Differential corporate taxation and inter-asset investment distortions in South Africa

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Abstract

South Africa has since the 1990's actively reformed its corporate tax policy to stimulate investment in various assets and industries. While the investment impact of corporate taxation has been evaluated in various studies, no effort has been made to assess the potential inter-asset distortions due to differential taxation. Using a unique asset-industry level dataset, we find evidence of inter-asset distortions arising from differential taxation of assets and industries in South Africa. In particular, compared to a counterfactual benchmark where tax rates are equalized, we find that differential taxation induces under-investment in non-residential structures and computer equipment and over-investment in machinery and transportation equipment. The immediate policy implications are that ignoring distortions due to heterogeneous tax treatment could understate the efficiency and redistributive effects of tax policy in South Africa.

Keywords: user cost of capital, investment, distortions, South Africa
JEL codes: H21, H25, H32, E22

1 Introduction

While the importance of corporate tax incentives in capital accumulation and economic growth has been widely researched in the corporate tax literature (Chirinko, Fazzari and Meyer, 1999; Vartia, 2008; Bond and Xing, 2015), there is little empirical evidence on the inter-asset distortion effect of differential corporate income tax. In most countries, tax policy employs a range of provisions such as accelerated depreciation, investment allowances and at times, reductions in the top marginal tax rates to attract and direct investment in specific capital assets and industries. Consequently, substantial differences in the effective

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tax rate of different capital assets and industries within the same country could exist, with non-trivial implications for the allocation of new capital investment. In particular, differential taxation of various investment assets may alter the structure of business investment, and to that extent, distort capital investments (Fatica, 2013).

Whereas empirical studies such as King and Fullerton (1984) and Auerbach (1996) have highlighted substantial differences in the effective tax burden faced by different asset categories due to differential tax treatment, there is very little research on the possible link between differential asset taxation and inter-asset distortions. Nearly all studies that have been done on this topic have been conducted in the USA and were designed around the major US tax reforms of the 1980s. Consequently, there have not been very recent studies that tackle this topic even within the USA, possibly due to the absence of large-scale sweeping reforms since the major reforms of 1986. Elsewhere, there is almost no study conducted on this topic, with Fatica (2013) who investigates the likely inter-asset distortions of differential corporate taxation in Europe being the only exception.

Although a very limited number of studies on corporate tax in developing regions such as Africa exist, most focus on the direct link between corporate tax and investment (World Bank, 2016). Studies on the efficiency implications of differential corporate tax are certainly non-existent in developing countries, including South Africa. The lack of evidence on this topic is very surprising given that the continued use of differential taxation is largely associated with various distortions. Besides the potential inter-asset and productivity distortions, differential taxation could significantly increase corporate tax revenue losses and tax administration costs. Moreover, non-uniform taxation may also lead to unsustainable investment from speculative and footloose investors. The use of differential taxation could therefore be at variance with various national policies on sustainable, efficient, and effective investment.

This paper contributes new empirical evidence on the inter-asset distortion effects of the differential corporate taxation using South Africa as a case study. The study uses an unexplored dataset of industry panels with data on asset-level investment patterns over the period 2007 to 2014. Using this dataset, we compute asset shares and user-costs of capital and estimate both the own and cross-asset substitution elasticities. Given the quality issues surrounding the industry-level Annual Financial Statistics (AFS) series from Statistics South Africa (StatsSA), the findings that differential taxation distorts investment allocation could be taken as exploratory and as a foundation for further debate and research on the efficiency of differential taxation in South Africa and other developing countries.

2 Related empirical studies

The empirical literature on the economic distortions of corporate taxation is very limited and has generally not advanced since the last major tax reforms in the USA in the 1980's and in developing countries around the 1990's. Most efforts to study distortions of differential taxation are therefore quite out-dated.

The few existing studies could however be organised around three main strands. The first set of studies attempts to highlight the impact of differential taxation on capital asset distortions indirectly by calculating tax-induced differences in the marginal cost of investment in different assets and industries. Evidence for the existence of asset allocation distortion is established when large asset-specific marginal cost differences attributed to tax policy changes are found. This identification strategy has been used in studies (such as Auerbach, Aaron and Hall, 1983; King and Fullerton, 1984; Auerbach and Hassett, 1991; Mackie, 2002) which find significant tax-induced variations and distortions in the asset level user-cost of capital and marginal effective tax rates in the US economy. Auerbach et. al (1983) for instance finds that the social cost of misallocation of capital arising from differential taxation stood at 3.19 percent of total capital stock in the US in 1981. Mackie (2002) also finds that differential taxation in the US tends to favour investment in equipment assets while disadvantaging non-residential structures.

The second strand has used general equilibrium approaches to study the capital misallocation and welfare costs of differential taxation, particularly in the earlier studies. Various studies (such as Auerbach, 1989; Fullerton and Henderson, 1989a, 1989b; Jorgenson, 1996) have found evidence of asset-distortions and welfare losses due to differential corporate taxation. In evaluating the welfare implications of the US corporate tax reforms, Auerbach (1989) showed that increasing overall corporate taxes would result in a welfare loss similar in magnitude to the welfare gain that would result from implementing uniform corporate taxation. Focusing on the same USA reform efforts of the 1980s, Fullerton and Henderson (1989a) found that inter-asset distortions were larger than inter-industry distortions, thereby showing that the level of aggregation matters when assessing the effects of tax policy changes. Fullerton and Henderson (1989a) also found that due to distortions caused by non-uniform taxation, the US suffered welfare costs estimated at around 0.18 percent of gross national income (GNI).

The last strand of literature attempts to directly estimate the inter-asset distortions of the corporate income tax (Liu, 2011; Fatica, 2013). These studies have adopted empirical methods from the productivity literature (Berndt and Wood, 1975, 1979) to study the responsiveness of asset-level investment to their own- and cross-asset tax incentives. The studies exploit the rich substitution properties of the trans-logarithmic function specification (Berndt and Christensen, 1973; Christensen, Jorgenson and Lau, 1973) to estimate investment cost-share functions using the seemingly unrelated regression (SUR) estimation technique. Although the application of the translog function and estimation of substitution possibilities is new in the corporate tax literature, these methods have been used extensively in other sectors such as technology, energy, forestry and agriculture (Morrison, 1997; Saal and Parker, 2000; Nagubadi *et al.*, 2004; Serletis, Timilsina and Vasetsky, 2010).

Two relatively recent applications have applied the translog function and investment share estimation in the US (Liu, 2011) and the OECD (Fatica, 2013).

The study by Liu (2011) used industry-asset panel data over the period 1962 to 1997 and investigates the responsiveness of investments in assets (such as structures, computer equipment (ICT), plant and machinery, and transportation equipment) to their own tax incentives and to the tax incentives of other assets. That study found evidence of sizeable inter-asset distortions due to differential taxation among some assets although in some cases the elasticities of substitution involving ICT assets were found to be unexpectedly high. Fatica (2013) who uses a similar approach and industry data obtained from 11 OECD countries finds results in support of significant inter-asset distortions.

While Fatica (2013) and Liu (2011) bring the much-needed evidence of the potential distortionary effects of differential taxation on asset-allocation using recent data, the use of industry-level data may be problematic. First, I argue that industry-level data may not appropriately characterise the asset investment process as such decisions are undertaken at the firm level. Second, in some very specialist industries with few players like computer technology, biotechnology etc, the industry estimates could be driven by a single dominating firm or a few outliers[1]. Some of the unexpectedly large asset elasticities found in Liu could simply be due to the influence of dominant firms in sectors such as ICT. For the above reasons, asset-specific information at the firm level would be the best dataset for the investigation of inter-asset distortions.

Due to various limitations, this study is unable to obtain South African asset-specific firm-level data. At present, industry-level data is the only option available to test the hypothesis of inter-asset misallocation due to non-uniform taxation. Owing to the significance of the research question, this study proceeds to use industry-level data to offer suggestive evidence of the likely implication of differential taxation in investment allocation. To the best of our knowledge, this study becomes the first to investigate inter-asset distortions of corporate taxation in a developing country context. The study also joins a very limited set of studies (Liu, 2011; Fatica, 2013) that directly estimate the inter-asset distortion effects of differential corporate taxation by estimating own and cross-tax elasticities of asset investment.

3 Empirical Framework and model specification

This section closely follows the methodological presentations in Fatica (2013) and Liu (2011), the two studies that have extended the translog function to the corporate tax literature. The transcendental logarithmic (translog) cost function allows for a rich pattern of substitution between input pairs and could thus be used to model the investment distortion effects of corporate taxation.

[1] These insights were obtained following discussions at UNIDO-PRISM global value chains workshop held at the School of Economics, University of Cape Town, 18th-19th September, 2019.

The general form of the long run translog cost function can be specified as:

$$\ln C = \alpha_0 + \alpha_Q \ln Q + \sum_i \alpha_i \ln P_i + \frac{1}{2}\gamma QQ(\ln Q)^2 + \sum_i \gamma Q_i \ln Q_i \ln P_i \tag{1}$$
$$+ \frac{1}{2}\sum_i\sum_j \beta_{ij} \ln P_i \ln P_i + \beta_t Time + \frac{1}{2}\beta_T Time^2 + \beta_{TQ} Time \ln Q$$
$$+ \sum_{i=1}^{n} \beta_{Tj} Time \ln P_i + \beta_I Industry + \frac{1}{2}\beta_I Industry^2 + \beta_{IQ} Industry \ln Q$$
$$+ \sum_{i=1}^{n} \beta_{Ii} Industry \ln P_i + \varepsilon$$

where P_i is the after-tax price of input i, Q is the industry level output and *TIME* and INDUSTRY are the time and industry dummies. The β_{ij}'s are the parameters of interest. By the shepherd's lemma, the set of input cost-minimising share equations are derived by differentiating the cost function in Equation (1) with respect to the log of the price of input i:

$$S_i = \frac{\delta lnC}{\delta lnP_i} = \frac{(X_i P_i)}{C} = \alpha_i + \gamma Q_i lnQ + \sum_j \beta_{ij} lnP_i + \beta_{Ti} Time + \beta_{Ii} Industry \tag{2}$$

Where S_i is the cost share of input i. All cost shares sum to one and the cost function is homogenous of degree one in price by definition. These conditions suggest that the following restrictions must hold for well-behaved investment shares:

$$\begin{aligned} \sum_i \alpha_i &= 1 \\ \sum_i \gamma Q_i &= 0 \quad and \\ \sum_i \beta_{ij} &= \sum_i \beta_{ij} = 0 \end{aligned} \tag{3}$$

Applying this system of equations (Equations 2 and 3) to the data demands that the error terms in the investment functions be defined. However, although the errors terms could be assumed independent across observations, the investment equation errors are likely correlated within each industry. This calls for the joint estimation of the system of equations in order to obtain efficient estimates. This paper applies Zellners' (1962) seemingly unrelated regression method to estimate the investment share equations. Empirically, we specify investment share equations for industrial structures, computer equipment, plant and machinery, and transportation equipment. However, the adding up property of the investment shares implies a singular variance matrix, because only N_{k-1} shares equations are linearly independent. This problem is easily solved by dropping one investment share equation. The Maximum likelihood estimation of the parameters of the investment equation are invariant to the choice of excluded equation (Barten, 1969). We therefore arbitrarily drop the transportation share equation and divide the UCC (and price) of every other asset by the UCC (or price) of transportation equipment. This yields the following investment share equation system that is estimated using the SUR method:

$$S_{ikt} = \alpha_i + \sum_j \beta_{ij} ln \left(\frac{UCC_{ikt}}{UCC_{trans,kt}} \right) + \sum_j \beta_{ij} ln \left(\frac{P_{ikt}}{P_{trans,kt}} \right) + \eta_k + \varepsilon_{ikt} \quad (4)$$

where S_{ikt} is the share of asset i in industry k at time t. The user-cost and the relative price of each asset i in industry k at time t are the dependent variables in this estimation model. The model also includes some time and industry dummies to control for any technological changes and industry-specific effects.

4 Data and variables

4.1 Dataset

This paper exploits detailed industry-level financial statement data published in the disaggregated annual financial statistics (AFS) reports by Statistics South Africa. The detailed data comprises consolidated industry-level income statement, balance sheet and fixed asset information of various industries in South Africa. The data is presented at all the standard industrial classification (SIC) levels but excludes mining due to varying and complex applications of tax incentives in those sectors. We use data at the SIC 4-digit level as this has the most sub-group industries and observations over the period. At the SIC 4-digit level, data is available for 8 years period from 2007 to 2014 and covers at least 200 industrial groupings. However, as the tabulation of these codes would produce excessive output, I simply provide the distribution of industries at the SIC 1-digit level which provides a concise summary. Table 1 shows that the majority of the observations come from the manufacturing and services sectors.

An important problem already highlighted with industry data is that some sectors (such as biotechnology) could be dominated by a single large monopoly firm that drive all the results in that sector. Perhaps the most important data challenge is that the AFS series from Statistics South Africa does not follow a consistent sample of firms in a specific industry, and some industrial classification may not be sampled in subsequent waves. For this specific study, these data challenges imply that our findings can only be taken as explorative[2] evidence. Future study efforts could therefore use this as a foundation and reference for more fine-grained analysis should better datasets become available.

4.2 User-cost of capital and asset shares

Based on the AFS data described above, we now turn to the calculation of the user-cost of capital and investment share variables and other parameters relevant

[2] Despite the noted problems in the AFS, other studies such as World Bank (2015) have used this same industry panel dataset to calculate costs of capital.

in this study. This paper uses the King and Fullerton (1984) methodology of calculating the user-cost of capital (UCC) given that assets are disaggregated into standard categories in the AFS dataset. In particular, the approach here offers more variation due to disaggregated asset composition. For each given asset, variation in the UCC is derived from changes in the headline corporate tax rate, changes in tax depreciation, variations in the accumulated depreciation over time and well as changes due to the influence of macroeconomic parameters such as inflation and government bonds and treasury bill rates as proxies for the long- and short-term interest rates, respectively. The derivation of the UCC using the King and Fullerton (1984) approach is detailed. Refer to appendix A1 and A2 for more information on the derivation of the model and calculation of the parameters of interest. The asset-level UCC for asset i in industry k at time t can be presented as:

$$UCC_{ikt}=\frac{(r_{kt}-\pi_t+\delta_i)\,(1-\tau_t z_{ikt})}{(1-\tau_t)} \tag{5}$$

Where r is the industry-specific interest rate, π is the inflation rate and δ is the asset-specific depreciation rate. τ is the corporate tax rate while z is the asset-specific accumulated tax depreciation allowance rate. The paper follows the UCC estimation approach presented in an earlier study done by the World Bank (2015) for South Africa[3]. The data used in constructing the user-cost of capital comes from various sources. The nominal interest rate (r) is calculated using inter-bank prime lending rate and the 10-year yield government bond rate are used as proxies for the cost of debt and equity, respectively. The rates were obtained from the South African Reserve Bank. The CPI data from StatsSA is used to capture inflation. The effective statutory tax rates used in calculating the asset-industry user-cost of capital is the average of the headline corporate tax rate and the secondary tax rates. The evolution of these series (interest rates, inflation and corporate tax rates) in shown in Figure A1 in the appendices. Data such as the asset level economic depreciation rates and tax depreciation rates were obtained from the World Bank study on marginal effective tax rates in referenced earlier (World Bank, 2015). The above study is particularly relevant given that it uses the same context and similar data as this study.

Table 2 above presents the summary distribution of the UCC and the present value of depreciation allowances (z) associated with the different capital investments.

The table shows that plant and machinery equipment and non-residential structures have the lowest user costs of capital. The lower user cost of capital for plant and machinery equipment is a result of the more generous depreciation allowances offered for capital investments in South Africa. In particular, the accelerated depreciation allowances available in industries such as manufacturing, agriculture, and mining sectors would contribute to lowering the user cost of capital. The lower user cost of capital for investment in structures could be a

[3]The paper uses approaches and assumptions that are generally applied in World Bank assessments of effective corporate taxation in developing countries.

result of mainly the relatively longer depreciation tax lives for structures. The higher cost of capital for computing equipment could be a result of the lack of significant tax depreciation incentives for ICT assets.

Before we turn to the rest of the summary statistics, we define the dependant variable as the share of investment in asset i relative to the annual gross additions in new fixed assets in a given industry k at a given time t. The StatsSA industry-level dataset classifies assets by nature of use according to standard accounting practice. In this paper, the fixed asset categories used are; i) plant and machinery ii) transportation equipment iii) non-residential structures and iv) computer and ICT equipment[4]. The PPI series used as proxies for the asset prices were obtained from Statistics South Africa.

4.3 Descriptive statistics

Table 3 presents summary statistics for the key variables used in the regression analysis. The mean, standard deviation as well as the 25th, 50th and 75th percentiles are presented for the investment shares, cost of capital, and price indices for the four asset categories.

As can be seen in Table 3, machinery equipment has the largest share of investment (53%), while ICT equipment has the smallest share (9%). Investment in non-residential structures constitutes about 13% of total investment share while transportation equipment stands at 25%. The cost of capital is most favourable for machinery and plant equipment and structures because those categories have lower user cost of capital rates. This could reflect the more generous depreciation allowances available for machinery equipment categories relative to ICT or transport equipment categories. We observe no unusual trends in the real prices indices and the investment shares.

5 Results

5.1 OLS and SUR estimates

This section presents the results of estimating equation (4) first starting with OLS as the benchmark model and then using SUR estimation in a subsequent specification. Table 4 reports the coefficient estimates of the system of equations obtained under various model specifications. Columns 1 and 2 show results from a pooled OLS regression under the assumption of no contemporaneous correlation between the error terms. Column (1) does not control for time and industry effects while Column (2) takes those effects fully into account. Column (3) includes the time and industry effects also but estimates the results using

[4] We exclude land and capital work-in-progress from the asset categories because the former is typically fixed for most industries and the latter is difficult to allocate to a specific asset category. The balance sheets also include intangible fixed assets such as the value of intellectual property rights and copyrights. These are also excluded because our focus in fixed depreciable tangible assets.

the seemingly unrelated regression model under the assumption of plausible cross-equation correlation of the error terms.

The coefficient estimates in Table 4 are not for direct interpretation and certainly not informative of the size of the effect of user-cost elasticities on investments. We merely use these estimates as parameter inputs in the estimation of the relevant substitution elasticities that this study aims to show. Nonetheless, we briefly comment on how the general results change across different specifications and suggest the preferred estimates for use as inputs into calculating the tax-adjusted UCC elasticities in the next section. As can be seen, the results are largely similar, and most coefficients on user-cost in the investment share equations are statistically significant. However, we note that OLS estimates that control for technological trends and industry effects (Column 2) yield more efficient estimates than those in Column (1) where technology and industry effects are not included. The OLS estimates may however be inefficient, due to the likelihood that the share investment equations within each industry may be correlated with the error term. Therefore, we use Zellners' (1962) SUR method to obtain efficient estimates. Column (3) presents the SUR estimates which are quite similar to the OLS estimates in Column (2). The Breuch-Pagan Langrage multiplier test for the independence of the disturbances across equations (with a chi-square (3) value of 198.55 and p-value of 0.000) suggests strong evidence of contemporaneous correlation between the error terms. The SUR model estimates in Column (3) are therefore our preferred parameter inputs into the calculation of the elasticities in the next stage[5]. For ease of reference, the SUR estimates (in column 3) including the imputed parameter estimates initially omitted (as already discussed) are presented in Table 5 below.

5.2 The UCC elasticities

Next, we estimate the elasticities of investment demand which can be used to establish the responsiveness of UCC elasticities of investment. We use the parameter estimates in Table 5 to calculate both the own- and cross-UCC elasticities of investment demand for the different asset categories. The own-UCC demand elasticities show the responsiveness of investment demand to corporate tax incentives for a given asset. But our interest is the cross-UCC demand elasticities which show the responsiveness of investments to other asset types. The cross and own tax elasticities of demand calculated under the assumption of fixed capital investment can be derived as (Uzawa, 1962; Liu, 2011):

$$\xi_{ij}=\frac{\hat{\beta}_{ij}+S_iS_j}{S_i}\forall\, i\neq j;\xi_{ij}=\frac{\hat{\beta}_{ii}+S_i^2}{S_i}\forall\, i \tag{6}$$

[5] Attempts to control for the likely endogeneity of our estimates using IV-SUR with investment growth opportunities and liquidity as standard instruments led to inconsistent and insignificant coefficients. IV estimation is therefore not pursued further in this study due to the data problems noted earlier. However, by using the SUR, we control for the problems of contemporaneous correlation of the error terms.

Where S_i and S_j are the investment shares for asset i and j respectively. The $\hat{\beta'}s$ are the estimated coefficients on the log of cost of capital. The associated variance of the demand elasticities are then calculated using the delta method (Pindyck, 1979; Dwenger, 2009):

$$V\left(\xi_{ij}\right) = \left(\frac{1}{S_i}\right)^2 * V\left(\hat{\beta}_{ij}\right) \forall\, i,j \tag{7}$$

The estimated own-COC and cross-COC elasticities of investment demand are shown in Table 6.

5.3 Findings and discussion

While this paper is mainly concerned with an assessment of inter-asset distortions, we begin our analysis with a brief discussion of the responsiveness of investments with respect to their own corporate tax policy incentives. This helps put our findings in context and enables generalized comparisons with similar studies. First, we note that as predicted by theory, the own-UCC elasticities are all negative, except for the coefficient on plant and machinery equipment which is insignificant. The absolute values of the coefficients are greater than 1, indicating that investment demands for all assets are elastic. Results show that the own investment elasticity for non-residential structures is -1.80, transportation equipment has an elasticity of -3.82 while computer equipment has a very high elasticity of -19.50 which is unreasonable. Nonetheless, the demand elasticities of structures are generally comparable with findings in the very small literature that uses disaggregated data. For example, Liu (2011) also finds that the own-user cost of capital for non-residential structures in the United States is elastic, with elasticity estimates of about -1.29. Our elasticity estimate of -3.82 for transportation equipment is substantially different from Liu (2011) and Fatica (2013) who find insignificant elasticity estimates in the US and the OECD, respectively. Like other studies which attempt to disaggregate the capital elasticities, we find that computer equipment is highly elastic in South Africa. The huge elasticity estimate of -19.50 could be largely driven by the relatively tiny share of computer equipment in aggregate capital investment. The inverse relationship between demand elasticities and investment share is apparent (as can be seen in Equations 6 and 7 above). Therefore, where investment shares vary widely as is the case in this study, the resulting elasticity estimates are likely to vary widely as well, with assets with smaller shares being relatively more sensitive to changes in the user costs of capital than assets with relatively larger investment shares.

On whether differential taxation induces inter-asset effects, this paper finds evidence of distortions across different assets. The cross-tax elasticities show a significant degree of substitutability between most assets. We find that Transportation equipment and structures; transportation equipment and computer equipment; and plant equipment and computer equipment are substitutes. On the other hand, we observe tax complementarity between computer equipment and structures. While economic theory does not predict how transportation, plant, computer equipment, and structures should be inter-related, it is not inconceivable that computer equipment and structures could be complements, particularly if one considers that modern industrial structures are often equipped with sophisticated computer networks and security systems. It is therefore highly likely that industrial structures and computer equipment complement each other in most industrial sectors. The finding that plant equipment and computer equipment are substitutes is also plausible if one considers that traditional mechanical plants are increasing being replaced with computerised systems like robotic artificial intelligence systems that can control production, especially in manufacturing. However, the finding that transportation equipment is a substitute for either industrial structures or computer structures is does not seem intuitive or reasonable, and quite unlikely to hold in reality in many sectors.

Of the 12 cross-elasticity estimates, 8 are statistically different from zero - indicating the presence of inter-asset distortions. Some asset-level investments could therefore be responding to the tax incentives intended for other assets. We find that a 1 percent change in the user cost of computing equipment leads to on average a 3.4 percent decrease in investment in non-residential structures. Conversely, a 1 percent increase in the user cost of structures leads to a 4.9 percent decrease in investment in computer equipment. While we find that structures and computer equipment are complementary inputs, studies such as Fatica (2013) finds that the two inputs are tax-substitutes, though Liu (2011) finds no relationship. We note that the asymmetries in elasticity estimates arise from the inverse relationship between cross-elasticities and input shares. Investments in assets with relatively smaller shares are more responsive to changes in the user costs of assets with larger shares.

With regard to transportation and structures, we find that a 1 percent change in the user cost of structures is associated with a 1.3 percent increase in the investment in transport equipment with the asymmetric elasticity being about twice as large. These results contrast the results in Fatica (2013) who finds complementarity between the two inputs. We also find a tax-elasticity of 3.6 between transportation equipment and computer equipment with an asymmetric elasticity between the two inputs of about 3 times larger. Our results further show that differential taxation between plant equipment and computer equipment does induce investment distortions. In particular, we find that plant equipment and computer equipment are substitute tax-inputs. A 1 percent increase in the user cost of computer equipment is associated with an increase in plant investment of about 2.3 percent. These findings conform with results in Liu (2011) who finds a similar elasticity coefficient of about 2.5.

Our estimates, though much larger than those found in the US (Liu, 2011) and the OECD (Fatica, 2013) provide some support of potentially non-trivial inter-asset distortions present in developing country contexts where differential taxation of capital remains an important feature of corporate tax policy. The larger coefficients reported here could be due to the much higher variation in user cost of capital captured in this study. While Liu (2011) and Fatica (2013) only consider assets employed at the SIC 2-digit level and only for the manufacturing industry, our analysis is based on more disaggregated data at the SIC-4 digit level and covers all major industries such as manufacturing, construction, electricity and others. The tax treatment for investment assets used in these industries vary as different tax depreciation rates are applied across different industries. This kind of variability in asset treatments across different industries is not available in other studies which only focus on one sector and are based on data aggregated at higher levels. Our study therefore potentially unravels the kind of elasticities that more disaggregated datasets could reveal. Empirical estimates of elasticities from both the productivity and investment literature suggests that more disaggregated datasets provide much larger elasticity estimates.

To gain a sense of the size of the inter-asset distortion due to differential taxation in terms of gaps in the investment shares, we follow the approach in Liu (2011) and impute hypothetical distributions of investment under neutral taxation and compare with the observed investment shares. Therefore, for each year, all assets are assigned the UCC computed with the equalised average tax rate across the sectors. Then using the coefficients of the SUR model, we predict investment shares corresponding to the equalized user cost of capital. This counter-factual experiment is revenue neutral given that total investment is held constant. Figure 1 shows the comparison of the hypothetical investment shares against the actual shares.

Figure 1 shows that on average, differential taxation of investments has over the period induced under-investment in structures and computer equipment. We further note that there is systematic over-investment in plant and machinery equipment mostly driven by the generous tax treatment of plant and machinery relative to computer equipment. Results further show that prior to 2009, there was under-investment in transportation equipment. The trend however changes after 2010 where we observed over-investment in transportation equipment. The existence of significant inter-asset distortions due to differential taxation raises important policy questions, in particular, whether non-uniform taxation of assets and industries should be abandoned? At the minimum, such considerations would require a comparison of the financial and employment benefits versus the financial and job loss costs arising from differential taxation. Where differential tax results in a net increase in industrial profitability and increased jobs, and increased tax revenues, the government could pursue the policy provided measures are taken to ensure the job losses and inefficiencies caused in other sectors are mitigated. A further recommendation is that differential taxation of assets and industries could be prescribed for very specific sectors and industries, particularly those at risk of collapse such as the steel, and aviation sectors that have seen catastrophic declines in productivity and revenues in the recent past.

6 Conclusion

This paper investigated the inter-asset distortion effects of differential corporate taxation on the allocation of investment assets in South Africa. While there is substantial variation in the tax treatment of investments in assets and across industries, little empirical evidence exists on the nature of any investment distortions due to differential taxation. Using a unique dataset of disaggregated industry-level financial statement data from 2007 to 2014, our estimates of inter-asset user cost elasticities reveal statistically significant and economically non-negligible inter-asset distortions due to non-uniform taxation of investments. In general, we show that investments in given assets not only respond to their own tax incentives, but to the incentives of other assets.

The findings in this paper should however only be taken as exploratory, given the problems associated with the industrial panel used in this study where the composition of the firms in the sample may vary from year to year. Besides, using industrial units as investment decisions is conceptually problematic because investment discussions are usually undertaken at the firm level. Our findings are therefore only suggestive, but nonetheless provide a strong foundation for future debate and studies on the economic and efficiency implications of differential taxation of assets and industries in South Africa and other developing countries more broadly.

An immediate implication of our findings is that ongoing corporate tax reforms in both South Africa and the developing world at large should design policies that minimise the potential investment distortions due to differential taxation. Ignoring the distortive implications of heterogeneous tax treatment could understate the efficiency and redistributive effects of tax policy.

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Table 1: Distribution of the Observations at the SIC -1digit level

Industry (SIC 1-digit)	Freq.	Percent	Cum.
Manufacturing	472	44.32	44.32
Electricity	8	0.75	45.07
Construction	59	5.54	50.61
Trade	180	16.9	67.51
Transport	63	5.92	73.43
Financial	170	15.96	89.39
Services	113	10.61	100
Total	1,065	100	

Notes: Own estimates based on the AFS datasets from StatsSA

Table 2: Mean and Standard Deviation of UCC and z

Tax Parameters	2007-2008	2009-2010	2011-2012	2013-2014
UCC: Structures	8.77	12.71	11.25	9.93
	(2.28)	(2.94)	(2.64)	(2.26)
UCC: Computer	31.62	43.38	40.48	41.74
	(9.94)	(10.93)	(11.11)	(10.81)
UCC: Transport	24.41	28.71	26.94	25.82
	(3.20)	(3.31)	(3.49)	(3.46)
UCC: Plant	17.84	21.82	20.52	19.58
	(0.98)	(1.68)	(1.55)	(1.48)
z : Structures	0.45	0.52	0.54	0.53
	(0.01)	(0.02)	(0.03)	(0.02)
z : Computer	0.81	0.84	0.85	0.85
	(0.01)	(0.01)	(0.01)	(0.01)
z : Transport	0.80	0.83	0.84	0.83
	(0.01)	(0.02)	(0.02)	(0.02)
z : Plant	0.82	0.83	0.85	0.84
	(0.02)	(0.03)	(0.02)	(0.02)

Note: *UCC* and *z* are the user cost of capital and present value of depreciation allowance for each given asset, respectively. The means and standard deviations of the selected tax parameters have been winsorized at the 1 and 99 percent of their empirical distributions. Standard deviation in parentheses.

Table 3: Summary Statistics

	Mean	Std. Dev	25%	50%	75%	N
Plant Equipment						
Investment Share	0.53	0.24	0.35	0.56	0.73	1065
COC (%)	20.21	1.880	18.96	20.33	21.28	1065
Real price index	101.6	9.020	94.23	97.01	107.1	1065
Structures						
Investment Share	0.130	0.160	0.0200	0.0700	0.180	1065
COC (%)	10.88	2.830	8.490	10.08	13.05	1065
Real price index	93.41	4.820	88.22	94.42	97.13	1065
Computer and ICT Equipment						
Investment Share	0.09	0.14	0.02	0.04	0.09	1065
COC (%)	40.54	11.31	28.82	44.57	51.23	1065
Real price index	100.5	5.560	94.81	98.77	102.0	1065
Transportation Equipment						
Investment Share	0.250	0.210	0.0900	0.190	0.360	1065
COC (%)	26.69	3.640	22.98	28.28	29.45	1065
Real price index	103.9	7.720	98.32	98.99	110.7	1065

Note: summary statistics given for all industries in South Africa. Investment share is defined as the rand investment in a given asset over the total capital investment in a given industry. COC is the user cost of capital expressed in percentages. Real prices are proxied by the PPI for the respective asset.
Source: AFS (2007-2014), Statistics South Africa

Table 4: Seemingly Unrelated Regression Estimates

		(1)	(2)	(3)
Equation for Structures	$UCCstruc$	0.01	-0.13*	-0.12**
		(0.03)	(0.07)	(0.06)
	$UCCcomp$	0.07***	-0.49***	-0.45***
		(0.02)	(0.16)	(0.14)
	$UCCTrans$	-0.23***	0.32***	0.29***
		(0.03)	(0.12)	(0.10)
Equation for Computers	$UCCstruc$	0.07***	-0.49***	-0.45***
		(0.02)	(0.16)	(0.14)
	$UCCcomp$	0.15***	-1.78***	-1.62***
		(0.02)	(0.53)	(0.48)
	$UCCTrans$	-0.05***	0.90***	0.88***
		(0.02)	(0.32)	(0.31)
Equation for Transport	$UCCstruc$	-0.23***	0.32***	0.29***
		(0.03)	(0.12)	(0.10)
	$UCCcomp$	-0.05***	0.90***	0.88***
		(0.02)	(0.32)	(0.31)
	$UCCTrans$	0.12**	-0.61	-0.77
		(0.05)	(0.52)	(0.50)
N		1,065	1,065	1,065

Note: Standard errors in parenthesis. * indicates significance at 0.10 level, ** indicates significance at 0.05 level, *** indicates significance at 0.01 level. *Source*: AFS (2007-2014), Statistics South Africa

Table 5: Summary of SUR parameter estimates

	Coefficient	Std. Error	95% Confidence Interval	
$\beta_{struc,struc}$	-0.120	0.061	-0.239	0.000
$\beta_{struc,comp}$	-0.448	0.144	-0.730	-0.166
$\beta_{struc,trans}$	0.291	0.100	0.095	0.487
$\beta_{comp,comp}$	-1.625	0.484	-2.574	-0.675
$\beta_{comp,trans}$	0.882	0.311	0.273	1.491
$\beta_{trans,trans}$	-0.773	0.495	-1.743	0.197
$\beta_{plant,struc}$	0.276	0.210	-0.135	0.688
$\beta_{plant,comp}$	1.190	0.627	-0.038	2.419
$\beta_{plant,trans}$	-0.400	0.525	-1.430	0.629
$\beta_{plant,plant}$	-1.066	1.023	-3.072	0.939

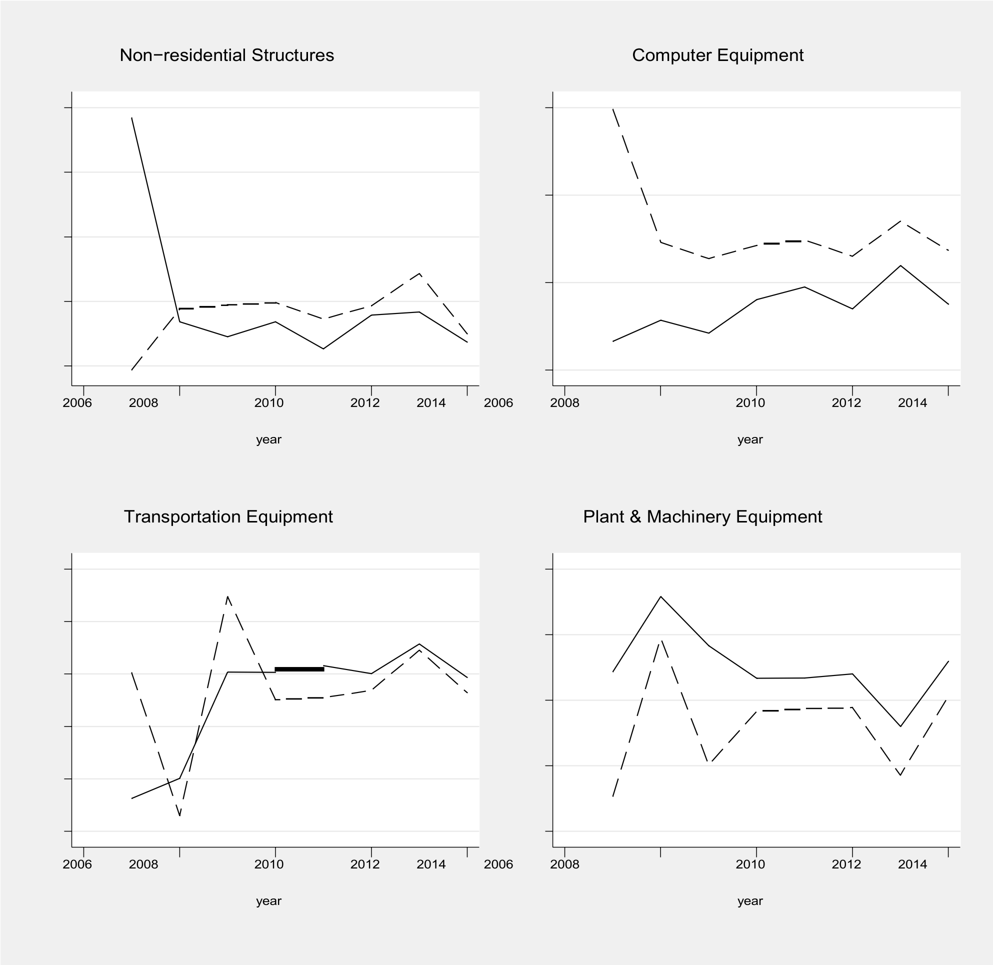
Note: The parameter estimates related to the plant equation are imputed using regression estimates from the SUR model. All other parameters are simply summarized from column (3) of Table 3.
Source: AFS (2007-2014), Statistics South Africa

Table 6: Own & Cross-COC elasticities

	Structures	Computer Equipment	Transportation Equipment	Pant & Machinery Equipment
input shares	12.81%	8.74%	25.16%	53.30%
Factor i	ξ_i, *struc*	ξ_i, *comp*	ξ_i, *trans*	ξ_i, *plant*
Structures	-1.807***	-3.409***	2.525***	2.691
	0.476	1.123	0.782	1.640
Computer	-4.999***	-19.510***	10.350***	14.159**
	1.647	5.546	3.556	7.176
Transportation	1.286***	3.594***	-3.821*	-1.058
	0.398	1.235	1.968	2.088
Plant & Machinery	0.647	2.32**	-.500	-2.468
	0.3940	1.1760	0.9856	1.9196

Note: Standard errors in parenthesis. * indicates significance at 0.10 level, ** indicates significance at 0.05 level, *** indicates significance at 0.01 level.
Source: AFS (2007-2014), Statistics South Africa

Figure 1: Comparisons of investment shares under uniform and differential taxation of assets



Notes: The dotted lines represent fitted investment shares (neutral taxation) while the solid line represents the actual investment shares (prevailing non-uniform taxation). The y-axis represents investment shares. Source: AFS (2007-2014), Statistics South Africa

Appendices

A1: Brief derivation of the King and Fullerton (1984) user cost of capita concept used in this paper.

As already pointed out, the appropriate channel through which taxation affects investment is the user cost of capital (Jorgenson, 1963; Hall and Jorgenson, 1967). Below, we briefly development the UCC concept used in this paper.

Under the behavioural assumption of profit maximisation and in the simplest case of no taxation, no inflation, no depreciation and no consideration for capital gains or losses, a firm will hire capital until the value of an additional unit of investment is equal to its cost. This cost of capital rental, when evaluated at the profit maximising point is what is referred to as the user cost of capital. In the simplified case above, the user cost of capital is equal to the opportunity cost of capital (or rate of interest). The level of capital investment will therefore vary with changes in the equilibrium user cost of capital. Allowing for economic depreciation, δ, which effectively increases the rental cost of capital, the user cost of capital (UCC) in a particular asset could be presented as:

$$UCC = r + \delta \#(1)\#$$

Introducing corporate taxation necessitates modifying the equilibrium outcome in equation (i) to accommodate various features of the corporate tax system. For example, tax depreciation allowances or investment tax credits imply a reduction in the effective per unit cost of capital by some amount, ξ, such that the per unit cost becomes $\$(1-\xi)$. On the other hand, the statutory marginal corporate tax rate, τ, effectively increases the required return to capital. Putting these new terms together, equation (1) now becomes:

$$UCC = \frac{(r^* + \delta)(1-\xi)}{(1-\tau)} \#(2)\#$$

where r^* is the after-tax real interest rate. In countries where inflation and depreciation allowances are significant parameters, equation (2) can be more specifically written as:

$$UCC = \frac{(r - \pi + \delta)(1-\tau\phi)}{(1-\tau)} \#(3)\#$$

where r, π and ϕ represent the nominal interest rate, inflation rate and present value of accumulated depreciation allowances, respectively. The equilibrium condition defining the user cost of capital states that the after-tax cost of capital associated with the effective investment of $\$(1-\xi)$ must equal the after-tax return. The UCC is therefore the before-tax capital rental, or rate of return that equalises the (after-tax) cost of capital to the post-tax returns. Conceptually, it is the minimum return a firm needs on the marginal investment to cover depreciation, taxes, and the opportunity cost of an investment (Liu, 2011)[1]. Thus, the UCC is comprehensive, considering the investment effects of not only tax policy (e.g. statutory tax rates, depreciation and investment allowances etc) but also macro-economic price effects and asset and financing structures.

As seen in equation (3) above, various factors can influence the user cost of capital and a firm's investment decision. Economic depreciation for instance, which allows a given portion of

[1] A detailed introduction and discussion of the user-cost of capital approach used in this paper is provided in (Creedy and Gemmell, 2017)

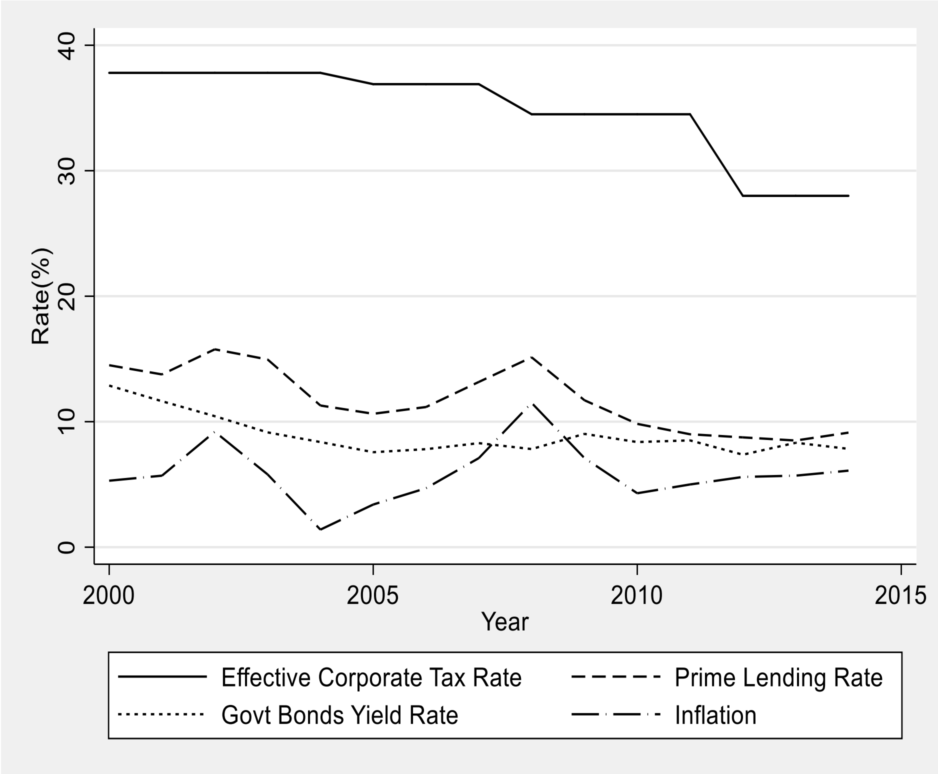
investment costs to be deducted from taxable income could lower the user cost of capital. To the extent that tax depreciation is higher than economic depreciation, a higher portion of after-tax income is retained early in the depreciation cycle of an asset. Effectively, tax depreciation that is higher than economic depreciation creates an investment subsidy and may encourage investment. Other more direct provisions such as investment expenditure allowances or investment credits directly reduce the unit cost of investment by writing o of a portion of investment expenditures against taxable incomes or reducing taxes paid by a given percentage. The effect of rising inflation can affect investment decisions through multiple mechanisms. An increase in inflation can result in a decline in the real value of depreciation allowances, thus eroding the tax benefits of depreciation allowances and increasing the user cost of capital. On the other hand, factors such as the deductibility of interest on debt capital and given high inflation reduces the tax burden and effective cost of capital. These results hold especially in jurisdictions where debt deductions or depreciation allowance are not indexed for inflation.

Associated with the concept of user cost of capital is the marginal effective tax rate (METR), which is the effective tax burden on a marginal investment. The METR is defined as the difference between the UCC net of depreciation and the after-tax rate of return on an alternative asset over the cost of capital net of depreciation:

$$METR = \frac{\tilde{\rho} - \bar{r}}{\tilde{\rho}} \#(4)$$

Where $\tilde{\rho}$ is the UCC net of depreciation or the real social rate of return and $\bar{r}$ is the after-tax rate of return on an alternative asset. The METR effectively measures the tax wedge on a marginal investment, or the proportion of the returns of a marginal investment given up to compensate for taxation. It is the extent to which corporate taxation increases the cost of capital above $\bar{r}$ (Fatica, 2013; World Bank, 2015).

Figure A1: Evolution of Corporate tax rates, Inflation and Interest rates used in the calculation of the UCC



Notes: Effective corporate tax rate is the average of the headline and secondary tax rates period.
Source: SARS and the South African Reserve Bank data series website.

Figure 1 shows movements in the effective corporate tax rate, inflation rate and the prime interest rate and the 10-year government yield rate over the period 2000 to 2014. Although only the series over the period 2007 to 2018 are used, we show the series over a longer period for a more complete picture of the movement in the series. As can be seen, the tax code has consistently reduced both the headline and secondary tax rates on companies. Since 2005, inflation, together with the inter-bank prime rate and government bond rates have somewhat declined.

A2: Calculation of interest rates and depreciation allowances

Following the literature, the calculation of asset level cost of capital requires first estimating the nominal interest rate and present value of depreciation allowance on a unit value of investment. The components are computed as follows:

Nominal Interest Rate, r_{kt}

We calculate the nominal discount rate for industry *k* at time *t* as the weighted average of the after-tax rates of return to debt and equity:

$$r_{kt} = i_t(1 - \tau_t) + (1 - \theta_{kt})e_t\#(1)$$

Where θ_{kt} is the share of assets financed by debt calculated as the ratio of total liabilities to total assets. I calculate these ratios using the disaggregated industry level balance sheets for each industry. i_t and e_t are the inter-bank prime lending rate and the yield rate on 10-year South African government bonds used as proxies for the cost of debt and equity (respectively). Note that the tax term $(1-\tau_t)$ represents the tax deductibility investment incentive provided for in the South African tax code.

Depreciation allowances, $\boldsymbol{Z_{ikt}}$

The calculation of present value depreciation allowances requires information on the depreciation methods as well as the appropriate industry-level discount rates and tax asset lives. Assuming a 1dollar investment, the present value of the depreciation allowance over the life of the investment can be presented as:

$$z_{ikt} = \int_0^{Y_{it}} e^{-r_k t s_{it}} D_{it}(s_{it}) ds \,\#(2)$$

Where Y_{it} represents the tax life of asset *i* in year *t*, and r_{kt} is the nominal discount rate previously defined. D_{it} represents the depreciation method. In the case of straight-line depreciation as is provided for in the South African tax code, the present value of the depreciation allowances can be expressed as:

$$z_{ikt} = \frac{1-e^{-rY}}{rY} \,\#(3)$$

Using the above parameters and variables, the asset-specific user-cost of capital asset *i*, in industry *k* and at time *t* as follows:

$$UCC_{ikt} = \frac{(r_{kt} - \pi_t + \delta_i)(1-\tau_t z_{ikt})}{(1-\pi_t)} \,\#(4)$$