Tax Incentives, Supply Shocks, and Equipment Prices

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JEL Classifications: H25, E22
June 2000

Abstract

An important question concerning the efficiency of investment tax incentives in promoting capital accumulation is whether they raise capital equipment prices because of an upward-sloping equipment supply curve. Goolsbee (1998) presents evidence of a positive relationship between tax incentives and equipment prices as evidence of a significantly upward-sloping supply curve for equipment. This paper shows that investment tax incentives are a poor instrument for identifying this supply curve because they are correlated with supply shocks for equipment producers. Once input costs for equipment producers are controlled for, there is no evidence of a relationship between tax incentives and equipment prices. In fact, the evidence favors a flat supply curve.

*Mail Stop 80, 20th and C Streets NW, Washington DC 20551. Email: kwhelan@frb.gov. I wish to thank Darrel Cohen, Spencer Krane, Jonathan Parker, Stacey Tevlin, and, in particular, Austan Goolsbee for comments on a previous draft. The views expressed in this paper are those of the author and do not necessarily reflect the views of the Board of Governors or the staff of the Federal Reserve System.

1 Introduction

The economic impact of the tax treatment of investments in physical capital is one of the major issues in public finance. The current system of U.S. capital taxation - under which capital income is taxed but firms can deduct investment expenditures from the tax base as the capital depreciates - is widely viewed as overly complex. Moreover, each of the major proposals for fundamental tax reform have stressed their ability to promote capital accumulation, and thus productivity, by reducing the effective tax rate on capital investments.[1] A problem for assessing these claims is that the effects of the capital taxation system on investment are not well understood. While some studies, such as Cummins, Hassett, and Hubbard (1994) have argued that, around major tax reforms, investment is responsive to the tax component of the cost of capital, estimates based on time series regressions, such as those of Clark (1993) tend to find a weak relationship.

In an important contribution, Austan Goolsbee (1998) has provided a potential explanation for why tax incentives may impart only a limited stimulus to investment: If the supply curve for capital equipment is sufficiently upward-sloping, then the outward shift in the demand curve for equipment induced by improved investment tax incentives will result principally in higher prices rather than higher quantities. As evidence for this hypothesis, Goolsbee documented a strong positive relationship between investment tax incentives and equipment prices. This result is important because it suggests that much of the benefit of these tax incentives goes to capital suppliers instead of generating productivity improvements through faster capital accumulation.

This paper takes another look at the relationship between equipment prices and tax incentives and comes to a different interpretation of the evidence from that of Goolsbee. The principal point of the paper is that the correlation between tax incentives and equipment prices can be used to interpret the slope of the equipment supply curve only if incentives are weakly correlated with the shocks that shift that supply curve. However, examination of the evidence on intermediate input costs for equipment producers reveals that tax incentives have actually been highly correlated with shocks to the supply curve for equipment. Once these supply shocks are controlled for, there is no evidence of a relationship between equipment prices and tax incentives. In fact, the evidence on the response of equipment

[1] See, for instance, Slemrod and Bakija (1996) for a discussion of some of the proposals for fundamental tax reform.

prices to these supply shocks is instead broadly consistent with a flat supply curve.

The paper starts with a brief theoretical discussion in Section 2. Section 3 describes the data and presents some preliminary evidence on the relationships between equipment prices, tax incentives, and intermediate input prices for equipment producers. Sections 4 and 5 contain the econometric results. Section 6 discusses the implications of the results for the equipment supply curve.

2 Supply, Demand, and Equipment Prices

Consider the simplest possible model of the determination of equipment prices. The quantity of equipment supplied is a positive function of the price of equipment and a negative function of input costs:

$$q^s = \alpha_s + \beta_s p - \gamma c + \epsilon_s \tag{1}$$

where the lower-case letters indicate logs. Demand depends negatively on the price of equipment, adjusted for the effect of tax incentives[2]:

$$q^d = \alpha_d - \beta_d (\tau + p) + \epsilon_d \tag{2}$$

The equilibrium price is

$$p = \frac{\alpha_d - \alpha_s}{\beta_s + \beta_d} - \frac{\beta_d \tau}{\beta_s + \beta_d} + \frac{\gamma c}{\beta_s + \beta_d} + \frac{\epsilon_d - \epsilon_s}{\beta_s + \beta_d} \tag{3}$$

Equipment prices depend positively on input costs and negatively on the implicit tax rate, τ, with the size of the tax effect depending on the slopes of both the demand and supply curves. Obviously, the more sensitive is investment demand to tax incentives (the larger is β_d) then the larger the response of prices to a change in τ will be. The magnitude of the effect of τ on prices also depends negatively on the slope of the supply curve (β_s.) If the market for equipment is competitive and quantities supplied are highly sensitive to prices (β_s is high) then tax incentives will have little effect on the equilibrium level of prices. In contrast, if the supply curve is steep, so that the quantity supplied is relatively insensitive to price, then tax incentives could show up mainly as higher equipment prices, perhaps implying an important deadweight loss. For this reason, Goolsbee (1998) has interpreted

[2] A more complete model of equipment demand would also include interest rates and depreciation. However, since we are only focusing on prices and taxes, this is a reasonable simplification for our purposes.

evidence of a positive relationship between capital equipment prices and investment tax incentives as implying a significantly upward-sloping supply curve for equipment.

While this is one explanation for the relationship between equipment prices and tax incentives, it is important to note that the regressions in Goolsbee's study did not explicitly control for cost shocks for producers of equipment (this is discussed further below.) And if tax incentives are positively correlated with these omitted supply shocks ($\text{Cov}(\tau, c) < 0$), then regression analysis could spuriously attribute to tax incentives an effect that is actually due to higher input costs, thus mixing up the effects of a shift in the demand curve with the effects of a shift in the supply curve. This point can be understood in terms of omitted variable bias, but it can also be interpreted in terms of the theory of instrumental variables. Inferring the slope of the supply curve from the correlation between tax incentives and prices can be interpreted as using tax incentives as an exogenous demand instrument to estimate the supply relationship. However, this method is only valid if the instrument is uncorrelated with shocks to the supply curve.[3] The evidence presented next suggests that equipment tax incentives resoundingly fail this requirement because they are correlated with costs shocks for equipment producers.

3 The Data

3.1 Description

The dataset consists of annual time series on prices, tax incentives, and intermediate input costs for 22 different categories of equipment in the U.S. National Income and Product Accounts, which together cover all private investment spending on equipment.

Equipment Prices: The equipment prices are the detailed investment deflators from Table 7.8 of Department of Commerce (1998.) Because these deflators are used to create the real investment component of GDP, which measures output of final goods only, they are constructed using mainly detailed Producer Price Indexes for specific categories of equipment that are sold only as final goods. The sample used (1959-94) is longer than the 1959-1988 sample used by Goolsbee, which was taken from Department of Commerce (1993); because

[3]See for instance the work of John Shea (1993). Shea uses input-ouput tables to exhaustively search for instruments that have an important effect on demand and but are uncorrelated with supply shocks.

many of these series are based on quality adjustment methodologies that have changed over time, his estimates cannot be replicated exactly with this data set but the qualitative features of his results are also obtained from these data.

Tax Incentives: Two measures of investment tax incentives are used. The first is the investment tax credit (ITC). This was first introduced in 1962 and set at various rates across different types of equipment. The credit was briefly discontinued during the late 1960s, re-introduced in 1971, strengthened in 1974, and then strengthened again for a small number of equipment types in the early 1980s. The ITC was abolished in 1986 and has not been re-introduced since. Data on the ITC were taken from Gravelle (1994). The second measure is the Hall-Jorgenson tax term that features in the user cost of capital formula. This variable incorporates the effects on the cost of equipment investment of changes in corporate income tax rates and depreciation allowances, but its most notable swings over time are due to the ITC. The tax term is defined as $\frac{1-ITC-\tau z}{1-\tau}$, where τ is the marginal corporate income tax rate and z is the present discounted value of depreciation allowances per dollar invested. The details behind the construction of this variable are in Appendix A.

Intermediate Input Prices: Time series for the cost of intermediate inputs for equipment producers were obtained by matching each capital good with the two, three, or four-digit SIC industry that produces it and then using the matching industry-specific price deflator for intermediate inputs from the NBER manufacturing productivity database.[4] These intermediate input price deflators were calculated using Input-Output tables and prices for 529 types of material inputs and 6 types of energy inputs. Note that if an equipment-producing industry also produces some of its own material inputs, then those input prices will affect this input deflator, but, as noted above, these prices would *not* be used to construct the equipment investment price deflator. I point this out to avoid concerns over whether there is a potential for a spurious "correlation by construction" between our measures of equipment and intermediate input prices.

[4]The details of this matching exercise are provided in Appendix B. See Bartelsman and Gray (1996) for a discussion of the NBER manufacturing database.

3.2 Preliminary Evidence

Charts 1A, 1B, 2A, and 2B provide some preliminary evidence on the relationships between equipment prices, tax incentives, and intermediate input prices. In each of these charts, equipment prices are normalized by the GDP deflator and because many of these relative prices trend over time (usually downward) they are also detrended using simple regressions of the log of the series on a time trend. Charts 1A and 1B compare detrended relative equipment prices with the time series for the ITC for each of our categories. A clear positive correlation between the price series and the ITC is evident for most of the categories. It is also clear that, for most of the equipment categories, the positive correlation is driven by the hump-shaped pattern for relative prices since the mid-1970s. Twenty of the twenty-two relative equipment prices rose substantially beginning with the 1974-75 period, with most falling back again at varying speeds during the 1980s; similarly, the ITC was strengthened in the mid-1970s and abolished in the mid-1980s. This relationship is not perfect, however. In particular, detrended relative equipment prices fell throughout the 1960s despite the introduction of the ITC and, for most categories, the timing of the 1980s decline in relative prices does not line up well with the 1986 repeal of the ITC. So, while some categories have correlations between the ITC and detrended relative prices higher than 0.4, the average correlation is only 0.09.

The relationship between the ITC and equipment prices suggests the possibility that the swings in these prices have been due to shifts in the demand for equipment caused by changes in tax incentives. An alternative possibility is that these swings were due to supply shocks. Indeed, the most notable jump in equipment prices, during the 1974-75 period, lines up exactly with the initial OPEC energy price increases. The 1975 *Economic Report of the President* (pg. 39) noted the rapid growth in equipment prices and explained it as being the result of rising costs. During this period, firms had to deal with more than just a surge in energy prices. The abolition of price controls in 1974 and a worldwide jump in commodity prices also contributed to rising materials costs. The PPI for intermediate materials rose an average of 11.2 percent per year over the period 1974-81, compared with an average rise of 8.1 percent for the GDP deflator. This likely contributed to equipment prices rising faster than GDP prices, since the bundle of goods and services making up GDP contains a number of large categories, most notably personal consumption expenditures on non-energy services, which require very little raw materials.

Figures 2A and 2B illustrate the relationships over time between detrended relative equipment prices (the solid lines) and detrended relative prices of intermediate inputs (the dashed lines.)[5] These figures show that intermediate input prices match up much closer with equipment prices than do the investment tax credits. The average correlation of 0.42 is far higher and 12 of the 22 categories have correlations higher than 0.54, which is the highest correlation between any of the prices and the ITC. However, while certainly suggestive, these summary statistics do not rule out the hypothesis that investment tax incentives also affect equipment prices, but rather suggest the need to include input costs as explanatory variables in equipment price regressions.

4 Regressions

The base regression specification is

$$\log(P_{it}) = \alpha_i + \beta_i (TAX_{it}) + \gamma_i \log(PM_{it}) + \theta_i t + \gamma_i GROW_t + \delta_i NIXON_t + \epsilon_{it} \qquad (4)$$

where P_{it} is the relative price of equipment of type i (where relative means in relation to the GDP deflator), PM_{it} is the relative price of intermediate inputs for producers of equipment of type i, t is a time trend, $GROW$ is GDP growth, $NIXON$ is a variable accounting for the Nixon price controls from 1971-74, and TAX_{it} is a measure of investment tax incentives, either the ITC or the Hall-Jorgenson tax term. This specification differs from that in Goolsbee's study only in including PM_{it} and omitting exchange rate variables, which I did not find to have a significant effect or influence the results. The 22 equations were estimated jointly using the Seemingly Unrelated Regression technique.

The first columns of Tables 1 and 2 show the results from estimating equation (4) without including PM_{it}, with Table 1 using the ITC as the TAX_{it} variable and Table 2 using the Hall-Jorgenson tax term. The results are very similar to those reported in Goolsbee's study. For both the ITC and the tax term, 13 of the 22 categories reveal a statistically significant positive effect of tax incentives on equipment prices (in the tax term regression, this implies a negative coefficient.) The estimated effects are quite large. Restricting the effect of the tax variables to be the same across all equipment types gives a

[5] It was necessary to detrend the relative intermediate input prices since for some industries, such as computing equipment, intermediate materials prices have fallen rapidly over time.

coefficient of 0.30 on the ITC, implying that a 10 percent tax credit raises equipment prices by 3 percent, and an elasticity with respect to the full tax term of -0.11.

The second columns of Tables 1 and 2 report that the significant positive relationship between tax incentives and equipment prices does not hold up once PM_{it} is added as an explanatory variable.[6] For the ITC regression, all but one of the significant positive coefficients disappear, 14 of the 22 coefficients are negative, and the pooled coefficient is significantly negative.[7] The results from the tax term regressions are even more striking: 20 of the 22 coefficients on the tax term are positive once we include PM_{it} and the pooled coefficient is also significantly positive. Thus, if anything, it appears that increased investment tax incentives are associated with *lower* rather than higher equipment prices. One possible explanation for this result is that tax incentives are introduced at times when there are exogenous negative shocks to equipment demand, not captured by the inclusion in the regression of GDP growth ($\text{Cov}(\tau, \epsilon_d) > 0$.) However, having noted this possibility, I will not pursue it further.

In each of these regressions the coefficients on PM_{it} (not shown) are positive and statistically significant, confirming the pattern suggested by Figures 2A and 2B. Moreover, the inclusion of this variable improves the fit of the regressions, most notably for those categories which had previously suggested a strong relationship between equipment prices and tax incentives. Adding PM_{it} raises the average $\bar{R}^2$ for the ITC regressions from 0.814 to 0.884, and the tax term regressions from 0.791 to 0.891.

These results indicate that regressions relating equipment prices to investment tax incentives but excluding prices for intermediate inputs are mis-specified. The correlation between the tax variables and input prices results in spurious estimates of a large effect of tax incentives on equipment prices, estimates that disappear once one controls for input prices. The graphical evidence on the relationships between these variables provide a simple explanation for this result. Much of the variation in equipment prices correlates with the surge in materials prices in the mid-1970s and the decline in the 1980s. Without controlling for these supply shocks, we may be led to an incorrect conclusion by the fact that relative

[6]The regressions in this paper differ from those in Goolsbee's study in not correcting for autocorrelation. Goolsbee's regressions used an AR(2) correction. The results reported here were robust to this correction as well as to other specifications allowing for dynamics. However, the autocorrelation of the errors was significantly less pronounced once we included intermediate input prices.

[7]This regression also restricted the coefficient on PM_{it} to be the same across all equations.

Table 1: ITC Coefficients

Asset Class	No Input Prices	Including Input Prices PM_i	PE_i	Steel-Oil
1. Furniture	0.11 (.06)	-0.25 (.05)	-0.13 (.08)	-0.14 (.06)
2. Fabricated Metals	1.02 (.12)	0.08 (.09)	-0.26 (.10)	-0.12 (.11)
3. Engines	0.50 (.13)	-0.67 (.18)	-0.48 (.17)	-0.42 (.16)
4. Tractors	0.49 (.08)	0.09 (.08)	-0.25 (.06)	0.03 (.07)
5. Agric. Machinery	0.65 (.09)	0.26 (.09)	-0.03 (.08)	0.15 (.08)
6. Constr. Machinery	0.56 (.07)	-0.45 (.03)	-0.37 (.06)	-0.38 (.02)
7. Mining Machinery	1.44 (.16)	0.01 (.11)	0.13 (.11)	-0.11 (.09)
8. Metalworking Mach.	0.21 (.06)	-0.32 (.05)	-0.37 (.06)	-0.36 (.03)
9. Special Ind. Mach.	0.17 (.05)	-0.30 (.04)	-0.39 (.05)	-0.27 (.06)
10. General Ind. Mach.	0.27 (.08)	-0.36 (.08)	-0.16 (.10)	-0.39 (.04)
11. Office & Computers	-0.72 (.32)	-1.61 (.27)	0.74 (.29)	-0.12 (.33)
12. Service Ind. Mach.	-0.15 (.05)	-0.05 (.05)	-0.14 (.06)	-0.15 (.04)
13. Electrical Dist.	0.07 (.06)	-0.11 (.07)	-0.10 (.07)	-0.16 (.02)
14. Communications	0.20 (.10)	0.16 (.11)	0.65 (.09)	0.22 (.14)
15. Oth. Electr. Equip.	0.03 (.11)	-0.11 (.11)	-0.75 (.08)	-0.24 (.10)
16. Trucks and Buses	-0.03 (.10)	0.08 (.12)	-0.49 (.17)	0.12 (.06)
17. Autos	-2.33 (.16)	-1.43 (.14)	-2.31 (.18)	-1.33 (.12)
18. Aircraft	0.12 (.09)	0.15 (.09)	-0.19 (.10)	0.10 (.07)
19. Ships	0.39 (.07)	0.09 (.07)	-0.03 (.06)	0.23 (.07)
20. Railroad Equipment	1.38 (.15)	-0.20 (.08)	-0.01 (.15)	0.17 (.11)
21. Instruments	-0.29 (.04)	-0.18 (.05)	-0.30 (.05)	-0.11 (.05)
22. Other Equipment	-0.20 (.11)	-0.14 (.12)	-0.48 (.13)	-0.08 (.13)
POOLED	0.30 (.02)	-0.27 (.02)	-0.11 (.02)	-0.10 (.01)
Average $\bar{R}^2$	0.814	0.884	0.882	0.880

Sample is 1959-1994. Standard errors in parentheses. The dependent variable is the log of the equipment price minus the log of the GDP deflator. PM_i and PE_i are the logs of the industry-specific prices (relative to the GDP deflator) for all material inputs and energy inputs respectively. Regression in final column uses the aggregate PPIs for steel and oil. Each equation also includes an intercept, a time trend, GDP growth, and a Nixon price controls variable. The 22 equations were estimated jointly using SUR. Pooled coefficients were restricted to be the same across all equations.

Table 2: Hall-Jorgenson Tax Term Coefficients

Asset Class	No Input Prices	Including Input Prices PM_i	PE_i	Steel-Oil
1. Furniture	-0.13 (.02)	0.01 (.02)	-0.06 (.02)	-0.03 (.01)
2. Fabricated Metals	-0.40 (.04)	0.09 (.04)	0.07 (.03)	0.08 (.02)
3. Engines	-0.25 (.06)	0.32 (.06)	0.26 (.07)	0.21 (.05)
4. Tractors	-0.03 (.02)	0.21 (.02)	0.10 (.02)	0.13 (.01)
5. Agric. Machinery	-0.08 (.02)	0.15 (.02)	0.11 (.02)	0.10 (.01)
6. Constr. Machinery	-0.20 (.01)	0.05 (.01)	-0.06 (.02)	0.00 (.00)
7. Mining Machinery	-0.28 (.05)	0.30 (.03)	0.06 (.04)	0.16 (.03)
8. Metalworking Mach.	-0.11 (.01)	0.08 (.01)	-0.01 (.02)	0.07 (.01)
9. Special Ind. Mach.	-0.10 (.01)	0.09 (.01)	0.02 (.02)	0.05 (.01)
10. General Ind. Mach.	-0.23 (.02)	-0.03 (.03)	-0.16 (.04)	-0.01 (.01)
11. Office & Computers	-0.16 (.10)	0.23 (.15)	-0.55 (.09)	0.35 (.06)
12. Service Ind. Mach.	0.10 (.02)	0.07 (.02)	0.07 (.02)	0.05 (.00)
13. Electrical Dist.	-0.00 (.03)	0.09 (.04)	0.06 (.04)	0.04 (.00)
14. Communications	-0.15 (.06)	-0.13 (.07)	-0.27 (.07)	-0.07 (.02)
15. Oth. Electr. Equip.	0.11 (.02)	0.27 (.03)	0.29 (.03)	0.18 (.02)
16. Trucks and Buses	0.34 (.03)	0.35 (.03)	0.37 (.03)	0.27 (.00)
17. Autos	-0.20 (.04)	-0.04 (.03)	-0.02 (.04)	0.34 (.00)
18. Aircraft	0.06 (.03)	0.10 (.04)	0.13 (.04)	0.00 (.03)
19. Ships	-0.15 (.02)	0.01 (.02)	0.04 (.02)	-0.07 (.01)
20. Railroad Equipment	-0.65 (.07)	0.07 (.03)	-0.07 (.06)	-0.05 (.03)
21. Instruments	0.11 (.02)	0.05 (.02)	0.07 (.02)	0.04 (.01)
22. Other Equipment	0.18 (.04)	0.23 (.04)	0.24 (.05)	0.16 (.03)
POOLED	-0.11 (.06)	0.09 (.05)	-.0.01 (.05)	0.02 (.00)
Average $\bar{R}^2$	0.791	0.891	0.889	0.891

Sample is 1959-1994. Standard errors in parentheses. The dependent variable is the log of the equipment price minus the log of the GDP deflator. PM_i and PE_i are the logs of the industry-specific prices (relative to the GDP deflator) for all material inputs and energy inputs respectively. Regression in final column uses the aggregate PPIs for steel and oil. Each equation also includes an intercept, a time trend, GDP growth, and a Nixon price controls variable. The 22 equations were estimated jointly using SUR. Pooled coefficients were restricted to be the same across all equations.

equipment prices were high during the mid-1970s and early 1980s when tax credits were at their most generous and were low during the late 1980s and 1990s after the repeal of the ITC.

This explanation assigns most of the variation in equipment prices to aggregate phenomena such as the emergence of OPEC and other forces driving worldwide commodity prices in the 1970s and 1980s. In light of this, it is worth noting that Goolsbee's study did attempt to control for missing aggregate variables by adding year dummies and reported that this did not have much effect on the estimated effect of tax incentives. This result is still qualitatively true with this updated data set. Adding year dummies to the regressions without PM_{it} produces weaker estimates of the relationship between tax incentives and equipment prices, but many of the tax coefficients are still significant. Nevertheless, this finding does not invalidate the conclusion that intermediate input prices account for most of the variation in equipment prices. This is because year dummies cannot capture the effect that intermediate input prices have had on equipment prices. The size of the 1970s-1980s swings in relative equipment prices and in input costs differed markedly across different equipment categories.[8] So, the impact of intermediate input prices simply cannot be captured by an effect that is fixed across categories. And once one allows the input price effect to be accounted for, the regressions clearly point against a positive relationship between tax incentives and equipment prices.

5 Exogeneity of the Supply Shocks

I have implicitly assumed up to now that changes in the prices of the intermediate inputs used to produce equipment are true "supply shocks" that are independent of the tax treatment of equipment purchases. This assumption could be false. Assuming equipment demand is price sensitive, more generous investment tax incentives will raise demand for the materials used to produce equipment. And if equipment producers represented a sufficiently large fraction of the demand for their material inputs and the supply curve for these inputs were upward-sloping, then this increase in demand could raise the price of intermediate inputs. Indeed, it may be that through this "bottleneck" mechanism there is

[8] For example, while the timing of the swings in the relative prices of construction machinery and mining machinery are similar, the detrended relative price of the former increased 19 percent between 1974 and 1980 while the increase for the latter was 37 percent.

a significant crowding out of the positive demand effect of tax incentives.

The third and fourth columns of Tables 1 and 2 investigate whether this provides a possible explanation for our results by using narrower measures of intermediate input costs that are more obviously exogenous to the tax treatment of equipment. The regressions in the third column replace PM_{it}, the industry-specific intermediate input deflator, with PE_{it} an industry-specific energy cost deflator, also taken from the NBER productivity database. The regressions in the fourth column use the aggregate PPIs for energy and steel in place of industry-specific measures. Prices for energy and steel are largely determined by worldwide supply and demand conditions. Because the capital-equipment-producing sector has, on average, accounted for under 7 percent of U.S. GDP, it seems highly unlikely that demand created by tax incentives for equipment investment can have much effect on either energy or steel prices. These regressions still report significant coefficients for the new measures of intermediate input costs and confirm the results in the second column which imply that tax incentives do not have a significant positive effect on equipment prices.

Information on investment quantities also points against the demand-shock interpretation of input price movements. The correlation between tax incentives and input prices for equipment producers is largely driven by the common inverse-U-shaped pattern starting with the 1974-75 surge in materials prices. However, the behavior of investment quantities during this crucial period suggests the exact opposite of a demand-driven boom: After growing 18 percent in 1973, real equipment investment grew only 2 percent in 1974 and fell 10.5 percent in 1975, the largest decline in the period 1959-98 (and a much larger decline than in the deeper recession of the early 1980s). Clearly, these quantity movements are far more consistent with a negative supply shock.

6 Implications for the Equipment Supply Curve

Our results imply that investment tax incentives do not have a significant positive effect on equipment prices. As discussed above, there are two possible explanations for this result. One is that investment demand is not affected by tax incentives, so $\beta_d = 0$. The other is that the supply curve for equipment is approximately flat, so that β_s is large. One can show that our regressions suggest the latter interpretation. To see why, let us put a little more structure on the simple supply-and-demand model.

Simplify the demand curve to be

$$q^d = -\beta_d (\tau + p) \tag{5}$$

and assume that equipment is produced with materials as the only variable input according to production function $Q = M^\alpha$. Consider now two cases, both of which assume competitive markets in the sense that firms treat equipment prices as given, but one of which treats the number of firms N as given, implying a standard upward-sloping industry supply curve, while the other assumes the textbook case of perfect competition, in which the number of firms adjusts to keep economic profits at zero, implying a flat supply curve.

The marginal cost of producing equipment is $\frac{C}{\alpha} Q^{\frac{1}{\alpha}-1}$ where C is the cost of materials; each firm prices by setting marginal cost equal to price, implying $Q^S = N \left(\frac{\alpha P}{C}\right)^{\frac{\alpha}{1-\alpha}}$. Again using lower case letters to represent logs, the supply curve is

$$q^s = n + \frac{\alpha}{1-\alpha} (p - c + \alpha) \tag{6}$$

and the equilibrium price is

$$p = -\frac{(1-\alpha)}{\alpha + \beta_d (1-\alpha)} n - \frac{\beta_d (1-\alpha)}{\alpha + \beta (1-\alpha)} \tau + \frac{\alpha}{\alpha + \beta_d (1-\alpha)} (c - \alpha) \tag{7}$$

In the alternative case in which N adjusts to keep profits at zero, one can show that the price of equipment is

$$p = \log(\frac{F^{1-\alpha}}{\alpha^\alpha - \alpha}) + \alpha c \tag{8}$$

where F is the level of fixed costs.

The coefficients on tax incentives are zero in both the case where the supply curve is upward-sloping and $\beta_d = 0$ and the case where the supply curve is flat. However, what is different in these two cases is the coefficient on c. In the upward-sloping case, equation (7) tells us that $\beta_d = 0$ implies an elasticity of 1 with respect to materials costs or, more accurately, a coefficient equal to materials' share in total variable cost, here assumed to be 1. For our sample of 22 equipment-producing industries the average value for the ratio of intermediate input costs to total variable cost (defined as the sum of energy, material, and labor costs) is 0.68. In the flat-supply curve case, the elasticity with respect to materials costs will be α. Note that, when firms are price takers, $\frac{cM}{pQ} = \alpha$ is a first-order condition, implying that α can be observed as the ratio of materials costs to the value of output. In our sample, the average value for this ratio is 0.49. Finally, the average elasticity of equipment prices with respect to intermediate input prices, as estimated from pooled regressions that restrict the elasticity to be the same across all equations, is 0.47 in the tax term regression and 0.54 in the ITC regression, both with standard errors of 0.01. These estimates are much closer to the estimate implied by a flat supply curve than that implied by an upward-sloping curve.

So, the evidence favors the flat supply curve interpretation, implying a highly competitive market structure with free entry keeping economic profits low. Is this a credible conclusion? While the extreme assumptions of competition and free entry may not match reality, the market for capital equipment in the U.S. is extremely open to international trade compared to other markets, and this probably helps to keep prices near the level consistent with low levels of economic profits. Some recent evidence on this subject has been presented by Kevin Hassett and Glenn Hubbard (1998), who show that capital equipment prices in industrialized countries have tended to move together pretty closely.

7 Conclusion

The effect of tax incentives on capital investment is an important economic policy issue. In addition to macroeconomic issues, such as whether the investment tax credit is a useful cyclical tool, understanding the response of investment to tax incentives is crucial for assessing the likely long-run effects of tax reform proposals. Thus, the hypothesis of a steep upward-sloping supply curve for capital equipment, as proposed by Goolsbee, has profound implications for a number of policy debates. This paper has shown, however, that once supply shocks for equipment producers are controlled for, there is no evidence that tax incentives raise equipment prices. In fact, the evidence is broadly consistent with a flat supply curve for capital equipment. An important implication of a flat supply curve is that one can only identify the price elasticity of investment demand by examining quantity movements. Thus, the challenge appears to be the reconciliation of the macroeconomic evidence of a weak effect of tax incentives on investment quantities with microeconomic evidence such as that of Cummins, Hassett, and Hubbard (1994) which suggests a large effect.

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A Construction of the Full Tax Term

The full tax term was defined to be

$$\left[\frac{1 - ITC - (1 - \theta * ITC)\,\tau z}{1 - \tau}\right]$$

where τ is the marginal corporate tax rate, z is the present discounted value of depreciation allowances, ITC is the investment tax credit, and θ is the proportion of the investment tax credit that needs to be deducted from the depreciation base (this parameter was omitted in the text.)

Table 3 displays the investment tax credit for each type of equipment, taken from Gravelle (1994). The parameter θ was set equal to zero for all years apart from 1962 (for which it was set equal to 1) and the period 1982-86 (for which it was set to 0.5). The present discounted value of depreciation allowances was calculated based on the service life assumptions shown in Table 4, again largely taken from Gravelle. Prior to 1981, the income stream of depreciation allowances for each type of equipment was calculated based on the assumption that firms claimed allowances using the double declining balance method switching to the so-called "Sum of the Year's Digits" method. For 1981-86, the stream of allowances for each type of equipment was taken directly from IRS Publication 534, while the calculations for 1987-1994 were taken from IRS Publication 946. Present values of these depreciation allowances for each year's tax code were calculated using that year's value for the average interest rate on BAA-rated corporate bonds.

Equipment Class	59-61	62-68	69-70	71-73	74-80	81-86	87-97
1. Furniture	0	7	0	7	10	10	0
2. Fabricated Metals	0	7	0	7	10	10	0
3. Engines	0	5.1	0	5.6	10	10	0
4. Tractors	0	6	0	6	9	10	0
5. Agric. Machinery	0	7	0	7	10	10	0
6. Constr. Machinery	0	4.6	0	4.6	6.6	10	0
7. Mining Machinery	0	7	0	7	10	10	0
8. Metalworking Mach.	0	6	0	6	8.6	9.4	0
9. Special Ind. Mach.	0	7	0	7	10	10	0
10. General Ind. Mach.	0	6.4	0	6.4	9.1	9.6	0
11. Office & Computers	0	7	0	7	10	10	0
12. Service Ind. Mach.	0	7	0	7	10	10	0
13. Electrical Dist.	0	4.8	0	5.7	10	10	0
14. Communications	0	4.6	0	5.2	10	10	0
15. Oth. Electr. Equip.	0	7	0	7	10	10	0
16. Trucks and Buses	0	4.6	0	4.6	6.6	10	0
17. Autos	0	2.3	0	2.3	3.3	6	0
18. Aircraft	0	7	0	7	10	10	0
19. Ships	0	7	0	7	10	10	0
20. Railroad Equipment	0	7	0	7	10	10	0
21. Instruments	0	7	0	7	10	10	0
22. Other Equipment	0	7	0	7	10	10	0

Table 3: Investment Tax Credit Rates

Equipment Class	59-61	62-70	71-80	81-86	87-97
1. Furniture	14	10	8	5	7
2. Fabricated Metals	25	18	14	5	7
3. Engines	29	22	18	5	7
4. Tractors	12	9	7	5	5
5. Agric. Machinery	14	10	8	5	7
6. Constr. Machinery	10	7	5	5	5
7. Mining Machinery	16	11	9	5	5
8. Metalworking Mach.	14	9	8	5	7
9. Special Ind. Mach.	16	11	9	5	7
10. General Ind. Mach.	14	12	10	5	7
11. Office & Computers	10	7	7	5	7
12. Service Ind. Mach.	17	12	10	5	7
13. Electrical Dist.	22	17	14	5	7
14. Communications	19	14	12	5	5
15. Oth. Electr. Equip.	16	11	9	5	7
16. Trucks and Buses	10	7	5	5	5
17. Autos	4	3	3	3	5
18. Aircraft	16	12	9	5	5
19. Ships	28	20	16	5	10
20. Railroad Equipment	26	19	15	5	7
21. Instruments	18	13	10	5	7
22. Other Equipment	15	11	9	5	7

Table 4: Tax Service Lives

B SIC Codes for Equipment Producers

Equipment Class	SIC Codes
1. Furniture	25
2. Fabricated Metals	34
3. Engines	351
4. Tractors	3537
5. Agric. Machinery	352
6. Constr. Machinery	353 ex. 3537, 3532-3
7. Mining Machinery	3532-3
8. Metalworking Mach.	354
9. Special Ind. Mach.	355
10. General Ind. Mach.	356
11. Office & Computers	357
12. Service Ind. Mach.	358
13. Electrical Dist.	361
14. Communications	366
15. Oth. Electr. Equip.	36 ex. 361, 366
16. Trucks and Buses	3711
17. Autos	3711
18. Aircraft	372
19. Ships	373
20. Railroad Equipment	374
21. Instruments	38
22. Other Equipment	359

Not all of the equipment classes could be exactly matched up with an SIC code and so a couple of these matches are based on informed guesses. A full description of what types of equipment are covered by each category is contained in Appendix E of Benchmark Input-Output Accounts of the United States, 1992, available at http://www.bea.doc.gov/bea/an1.htm.

Figure 1A

Detrended Relative Equipment Prices and the ITC

Dashed Line is the ITC (Scale on Left Axis)

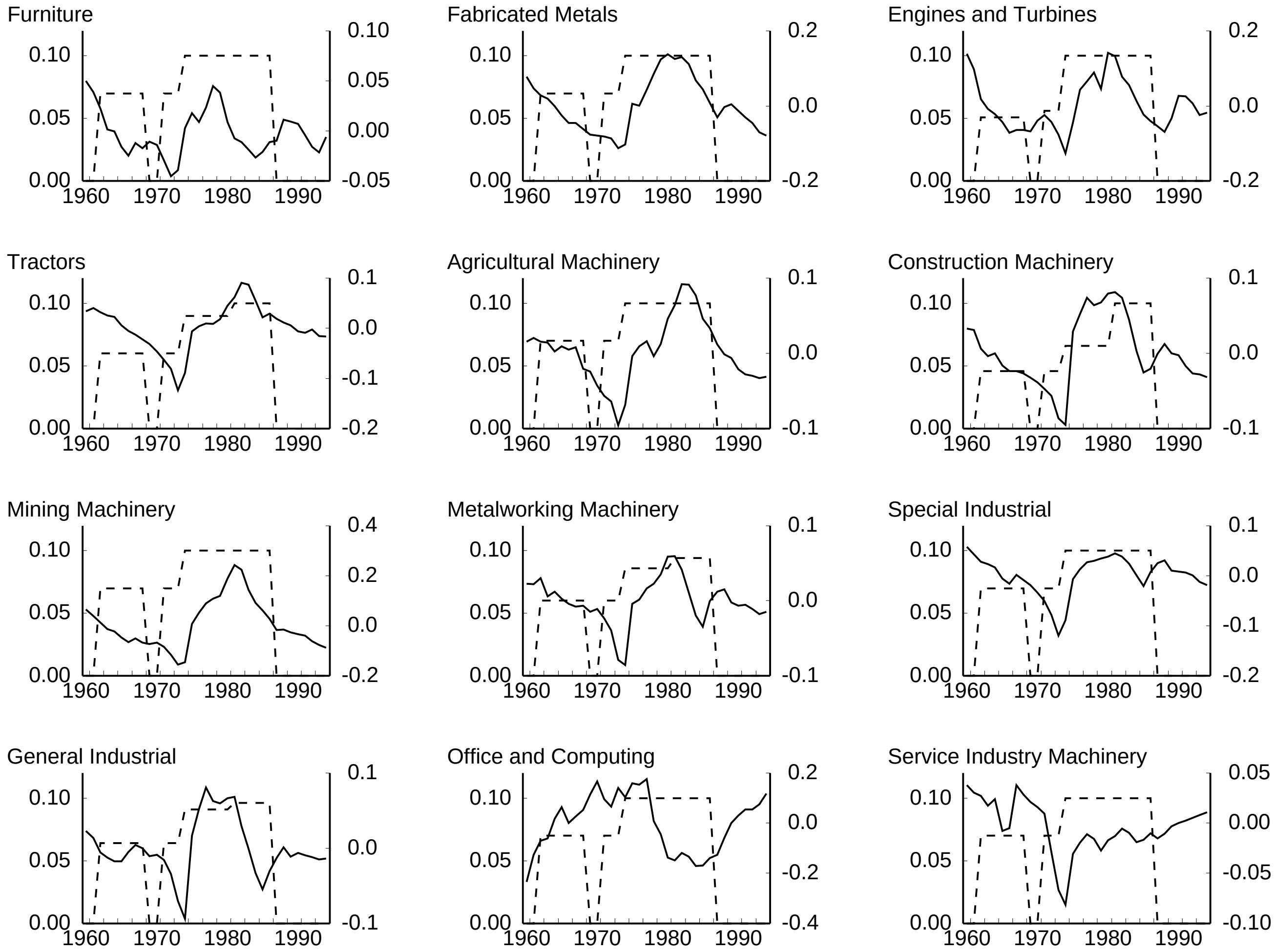

Figure 1B

Detrended Relative Equipment Prices and the ITC

Dashed Line is the ITC (Scale on Left Axis)

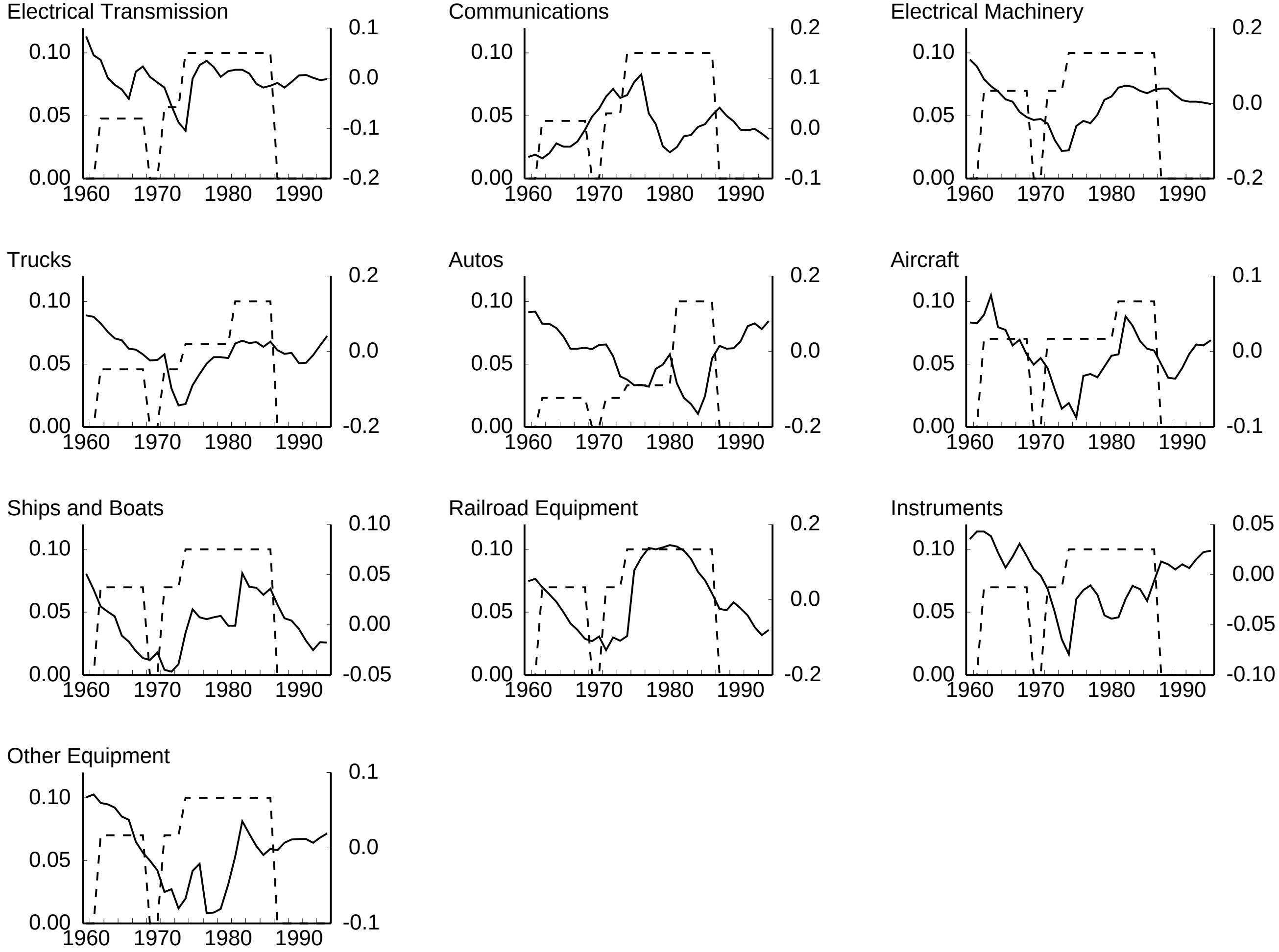

Figure 2A
Detrended Relative Prices for Equipment and Intermediate Inputs
Dashed Line is the Detrended Relative Price for Intermediate Inputs (Scale on Left Axis)

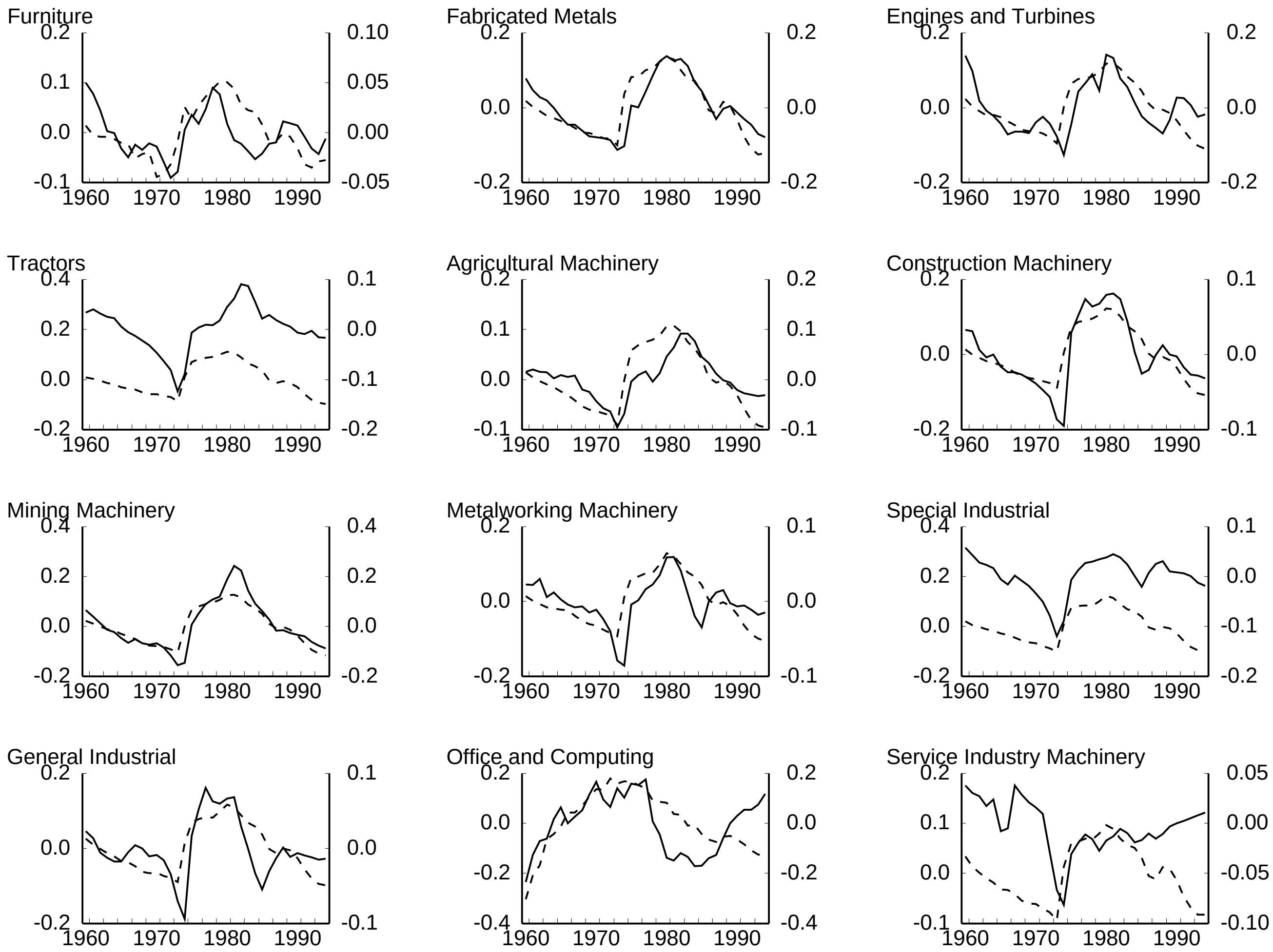

Figure 2B

Detrended Relative Prices for Equipment and Intermediate Inputs

Dashed Line is the Detrended Relative Price for Intermediate Inputs (Scale on Left Axis)