willing and able to sell at a given price of the Seller’s choosing.

In deciding what price and quantity to post to the market, you should always check the cost to you of selling the last unit that you post to sell. The cost to you of each unit is given by the numbers in the Cost column.
The Seller may Offer to sell as many units as they have available to sell. The column labeled “Qty” in the highlighted area of the screen indicates that the Seller may Offer to sell up to five units.

**Seller’s Figure 3**

![Figure 3: Seller's Offer Posting Interface](image)

**Submitting an Offer to the market**

A Seller posts Offers to the market in the highlighted area of the screen in Figure 3 above. The Offer price is entered in the box labeled “Price” in dollars and cents. For example, 77.32 indicates an Offer price of 77 dollars and 32 cents.
A Seller can post any price greater than $0 but less than $100.

The quantity is entered in the box labeled “Qty” and must be a whole number. For example, 3 indicates an Offer to sell 3 units. The posted quantity is the maximum number of units the Seller is willing to sell at the posted offer price. As previously explained, the Seller may offer to sell as many units as they have available to sell.

The Seller posts an Offer to the market by clicking on the “Post Offer” button on the trading screen. Be aware that once the Offer is posted to the market, it cannot be retrieved or recalled. Consider your decisions carefully before clicking on the “Post Offer” button.
Market Information: Knowing where you stand in the market

Once all Sellers have submitted their offers, Buyers will take turns accepting offers. The screen in Figure 4 above shows the sort of information that will be provided to you while buyers are making their decisions. **Note that a buyer bought one unit of your offer. You made profit of 19.32 dollars, and you still have an offer to sell two additional units at a price of $77.32 in the market.**

E. The progress bar in the highlighted area of the trading screen labeled A in Figure 4 above displays the amount of time remaining for Buyers to buy in this period.

F. The highlighted area labeled B displays your own Offer which is labeled *You*. 
G. The highlighted area labeled C displays your profit on each unit sold as well as the total period profit.

H. The highlighted area labeled D displays your total period profit for the period or round just completed.

**Questionnaire and payment**

After you have finished all of your decisions in today’s experiment, you will complete a brief online questionnaire. We will convert your total earnings in experimental dollars into U.S. dollars at the exchange rate announced at the beginning of today’s experiment. The more experimental dollars you earn, the more U.S. dollars you will be paid at the end of today’s experiment. You will receive payment of your earnings, and the experiment is over.
Today’s experiment:

This is an experiment in the economics of decision making in markets.

Your earnings will be determined by your own decisions and the decisions of others as described in the following instructions. SO IT IS IMPORTANT THAT YOU READ THESE INSTRUCTIONS CAREFULLY. This experiment is structured so that only you know your earnings. All of the money that you earn will be paid to you privately IN CASH immediately following the end of today’s experiment.

Scenario

You will be randomly assigned to the role of a Buyer or a Seller. As such, you will decide the number of units of a fictitious commodity that you would like to buy or sell. You will keep the same role for the entire experiment.

Anonymity

Your role and the role of others will be kept private. You will not know anyone’s role other than your own.

Trading screens

Sellers post offers to sell and Buyers accept offers through a series of action screens. We explain below how Buyers interact with these screens to accept Offers posted to the market by Sellers.
Buyer’s instructions:

You are a Buyer. Buyers are given an opportunity to purchase units of a fictitious commodity from Sellers in the market, by accepting Offers posted by Sellers.

A tax per unit is collected from the Buyers in the market. The amount of the unit tax is $12.00.

There will be several Buyers and several Sellers in the market.

How does a Buyer like yourself make money in today’s experiment?

Buyers make money in today’s experiment by purchasing units at prices lower than the Buyer’s values minus tax per unit. The Buyer’s value minus tax per unit is provided on a trading screen, as described below. A Buyer’s unit value information is private and will be revealed only to the Buyer. A Buyer’s profit from buying a unit is computed by subtracting the purchase price and the tax per unit from the Buyer’s value for the unit.

How does a Seller make money in today’s experiment?

Sellers make money in today’s experiment by selling units at prices greater than their costs. A Seller’s profit from selling a unit is computed by subtracting the Seller’s cost for that unit from the purchase price.

How does a Buyer like yourself trade in the market?

Below we explain how a Buyer interacts with the trading screen to accept Offers from the market. The Buyers take turns accepting offers from the market, and this phase of the experiment is called the accepting phase. There will be many rounds of the experiment and thus many opportunities to accept Offers from the market.

The numbers used in the example below are for instructional purposes only and may not be the same numbers you will see during the experiment.
**Time Remaining to Accept Offers:**

During each round of today’s experiment, Buyers are given an opportunity to accept offers available in the market. Each Buyer enters the market in a randomly assigned sequence. When a Buyer’s turn arrives, the Buyer, and only that Buyer, may accept Offers in the market. Each Buyer is given the same amount of time to complete their decisions. The highlighted area of the trading screen in Figure 1 above displays the status of the experiment. The pink area graphically represents when it is your turn and the time remaining for you to accept offers. Once the progress bar reaches the pink area, it is your turn to accept offers. In this example, some other Buyer has 30 seconds remaining to complete her (his) decisions.
Buying in the market BY ACCEPTING AN OFFER

The highlighted area of the screen in Figure 2 above is the Buyer’s action screen. The highlighted area shows the number of units available for sale and the Offer price of each Seller in the market. The highlighted area also shows that a 5.00 dollar tax per unit will be collected from the Buyer in this example.

When it is your turn to accept offers, you can accept a Seller’s Offer by clicking the “Buy” button next to the respective Seller’s quantity and price information. You will buy 1 unit each time you click the Buy button, as long as the respective Seller still has units available to sell.
Note that in this example, you bought one unit at a price of 59.12 dollars and made a profit of 7.88 dollars.

Buyer’s Figure 3

Making money in this experiment

The highlighted area of the trading screen in Figure 3 above provides information on the Buyer’s values per unit. A Buyer should consider this information before accepting an Offer in the market. Note that in this example there is a 5.00 dollar tax per unit which is collected from the Buyer.
In deciding whether to accept an Offer available in the market, you should always check the **Value Minus Tax to you** of the next unit. The Value Minus Tax to you is given by the number in the Value Minus Tax column in the first row that does NOT contain an entry for Trade Profit. The rightmost column is the “Trade Profit” column that shows the profit or loss that you made on each unit that you buy in the market.

When you have completed your decisions, you may click on the “I’m Done” button at the bottom of the screen.

**Buyer’s Figure 4**
Market Information: Knowing where you stand in the market

The highlighted area of the trading screen in Figure 4 above indicates the total period profit (loss).

Questionnaire and payment

After you have finished all of your decisions in today’s experiment, you will complete a brief online questionnaire. We will convert your total earnings in experimental dollars into U.S. dollars at the exchange rate announced at the beginning of today’s experiment. The more experimental dollars you earn, the more U.S. dollars you will be paid at the end of today’s experiment. You will receive payment of your earnings, and the experiment is over.
APPENDIX 1.3

Treatment 3

The market institution is a double auction market. The Seller is liable to pay a tax on each unit sold.

Today’s experiment:

This is an experiment in the economics of decision making in markets.

Your earnings will be determined by your own decisions and the decisions of others as described in the following instructions. SO IT IS IMPORTANT THAT YOU READ THESE INSTRUCTIONS CAREFULLY. This experiment is structured so that only you know your earnings. All of the money that you earn will be paid to you privately IN CASH immediately following the end of today’s experiment.

Scenario

You will be randomly assigned to the role of a Buyer or a Seller. As such, you will decide the number of units of a fictitious commodity that you would like to buy or sell. You will keep the same role for the entire experiment.

Anonymity

Your role and the role of others will be kept private. You will not know anyone’s role other than your own.

Trading screens

Sellers make offers and Buyers make purchases through a set of trading screens. We explain below how Sellers and Buyers interact with the trading screens to make offers and purchases in the market.
Sellers’ instructions:

You are a Seller. Sellers in the market have two options. You can sell units of a fictitious commodity by accepting Bid prices submitted by Buyers, and you can also post Ask prices and wait for Buyers to buy units, by accepting your Ask prices.

A tax per unit is collected from the Sellers in the market. The amount of the unit tax is $12.00.

There will be several Sellers and several Buyers in the market.

How does a Seller like yourself make money in this experiment?

Sellers make money in today’s experiment by selling units at prices greater than their costs plus tax per unit. The Seller’s cost per unit is provided on a trading screen, as described below. A Seller’s unit cost information is private and will be revealed only to the Seller. A Seller’s profit from trading a unit is computed by subtracting the Seller’s cost for the unit and the unit tax from the purchase price.

How does a Buyer make money in this experiment?

Buyers make money in today’s experiment by buying units at prices lower than the Buyer’s values per unit. A Buyer’s profit from buying a unit is computed by subtracting the purchase price from the Buyer’s value for the unit.

How does a Seller like yourself trade in the market?

Below we explain how a Seller interacts with the trading screen to submit an Ask price to the market or accept a Bid price from the market. Each trading period lasts two and one-half minutes. There will be many trading periods.

The numbers used in the example below are for instructional purposes only and may not be the same numbers you will see during the experiment.
**Seller’s Figure 1**

Time Remaining in a Trading Period and Summary Information:

Sellers (and Buyers) are given two and one-half minutes to complete their transactions in each round of today’s experiment. The highlighted area of the trading screen in Figure 1 above displays the current trading period, the Seller’s earnings during the session, and the time remaining in the trading period.
Selling in the market BY ACCEPTING A BID:

The highlighted area of the screen in Figure 2 above is the Seller’s action screen. **Sellers can accept Bids in the market by clicking the “Sell” button in the rightmost lower corner of the Seller’s action screen.** You will sell 1 unit each time you click the Sell button, if the Buyer’s Bids have not already been accepted.

How do you know what **price you will receive** if you click on the Sell button? The price you would receive appears in the “Price” box just above the Sell button. In this example, the price is 78.00 dollars. If you are the first Seller to click on the Sell button, then 78.00 dollars would be
your price. **Be aware** that this number can change quickly when other Sellers and Buyers are trading in the market.

The highlighted area of the screen also shows that a 5.00 dollar tax per unit will be collected from the Seller in this example.

**Seller’s Figure 3**

![Market link - Seller](attachment:image.png)

**Making money in this experiment**

The highlighted area of the trading screen in Figure 3 above provides information on the Seller’s costs per unit and costs plus tax per unit. **A Seller should consider this information before**
submitting an Ask price or accepting a Bid price in the market. Note that in this example there is a 5.00 dollar tax per unit which is collected from the Seller.

Suppose you accepted a bid of 78.00 dollars. Since it was your first unit, your cost plus tax was 63.00 dollars, and you made a profit of 15.00 \( (78.00 - 63.00) \) dollars. The rightmost column is the “Trade Profit” column that shows the profit or loss that you made on each unit that you trade in the market.

In deciding whether to submit an Ask price or accept a Bid price, you should always check the Cost Plus Tax to you of trading the next unit. The cost to you is given by the number in the Cost Plus Tax column in the first row that does NOT contain an entry for Trade Profit. In Figure 3, your next unit’s cost is 65.00 dollars.
Selling in the market BY SUBMITTING AN ASK:

The highlighted area of the screen in Figure 4 above is the Seller’s action screen. Sellers can make offers in the market by clicking the “Ask” button in the leftmost lower corner of the Seller’s action screen. Before clicking the Ask button, you need to enter your ask price in the “Price” box. The price entered can be in dollars and cents; for example, 77.32 denotes a price of 77 dollars and 32 cents. Note that your next unit’s cost plus tax is 65.00 dollars. If a buyer accepts your ask, you will make a profit of 12.32 (77.32 - 65.00) dollars.

A Seller can post any Ask price greater than $0 but less than $100.
After you have entered an Ask price, you can always replace it with a lower Ask price. To do so, just type in the new price and then click on the “Ask” button.

The highlighted area of the screen also shows that a 5.00 dollar tax per unit will be collected from the Seller in this example.

**Seller’s Figure 5**

![Figure 5](image)

**Market Information: Knowing where you stand in the market**

The highlighted area of the screen in Figure 5 above shows all outstanding Asks and Bids in the market. Your own outstanding Asks in the market will be indicated by an asterisk (*) symbol. Therefore, you will always be able to find out whether your Asks are high or low compared to
others in the queue of all Asks. You are also able to see how the best Bid that you could accept compares to other outstanding Bids and to the outstanding Asks. In Figure 5, there are two outstanding bids of $37.32 and $29.12.

Remember that you can always replace your Ask price with a lower one, as explained on the preceding page.

**Questionnaire and payment**

After you have finished all of your decisions in today’s experiment, you will complete a brief on-line questionnaire. We will convert your total earnings in experimental dollars into U.S. dollars at the exchange rate announced at the beginning of today’s experiment. The more experimental dollars you earn, the more U.S. dollars you will be paid at the end of today’s experiment. You will receive payment of your earnings, and the experiment is over.
Today’s experiment:

This is an experiment in the economics of decision making in markets.

Your earnings will be determined by your own decisions and the decisions of others as described in the following instructions. SO IT IS IMPORTANT THAT YOU READ THESE INSTRUCTIONS CAREFULLY. This experiment is structured so that only you know your earnings. All of the money that you earn will be paid to you privately IN CASH immediately following the end of today’s experiment.

Scenario

You will be randomly assigned to the role of a Buyer or a Seller. As such, you will decide the number of units of a fictitious commodity that you would like to buy or sell. You will keep the same role for the entire experiment.

Anonymity

Your role and the role of others will be kept private. You will not know anyone’s role other than your own.

Trading screens

Sellers make offers and Buyers make purchases through a set of trading screens. We explain below how Sellers and Buyers interact with the trading screens to make offers and purchases in the market.
Buyer’s instructions:

You are a Buyer. Buyers in the market have two options. You can buy units of a fictitious commodity by accepting Ask prices submitted by Sellers, and you can also post Bid prices and wait for Sellers to sell units, by accepting your Bid prices.

A tax per unit is collected from the Sellers in the market. The amount of the unit tax is $12.00.

There will be several Buyers and several Sellers in the market.

How does a Buyer like you make money in this experiment?

Buyers make money in today’s experiment by buying units at prices lower than the Buyer’s values per unit. The Buyer’s value per unit is provided on a trading screen, as described below. A Buyer’s unit value information is private and will be revealed only to the Buyer. A Buyer’s profit from buying a unit is computed by subtracting the purchase price from the Buyer’s value for the unit.

How does a Seller make money in this experiment?

Sellers make money in today’s experiment by selling units at prices greater than their costs plus tax per unit. A Seller’s profit from selling a unit is computed by subtracting the Seller’s cost for the unit and the unit tax from the purchase price.

How does a Buyer like yourself trade in the market?

Below we explain how a Buyer interacts with the trading screen to submit a Bid price to the market or accept an Ask price from the market. Each trading period lasts for two and one-half minutes. There will be many trading periods.

The numbers used in the example below are for instructional purposes only and may not be the same numbers you will see during the experiment.
Buyer’s Figure 1

Time Remaining in a Trading Period and Summary Information:

Buyers (and Sellers) are given two and one-half minutes to complete their transactions in each round of today’s experiment. The highlighted area of the trading screen in Figure 1 above displays the current trading period, the Buyer’s earnings during the session, and the time remaining in the trading period.
Buying in the market BY ACCEPTING AN ASK:

The highlighted area of the screen in Figure 2 above is the Buyer’s action screen. Buyers can accept Asks in the market by clicking the “Buy” button in the rightmost lower corner of the Buyer’s action screen. You will buy 1 unit each time you click the Buy button, if the Sellers have made Asks that have not already been accepted.

How do you know what price you will receive if you click on the Buy button? The price you would receive appears in the “Price” box just above the Buy button. In this example, the price is 38.00 dollars. If you are the first Buyer to click on the Buy button, then 38.00 dollars would be
your price. Be aware that this number can change quickly when other Buyers and Sellers are trading in the market.

Buyer’s Figure 3

Making money in this experiment

The highlighted area of the trading screen in Figure 3 above provides information on the Buyer’s values per unit. A Buyer should consider this information before submitting a Bid price or accepting an Ask price in the market.

Suppose you accepted an ask of 38.00 dollars. Since it was your first unit, your value was 72.00 dollars, and you made a profit of 34.00 (72.00 - 38.00) dollars. The rightmost column is
the “Trade Profit” column that shows the profit or loss that you make on each unit that you trade in the market.

In deciding whether to submit a Bid price or accept an Ask price, you should always check the **value to you of trading the next unit**. The value to you is given by the number in the Value column in the first row that does NOT contain an entry for Trade Profit. In Figure 3, your next unit’s value is 70.00 dollars.

**Buyer’s Figure 4**
Buying in the market BY SUBMITTING A BID:

The highlighted area of the screen in Figure 4 above is the Buyer’s action screen. **Buyers can** make bids in the market by clicking the “Bid” button in the leftmost lower corner of the **Buyer’s action screen.** Before clicking the Bid button, you need to enter your bid price in the “Price” box. The price entered in the box labeled “Price” can be in dollars and cents; for example, 37.32 denotes a price of 37 dollars and 32 cents. **Note that your next unit’s value is 70.00 dollars.** If a seller accepts your bid, you will make a profit of 32.68 (70.00 - 37.32) dollars.

**A Buyer can submit any bid price greater than $0 but less than $100.**

After you have entered a Bid price, you can always replace it with a higher Bid price. To do so, just type in the new price and then click on the “Bid” button.
Buyer’s Figure 5

Market Information: Knowing where you stand in the market

The highlighted area of the screen in Figure 5 above shows all outstanding Asks and Bids in the market. Your own outstanding Bids in the market will be indicated by an asterisk (*) symbol. Therefore, you are always able to find out whether your Bids are high or low compared to others in the queue of all Bids. You are also able to see how the best Ask that you could accept compares to other outstanding Asks and to the outstanding Bids. In Figure 5, there are two outstanding asks of $59.12 and $77.32.
Remember that you can always replace your Bid price with a higher one, as explained on the preceding page.

**Questionnaire and payment**

After you have finished all of your decisions in today’s experiment, you will complete a brief online questionnaire. We will convert your total earnings in experimental dollars into U.S. dollars at the exchange rate announced at the beginning of today’s experiment. The more experimental dollars you earn, the more U.S. dollars you will be paid at the end of today’s experiment. You will receive payment of your earnings, and the experiment is over.
Treatment 4

The market institution is a double auction market. The Buyer is liable to pay a tax on each unit sold.

Today’s experiment:

This is an experiment in the economics of decision making in markets. Your earnings will be determined by your own decisions and the decisions of others as described in the following instructions. SO IT IS IMPORTANT THAT YOU READ THESE INSTRUCTIONS CAREFULLY. This experiment is structured so that only you know your earnings. All of the money that you earn will be paid to you privately IN CASH immediately following the end of today’s experiment.

Scenario

You will be randomly assigned to the role of a Buyer or a Seller. As such, you will decide the number of units of a fictitious commodity that you would like to buy or sell. You will keep the same role for the entire experiment.

Anonymity

Your role and the role of others will be kept private. You will not know anyone’s role other than your own.

Trading screens

Sellers make offers and Buyers make purchases through a set of trading screens. We explain below how Sellers and Buyers interact with the trading screens to make offers and purchases in the market.

Sellers’ instructions:
You are a Seller. Sellers in the market have two options. You can sell units of a fictitious commodity by accepting Bid prices submitted by Buyers, and you can also post Ask prices and wait for Buyers to buy units, by accepting your Ask prices.

A tax per unit is collected from the Buyers in the market. The amount of the unit tax is $12.00.

There will be several Sellers and several Buyers in the market.

How does a Seller like yourself make money in this experiment?

Sellers make money in today’s experiment by selling units at prices greater than their costs. The Seller’s cost per unit is provided on a trading screen, as described below. A Seller’s unit cost information is private and will be revealed only to the Seller. A Seller’s profit from trading a unit is computed by subtracting the Seller’s cost for the unit from the purchase price.

How does a Buyer make money in this experiment?

Buyers make money in today’s experiment by buying units at prices lower than the Buyer’s values less tax per unit. A Buyer’s profit from buying a unit is computed by subtracting the purchase price and the tax per unit from the Buyer’s value for the unit.

How does a Seller like yourself trade in the market?

Below we explain how a Seller interacts with the trading screen to submit an Ask price to the market or accept a Bid price from the market. Each trading period lasts two and one-half minutes. There will be many trading periods.

The numbers used in the example below are for instructional purposes only and may not be the same numbers you will see during the experiment.
Time Remaining in a Trading Period and Summary Information:

Sellers (and Buyers) are given two and one-half minutes to complete their transactions in each round of today’s experiment. The highlighted area of the trading screen in Figure 1 above displays the current trading period, the Seller’s earnings during the session, and the time remaining in the trading period.
Selling in the market BY ACCEPTING A BID:

The highlighted area of the screen in Figure 2 above is the Seller’s action screen. Sellers can accept Bids in the market by clicking the “Sell” button in the rightmost lower corner of the Seller’s action screen. You will sell 1 unit each time you click the Sell button, if the Buyer’s Bids have not already been accepted.

How do you know what price you will receive if you click on the Sell button? The price you would receive appears in the “Price” box just above the Sell button. In this example, the price is 78.00 dollars. If you are the first Seller to click on the Sell button, then 78.00 dollars would be...
your price. **Be aware** that this number can change quickly when other Sellers and Buyers are trading in the market.

**Seller’s Figure 3**

![Seller's Figure 3](image)

**Making money in this experiment**

The highlighted area of the trading screen in Figure 3 above provides information on the Seller’s costs per unit. A Seller should consider this information before submitting an Ask price or accepting a Bid price in the market.

Suppose you accepted a bid of 78.00 dollars. Since it was your first unit, your cost was 58.00 dollars, and you made a profit of 20.00 (78.00 - 58.00) dollars. The rightmost column is
the “Trade Profit” column that shows the profit or loss that you made on each unit that you trade in the market.

In deciding whether to submit an Ask price or accept a Bid price, you should always check the cost to you of trading the next unit. The cost to you is given by the number in the Cost column in the first row that does NOT contain an entry for Trade Profit. In Figure 3, your next unit’s cost is 60.00 dollars.

**Seller’s Figure 4**
**Selling in the market BY SUBMITTING AN ASK:**

The highlighted area of the screen in Figure 4 above is the Seller’s action screen. **Sellers can make offers in the market by clicking the “Ask” button in the leftmost lower corner of the Seller’s action screen.** Before clicking the Ask button, you need to enter your ask price in the “Price” box. The price entered can be in dollars and cents; for example, 77.32 denotes a price of 77 dollars and 32 cents. **Note that your next unit’s cost is 60.00 dollars. If a buyer accepts your ask, you will make a profit of 17.32 (77.32 - 60.00) dollars.**

A Seller can post any Ask price greater than $0 but less than $100.

After you have entered an Ask price, you can always replace it with a lower Ask price. To do so, just type in the new price and then click on the “Ask” button.
Market Information: Knowing where you stand in the market

The highlighted area of the screen in Figure 5 above shows all outstanding Asks and Bids in the market. Your own outstanding Asks in the market will be indicated by an asterisk (*) symbol. In this example, your ask is $77.32. Therefore, you will always be able to find out whether your Asks are high or low compared to others in the queue of all Asks. You are also able to see how the best Bid that you could accept compares to other outstanding Bids and to the outstanding Asks. In Figure 5, there are two outstanding bids of $37.32 and $29.12.
Remember that you can always replace your Ask price with a lower one, as explained on the preceding page.

**Questionnaire and payment**

After you have finished all of your decisions in today’s experiment, you will complete a brief online questionnaire. We will convert your total earnings in experimental dollars into U.S. dollars at the exchange rate announced at the beginning of today’s experiment. The more experimental dollars you earn, the more U.S. dollars you will be paid at the end of today’s experiment. You will receive payment of your earnings, and the experiment is over.
Today’s experiment:

This is an experiment in the economics of decision making in markets.

Your earnings will be determined by your own decisions and the decisions of others as described in the following instructions. SO IT IS IMPORTANT THAT YOU READ THESE INSTRUCTIONS CAREFULLY. This experiment is structured so that only you know your earnings. All of the money that you earn will be paid to you privately IN CASH immediately following the end of today’s experiment.

Scenario

You will be randomly assigned to the role of a Buyer or a Seller. As such, you will decide the number of units of a fictitious commodity that you would like to buy or sell. You will keep the same role for the entire experiment.

Anonymity

Your role and the role of others will be kept private. You will not know anyone’s role other than your own.

Trading screens

Sellers make offers and Buyers make purchases through a set of trading screens. We explain below how Sellers and Buyers interact with the trading screens to make offers and purchases in the market.
Buyer’s instructions:

You are a Buyer. Buyers in the market have two options. You can buy units of a fictitious commodity by accepting Ask prices submitted by Sellers, and you can also post Bid prices and wait for Sellers to sell units, by accepting your Bid prices.

A tax per unit is collected from the Buyers in the market. The amount of the unit tax is $12.00.

There will be several Buyers and several Sellers in the market.

How does a Buyer like you make money in this experiment?

Buyers make money in today’s experiment by buying units at prices lower than the Buyer’s values less tax per unit. The Buyer’s value per unit is provided on a trading screen, as described below. A Buyer’s unit value information is private and will be revealed only to the Buyer. A Buyer’s profit from buying a unit is computed by subtracting the purchase price and the tax per unit from the Buyer’s value for the unit.

How does a Seller make money in this experiment?

Sellers make money in today’s experiment by selling units at prices greater than their costs. A Seller’s profit from selling a unit is computed by subtracting the Seller’s cost for the unit from the purchase price.

How does a Buyer like yourself trade in the market?

Below we explain how a Buyer interacts with the trading screen to submit a Bid price to the market or accept an Ask price from the market. Each trading period lasts for two and one-half minutes. There will be many trading periods.

The numbers used in the example below are for instructional purposes only and may not be the same numbers you will see during the experiment.
Time Remaining in a Trading Period and Summary Information:

Buyers (and Sellers) are given two and one-half minutes to complete their transactions in each round of today’s experiment. The highlighted area of the trading screen in Figure 1 above displays the current trading period, the Buyer’s earnings during the session, and the time remaining in the trading period.
**Buying in the market BY ACCEPTING AN ASK:**

The highlighted area of the screen in Figure 2 above is the Buyer’s action screen. **Buyers can accept Asks in the market by clicking the “Buy” button in the rightmost lower corner of the Buyer’s action screen.** You will buy 1 unit each time you click the Buy button, if the Sellers have made Asks that have not already been accepted. The highlighted area of the screen also shows that a 5.00 dollar tax per unit will be collected from the Buyer in this example.

How do you know what **price you will receive** if you click on the Buy button? The price you would receive appears in the “Price” box just above the Buy button. In this example, the price is
38.00 dollars. If you are the first Buyer to click on the Buy button, then 38.00 dollars would be your price. Be aware that this number can change quickly when other Buyers and Sellers are trading in the market.

**Buyer’s Figure 3**

![Image of the trading screen showing the Bid Ask Spread and Buyer Actions]

**Making money in this experiment**

The highlighted area of the trading screen in Figure 3 above provides information on the Buyer’s values and tax per unit. A **Buyer should consider this information before submitting a Bid price or accepting an Ask price in the market**. Note that in this example there is a 5.00 dollar tax per unit which is collected from the Buyer.
Suppose you accepted an ask of 38.00 dollars. Since it was your first unit, your value minus tax was 67.00 dollars, and you made a profit of 29.00 (67.00 - 38.00) dollars. The rightmost column is the “Trade Profit” column that shows the profit or loss that you make on each unit that you trade in the market.

In deciding whether to submit a Bid price or accept an Ask price, you should always check the **Value Minus Tax to you of trading the next unit**. The Value Minus Tax to you is given by the number in the Value Minus Tax column in the first row that does NOT contain an entry for Trade Profit. In Figure 3, your next unit’s value minus tax is 65.00 dollars.
Buyer’s Figure 4

Buying in the market BY SUBMITTING A BID:

The highlighted area of the screen in Figure 4 above is the Buyer’s action screen. **Buyers can make bids in the market by clicking the “Bid” button in the leftmost lower corner of the Buyer’s action screen.** Before clicking the Bid button, you need to enter your bid price in the “Price” box. The price entered can be in dollars and cents; for example, 37.32 denotes a price of 37 dollars and 32 cents. **Note that your next unit’s value plus tax is 65.00 dollars.** If a seller accepts your bid, you will make a profit of 27.68 (65.00 - 37.32) dollars. **A Buyer can submit any bid price greater than $0 but less than $100.**
After you have entered a Bid price, you can always replace it with a higher Bid price. To do so, just type in the new price and then click on the “Bid” button.

**Buyer’s Figure 5**

![Market Information: Knowing where you stand in the market](image)

**Market Information: Knowing where you stand in the market**

The highlighted area of the screen in Figure 5 above shows all outstanding Asks and Bids in the market. Your own outstanding Bids in the market will be indicated by an asterisk (*) symbol. Therefore, you are always able to find out whether your Bids are high or low compared to others in the queue of all Bids. You will also be able to see how the Best Ask that you could accept
compares to other outstanding Asks and to the outstanding Bids. In Figure 5, there are two outstanding asks of $59.12 and $77.32.

Remember that you can always replace your Bid price with a higher one, as explained on the preceding page.

**Questionnaire and payment**

After you have finished all of your decisions in today’s experiment, you will complete a brief on-line questionnaire. We will convert your total earnings in experimental dollars into U.S. dollars at the exchange rate announced at the beginning of today’s experiment. The more experimental dollars you earn, the more U.S. dollars you will be paid at the end of the experiment. You will receive payment of your earnings, and the experiment is over.
APPENDIX 2

QUESTIONNAIRE

For questions 1-5, please check the appropriate box.

1. In today’s experiment, I was a      BUYER       SELLER

2. What year are you in your studies?   Freshmen   Sophomore   Junior   Senior

3. Have you ever participated in an economics experiment before? Yes   No

4. Gender:  Male       Female

5. Race:  Asian       White       Black       Other

6. Age: ____

7. Major: ________________________  [ ] undecided

8. How many economics courses have you taken (include currently enrolled) ______

9. What is your cumulative grade point average? ______
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VITA

Asthा Sen was born on March 10, 1984 in the city of Alwar in India. She spent majority of her childhood in Jaipur, India. She received her bachelor’s degree in economics from Delhi University, India in 2005. She acquired her Master of Science degree in finance from Illinois Institute of Technology, Chicago in 2008. She is motivated by policy relevant research in the fields of public, experimental and behavioral economics. She is particularly interested in studying the effectiveness of tax policy reforms in developed and developing economies. Her dissertation extends an existing revenue efficiency model of taxation and looks at the effect of an important tax policy reform at the sub-national level in India on the revenue growth of indirect taxes and tax incidence. The last paper of her dissertation is an experimental research which captures the influence of market institutions on tax incidence. Her other working paper uses the YRBSS dataset to study the trends in risky behavior of the youth during recessions and this research has health policy implications. Her teaching interests include Principles of Microeconomics and Macroeconomics, Intermediate Microeconomics and Macroeconomics, Public Finance and Behavioral Economics. She joined Truman State University as a Temporary Assistant Professor of economics in the academic year of 2014-2015. She will be joining the economics department of Sonoma State University as an Assistant Professor in the fall of 2015.