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INVESTMENT BEHAVIOR OF U.S. FIRMS OVER HETEROGENEOUS CAPITAL GOODS: A SNAPSHOT

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Previous research has shown that the composition of investment and capital can matter for investment dynamics and productivity. However, very little is known about the composition of investment at the micro level. The goal of this note is to help fill this knowledge gap by assessing the nature of the cross-firm variation in investment composition using micro data from the 1998 Annual Capital Expenditure Survey (ACES), a sample of roughly 30,000 firms drawn from the private, nonfarm economy. The data reveal substantial variation that can be characterized by heterogeneous lumpiness of investment in the asset-type dimension. The data also show that some of the variation in investment composition is due to the state of firms' total investment; specifically, computers account for a significantly larger share of firms' incremental investment than of lumpy investment.

1. INTRODUCTION

Recent research has shown that the composition of investment can be vital to understanding investment dynamics over the business cycle (Tevlin and Whelan, 2003) as well as capital's role in explaining productivity differences (Caselli and Wilson, 2004; Wilson, forthcoming).[1] Yet, very little is known about the composition of investment at the micro level. Economists' priors to date have been based primarily on economy-wide or industry-level capital flows information.

Inferences regarding investment composition based on aggregate data may be limited or inaccurate, however. They may be limited because aggregate data can say little about the extent and nature of microeconomic heterogeneity in investment composition. They may be inaccurate for a couple of reasons. First, there is no reason to expect the capital flows patterns of individual firms to be similar to those at the aggregate level. This is particularly true in light of the growing body of evidence regarding heterogeneity at the micro level in terms of total-factor productivity, employment, and total investment (Caballero *et al.*, 1995; Davis *et al.*, 1996; Haltiwanger, 1997). Numerous studies have shown that aggregate measures, even those built up from microeconomic data, often mask important

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[1]The composition of investment is also crucially important for predicting the effects of certain tax incentives, such as bonus or accelerated depreciation allowances (see House and Shapiro, forthcoming).

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variations in the measures at the micro level. For example, investment at the aggregate level is fairly smooth over time despite enormous lumpiness at the micro level (Caballero *et al.*, 1995; Doms and Dunne, 1998). Second, industry-level capital flows data, at least in the U.S., currently are not based on micro source data. The U.S. capital flows tables, constructed by the Bureau of Economic Analysis (BEA), are instead primarily based on occupational employment distributions combined with data on the aggregate supply of asset-specific capital and aggregate investment by industry.[2]

Given this dearth of knowledge regarding micro-level investment composition, and in light of the growing body of evidence pointing to the importance of investment composition for investment dynamics and productivity, this note aims to empirically assess the nature of the cross-firm variation in investment composition using micro data from the 1998 Annual Capital Expenditure Survey (ACES). The ACES is a representative sample of roughly 30,000 firms drawn from the private, nonfarm economy.

These data reveal substantial firm heterogeneity in investment composition, even within narrowly-defined industries. This heterogeneity is characterized by heterogeneous lumpiness of investment in the asset-type dimension. That is, firm investment tends to be limited to a very small number of capital types, but which types these are varies greatly across firms. An important exception, however, is computers, for which investment is extensive. For all other capital types, investment is in fact a rare phenomenon, with far less that half of firms investing in a given year. Thus, similar to how the smoothness of aggregate investment dynamics has been shown to mask tremendous lumpiness in micro investment dynamics (Caballero *et al.*, 1995; Doms and Dunne, 1998), I find that firm-level investment is far lumpier, or more concentrated, across asset types than one might infer based on industry or aggregate investment-by-type data.

Finally, though the cross-sectional nature of the ACES data do not allow one to assess how the composition of investment varies within a firm over time, we can get some indirect sense of this by comparing the investment compositions of firms stratified according to whether they currently are in an incremental or lumpy investment episode (based on total investment). Previous research has shown that within-firm investment over long periods of time tends to be lumped into single-year spikes (Doms and Dunne, 1998). Thus, by stratifying firms into two investment states—incremental or spike—we can assess whether the composition of investment differs importantly according to the investment state of the firm. The data show that, for most capital goods, firm investment occurring during investment spikes represents a similar share of total investment as it does during periods of incremental investment. Again, however, computers are found to be an exception: computers account for a significantly larger share of firm investment during incremental investment periods than during spikes. Given that computers represent a third of the average firm's total investment, this suggests that capital composition and quality may have significant cyclical variation. For instance, if capital quality tends to be higher for incremental investment, and incremental

[2]See Becker *et al.* (2006) for a discussion of these BEA data and a comparison to potential alternative capital flows tables based on the 1998 ACES.

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investment is a lower share of aggregate investment during booms, then the volatility of quality-adjusted capital over the cycle may be less than previously thought.

2. Data

The principal source of data for this note is the 1998 Annual Capital Expenditures Survey (ACES).[3] The ACES is conducted annually by the U.S. Census Bureau to elicit information on capital expenditures by U.S. private, nonfarm companies. The annual ACES data are used by the BEA in constructing the National Income and Product Accounts (NIPA).

In typical years, the ACES queries companies on their expenditures on total equipment and total structures, in addition to related values such as book value of capital assets, accumulated depreciation, retirements, etc. In the 1998 survey, however, the ACES additionally required firms to report their investment broken down by 55 separate types of capital—26 types of equipment and 29 types of structures. These data on disaggregate investment allow one to observe the complete composition of a firm's investment.

The 1998 ACES sampling frame consists of all U.S. private, nonfarm employers.[4] All companies with 500 or more employees were surveyed while smaller employers were surveyed based on a stratified random sampling such that larger firms were sampled with a higher probability. Response to the ACES is legally required, so response rates are extremely high. The final sample consists of 33,818 firms, of which approximately half have 500 or more employees.

3. Results

3.1. *Firm Heterogeneity in Investment Composition*

Column (1) of Table 1 shows, for each asset type, its mean share of total firm investment. These means are computed using inverse-sampling-probability weights, thus one can think of these mean shares as investment shares for an average or representative U.S. firm. Looking at these mean investment shares, one gets the impression that investment dollars tend to be spread across a rather wide range of capital assets. The largest share is for computers, which average about a quarter of firm investment. Autos represent the second largest share at about 10 percent. The remainder of average firm investment appears to be distributed more or less evenly across a wide array of assets.

This aggregate investment composition, however, turns out to provide a very misleading impression of the typical firm's investment composition. A closer look at the data reveals a far lumpier, or more concentrated, distribution for the typical firm. The average number of equipment types purchased by companies in the full ACES sample of 33,818 firms is just 2.19 and the average of structures types purchased is just 0.47. As can be seen in Figure 1, this high level of concentration

[3]For more details regarding the 1998 Annual Capital Expenditures Survey, including the published aggregate data and the actual survey questionnaires, see Census Bureau (2000).

[4]In addition, a sample of companies with zero employees were sent an abbreviated questionnaire which did not request the disaggregate investment detail.

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TABLE 1

Investment Characteristics by Asset Type

Type	Description	Share of Total Investment		% of Sample with Positive Investment in that Type	Fraction of Investment-Share Variance Explained by Industry Effects
		Weighted Mean (1)	Std. Deviation (2)	(3)	(4)
311	Computer and Peripheral Equipment	0.262	0.341	45.4%	0.283
331	Cars and Light Trucks	0.104	0.248	19.6%	0.271
351	Furniture and Related Products	0.065	0.192	25.3%	0.232
141	Office, Bank, and Professional Buildings	0.063	0.151	12.3%	0.592
312	Office Equipment Except Computers and Peripherals	0.051	0.171	19.9%	0.106
131	Manufacturing, Processing, and Assembly Plants	0.043	0.143	10.1%	0.412
324	General Purpose Machinery[1]	0.042	0.161	12.9%	0.185
152	Stores—Food Related	0.040	0.137	2.5%	0.514
155	Other Commercial Stores/Buildings, NEC	0.037	0.136	1.4%	0.539
323	Special Industrial Machinery	0.037	0.156	13.2%	0.311
315	Medical Equipment and Supplies	0.035	0.157	6.5%	0.248
313	Communications, Audio, and Video Equipment	0.030	0.127	17.3%	0.381
334	Other Transportation Equipment	0.025	0.127	6.4%	0.346
354	Service Industry Equipment	0.025	0.133	4.8%	0.426
154	Warehouses and Distribution Centers (except Passenger)	0.022	0.097	3.6%	0.511
111	Residential Structures	0.022	0.114	1.1%	0.6446
332	Heavy Duty Trucks	0.021	0.121	4.7%	0.441
353	Construction Machinery	0.021	0.124	2.9%	0.378
322	Metalworking Machinery	0.020	0.118	5.0%	0.244
151	Automotive Facilities	0.019	0.100	1.0%	0.287
162	Special Care Facilities	0.019	0.096	1.9%	0.2851
171	Amusement and Recreational Facilities	0.015	0.084	0.9%	0.549
355	Other Miscellaneous Equipment	0.014	0.100	4.3%	0.296
361	Artwork, Books, and Other Equipment, NEC	0.014	0.097	4.8%	0.298
201	Preschool, Primary/Secondary, and Higher Education Facilities	0.014	0.092	0.6%	0.560
352	Agricultural Equipment	0.011	0.090	1.6%	0.438
121	Hotels, Motels, and Inns	0.010	0.078	0.6%	0.6922
153	Multi-Retail Stores	0.008	0.061	1.5%	0.438

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343	Electrical Equipment, NEC	0.008	0.078	2.5%	0.286
321	Fabricated Metal Products	0.007	0.067	3.2%	0.170
316	Capitalized Software Purchased Separately	0.006	0.051	11.1%	0.126
314	Navigational, Measuring, Electromedical, and Control Instruments	0.006	0.063	3.2%	0.301
192	Electric, Nuclear, and Other Power Facilities	0.005	0.059	0.9%	0.560
223	Other Non-building Structures, NEC	0.005	0.049	1.4%	0.2998
161	Hospitals	0.005	0.045	2.2%	0.533
191	Telecommunication Facilities	0.004	0.047	0.5%	0.492
112	Manufactured (Mobile) Homes	0.004	0.048	0.1%	0.6706
142	Medical Offices	0.004	0.039	1.5%	0.2375
202	Special School and Other Educational Facilities	0.002	0.038	0.2%	0.500
181	Air, Land, and Water Transportation Facilities	0.002	0.027	1.0%	0.0712
344	Mining and Oil and Gas Field Machinery and Equipment	0.002	0.036	1.0%	0.421
212	Petroleum and Natural Gas Wells	0.001	0.027	0.2%	0.511
342	Electrical Transmission and Distribution Equipment	0.001	0.021	1.6%	0.481
222	Highway and Street Structures	0.001	0.020	0.4%	0.550
193	Water Supply, Sewage, and Waste Disposal Facilities	0.001	0.019	0.5%	0.6532
333	Aerospace Products and Parts	0.001	0.021	1.2%	0.564
213	Other Mining and Well Construction	0.001	0.018	0.2%	0.534
341	Engine, Turbine, and Power Transmission Equipment	0.001	0.017	0.7%	0.407
132	Industrial Nonbuilding Structures	<0.001	0.013	0.4%	0.635
203	Religious Buildings	<0.001	0.010	0.1%	0.2614
221	Conservation and Control Structures	<0.001	0.003	0.1%	0.620
204	Public Safety Buildings	<0.001	0.005	–	0.9408
211	Mine Shafts	<0.001	0.004	0.0%	0.402
345	Floating Oil and Gas Drilling and Production Platforms	<0.001	0.002	0.1%	0.678
346	Nuclear Fuel	<0.001	0.001	0.1%	–

Notes: Total number of sample firms is 33,818. Weights used in means are inverse sampling probabilities.
[1]The full name of this category is "Ventilation, Heating, Air-Conditioning, Commercial Refrigeration, and Other General Purpose Machinery".

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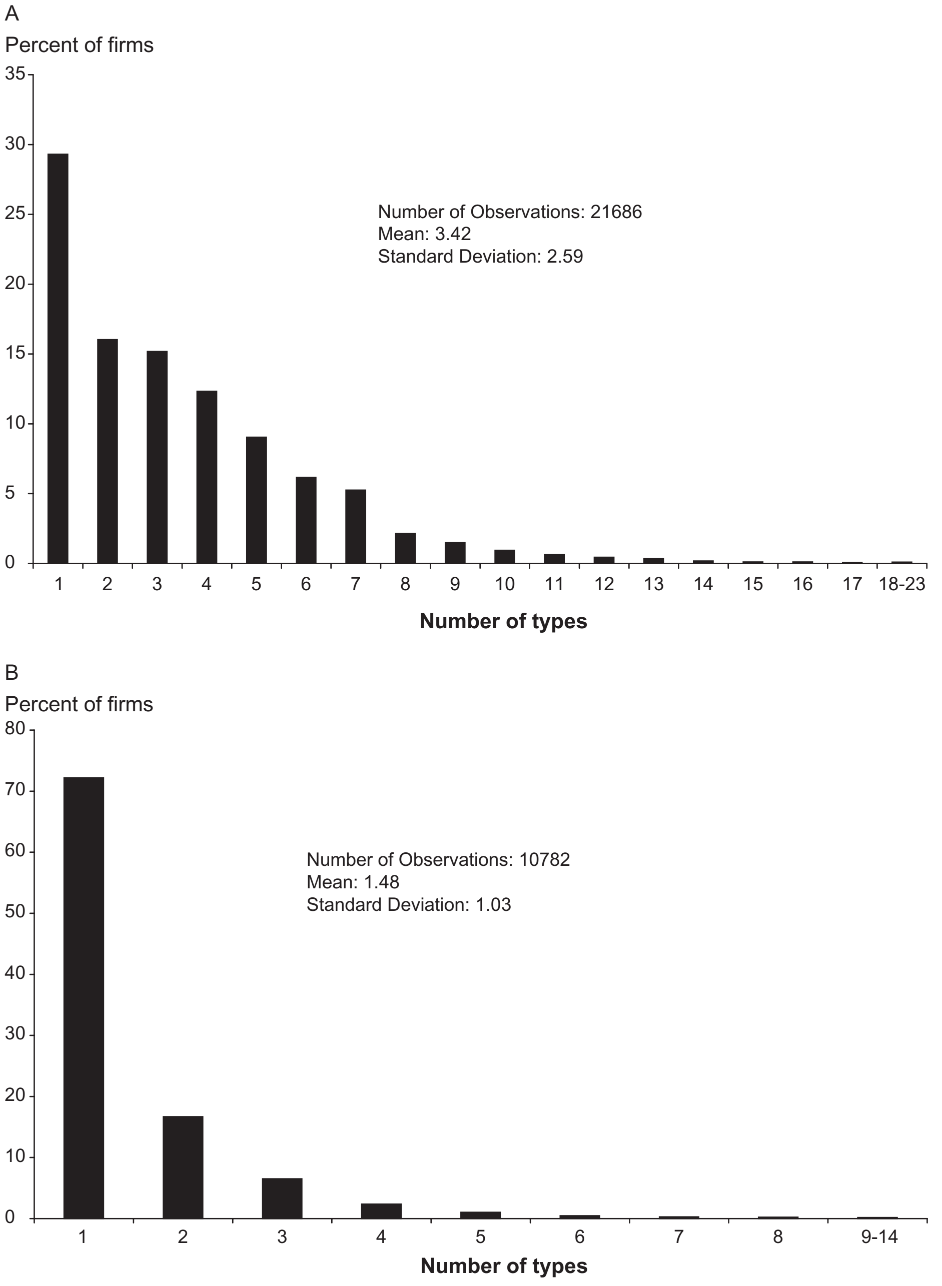

Figure 1. A. Distribution of Number of Equipment Types for which a Firm has Non-Zero Investment
B. Distribution of Number of Structure Types for which a Firm has Non-Zero Investment

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can be seen even within the subsample of firms with non-zero total investment. Panel A of Figure 1 shows the distribution of equipment-purchasing firms according to how many types of equipment they bought. Panel B shows the analogous distribution for structures-purchasing firms. One can see that, even after conditioning on positive equipment investment, the average firm invests in fewer than four types of equipment. In fact, 61 percent of equipment-purchasing firms invest in three or fewer types of equipment and 30 percent invest in just one type. Not surprisingly, the concentration is even greater for structures; 72 percent of structures-purchasing firms invested in just one type of structure.

Combining the fact that firm level investment tends to be concentrated in a very small number of capital types with the fact that aggregate investment is spread across a wide range of capital types clearly implies that there is a great deal of heterogeneity across firms in terms of which asset type or types the firm invests in. This can be seen most clearly by looking at the proportion of firms in the full ACES sample that invested in any given asset type, which is shown in Column (3) of Table 1. Not a single asset type was purchased by more than half of firms. The most commonly purchased asset type was Computers: 45 percent of sample firms invested in computers (55 percent of firms with positive total investment). For all other types, the proportion was 25 percent or less.

In addition to the high degree of heterogeneity in terms of which capital goods companies buy, there also is tremendous heterogeneity in how much they buy, conditional on buying. This can be seen, for any given asset type, by looking at the standard deviation in that type's share of firm investment among those firms that invested in that type. These standard deviations (along with the means) are shown in Table 1. For every single asset type, the standard deviation is greater than the mean; in most cases, it is several times greater.

Of course, one response to the high degree of firm heterogeneity in investment composition is that it simply reflects industry differences. In fact, industry does appear to explain much of the heterogeneity in composition of structures investment. However, industry turns out to explain very little of the heterogeneity in investment shares for equipment types. Column (4) of Table 1 shows, for each capital type, the fraction of the cross-firm variance in that type's investment share explained by 3-digit industry effects (i.e. the R^2 from regressing the type's investment share on a set of 3-digit industry dummies). Of the 29 types of equipment, this fraction is more than half for only two (Aerospace Products and Parts, and Floating Oil and Gas Drilling Platforms). Not surprisingly, this fraction is especially low for goods generally thought to be general purpose technologies, such as Computers ($R^2 = 0.28$) and Software ($R^2 = 0.13$).

3.2. *The Composition of Spikes versus Incremental Investment*

So far I have documented that there is a great deal of between-firm (within industry) heterogeneity in investment composition. One also can get a sense for how composition varies within a firm over time by comparing the investment compositions of firms stratified according to whether they currently are in an incremental or lumpy investment episode (based on total investment). Previous research has shown that the typical micro investment profile is characterized by

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periodic single-year spikes of investment preceded and followed by many consecutive years of low rates of investment (Doms and Dunne, 1998). Moreover, these investment cycles tend to be asynchronous across businesses. Thus, by stratifying firms into two investment states—incremental or spike—in our sample year, 1998, one can assess whether the composition of investment differs importantly according to the investment state of the firm, a key aspect of within-firm investment dynamics (see, e.g. Caballero and Engel, 1999).

To assess whether the composition of investment spikes is fundamentally different from that of incremental investment, I start with the firm-level investment share for each asset type. I then split the sample into firms that engaged in an investment spike (in terms of total investment) in 1998 and those that did not. Lastly, I compute the weighted-average investment share by type for each subsample (weighting each firm by its total investment) and perform a two-sample equality-of-the-means t-test.

The most common definition of an investment spike used in the literature (e.g. Doms and Dunne, 1998; Power, 1998), and thus the definition I use, is the following:

$$Spike_{it} = 1 \text{ if } I_{it}/K_{i,t-1} > 0.20,$$

$$Spike_{it} = 0 \text{ otherwise},$$

where i indexes firms, I_{it} denotes total investment, and $K_{i,t-1}$ denotes total beginning-of-year book value of capital.[5]

For most types, the mean investment share does not differ importantly between the two samples. A notable exception, however, is Computer investment: Computers comprise 14 percent of incremental investment, on average, versus 12 percent of investment spikes.[6] This difference is statistically significant at below the 1 percent level. Note this result is robust to controlling for 3-digit SIC industry (by demeaning investment shares by industry mean prior to computing the group means).

That computers represent a larger share of investment in periods of incremental investment could be because firms are locked into particular production processes that require a stable level of computer capital stock, making computer investment less cyclical than other types of capital.[7] Regardless of the explanation, the result has at least two implications. At the aggregate level, given that invest-

[5]For the sample used in this note, t is of course 1998. Note that though the data are for 1998 only, $K_{i,t-1} = K_{i,1997}$ is observed since beginning-of-year book value of capital is reported.

[6]Note these mean shares are lower than the mean Computers investment share reported in Table 1 because these means use total investment to weight firms. Larger firms invest less intensively in Computers, so these weighted-means are lower than the representative-sample mean in Table 1.

[7]Another possible explanation, suggested by a referee, is correlation between computer investment and measurement error in $K_{i,t-1}$. Because of declines in computer prices, book value measures of capital stock, which cumulate past investment at historical costs net of depreciation, may overstate true capital stock, and thus understate I/K, for firms with high computer investment. However, measurement error is likely to be a minor explanation for two reasons. First, computer price declines are largely captured by the depreciation schedules used by firms to measure book value. Second, similar price declines have occurred for software and communications equipment, and yet only computers have a different investment share during spikes.

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ment spikes are far more common during business cycle booms than during troughs, this result suggests that computers' share of the aggregate capital stock is countercyclical. Computers' share of capital has been shown to be important for understanding aggregate investment behavior since computer investment may be more sensitive to the user cost of capital (see Tevlin and Whelan, 2003). Another implication is that, given that computer investment likely embodies more technology per dollar than other types of investment (see Wilson (forthcoming) for evidence of this), investment in constant-quality units may actually be less lumpy at the micro level than previously thought.

4. Conclusion

The goal of this note was to characterize the composition of investment for the typical firm and assess the degree of heterogeneity in composition across firms using the micro data from a large-scale survey of U.S. firms in 1998. The data reveal substantial variation that can be characterized by heterogeneous lumpiness of investment in the asset-type dimension. The data also show that some of the variation in investment composition is due to the state of firms' total investment.

These findings have important implications in terms of the economic modeling of production, investment dynamics, and optimal public policy. Most economic models of production or investment assume a single capital stock, or perhaps one for equipment and one for structures. The finding in this note that the composition of capital varies greatly across firms suggests that these models may be misspecified, especially in light of recent research showing that the composition of capital is an important factor in production.[8] As our economic models evolve to incorporate the effects of capital composition, a solid understanding of the patterns of disaggregate investment at the micro level will be key.

In terms of investment dynamics, it is well known that much investment at the micro level takes place in spikes rather than smooth incremental investment. A number of macroeconomic models build on this micro evidence to explain aggregate investment dynamics (e.g. Caballero and Engel, 1999). It generally is assumed that the investment occurring in spikes and the investment occurring in incremental periods are of the same qualitative nature. In particular, it is assumed that there is no difference in quality, i.e. the capital-embodied technology, between lumpy and incremental investment. The finding that computers' share of investment during investment spikes is significantly lower than their share of incremental investment, however, suggests the true (i.e. quality-adjusted) lumpiness of investment could in fact be much different than is currently assumed.

Lastly, the findings in this note may have implications for public policy, particularly tax policy. For instance, policymakers in the U.S. often enact special accelerated depreciation allowances for certain capital types (e.g. high-tech equipment) as temporary measures aimed at spurring an economic recovery (see, e.g. House and Shapiro, forthcoming). Because the composition of investment varies greatly across firms and industries, these special allowances will benefit certain

[8]See, e.g. Cummins and Dey (1998), Jorgenson and Stiroh (2000), Caselli and Wilson (2004), and Wilson (forthcoming).

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firms and industries more so than others. The non-uniform incidence of these allowances likely is not fully appreciated by policymakers. Furthermore, if high-tech equipment comprises a larger share of investment during recessions (when incremental investment is predominant), then targeting this type of equipment with special allowances may in fact be optimal.

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