Capital Churning

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Abstract

This paper investigates gross flows of capital across firms. Using Compustat data, we construct measures of additions to and subtractions from capital on a firm-level basis. We then study the behavior of these flows over 37 years. We find that the gross flows of capital are large and are comparable to the gross flows of jobs. There was a significant increase in capital reallocation across firms and industries during the 1980s and 1990s. Moreover, capital reallocation appears to have economic consequences. Panel regressions across industries indicate that capital reallocation across firms leads to higher employment growth.

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1 Introduction

Most studies of the capital market focus on the stock demand for capital or on net investment. With a few notable exceptions, these studies assume the only declines in firm-level capital are from a fixed physical decay of capital.[1] Moreover, the distinction between whether the newly installed capital is new or used is typically suppressed. Of course, at the aggregate level, this distinction is absent. But just as net employment changes mask the large gross flows of workers in the labor market, the net change in the capital stock may disguise substantial flows of capital into and out of firms. Caballero, Engel and Haltiwanger (1995) construct separate measures of new equipment purchases and retirements using data from the LRD. They do not, however, study the gross flows separately; they only use them to form net rates of investment.

We seek to investigate the potential importance of gross capital flows in determining capital accumulation and employment and productivity patterns. Using Compustat data, we construct measures of additions to and subtractions from capital on a firm-level basis. We then study the behavior of these flows at various levels of aggregation, from the individual firm to the aggregate level. Our study of capital churning and reallocation is inspired by the work of Blanchard and Diamond (1989, 1990), Davis and Haltiwanger (1992) and Davis, Haltiwanger, and Schuh (1996). Just as their studies demonstrate how analyzing gross flows of workers leads to a deeper understanding of employment fluctuations, we show how studying gross flows of capital can shed light on capital accumulation as well as on fluctuations in other quantities, such as employment and productivity. In fact, we will suggest that there are important links between worker flows and capital flows.

The newly constructed data reveal some intriguing preliminary results. As we suspected, the net changes in capital hide large gross flows of capital. We find that the magnitude of the gross flows of capital are comparable to the gross flows of jobs. The data also suggest substantial temporal variation in the amount of "capital reallocation" – periods of simultaneously high capital addition and subtraction rates. While the rate of addition by firms during the 1980s and 1990s is comparable to the 1960s and 1970s, the rate of subtraction in the latter two decades is substantially higher. We also show that reallocation of capital across firms become substantially more important during the latter two decades.

Finally, panel regressions across two-digit manufacturing industries investigate the relationship between employment growth and gross flows. Net changes in capital have the predicted positive effect on employment growth. In addition, capital reallocation has positive employment effects, but within-firm capital churning has negative employment effects.

2 Determinants of Investment and Disinvestment

We begin by discussing the various motives that drive firms to accumulate or decumulate capital. It is important to note at the outset that any fluctuations in the firm's desired capital stock that are believed to be fairly temporary will typically not involve adjustments in the capital stock. As the literature on costly reversibility points out, firms will tend to have fairly wide bands of inaction for investment and disinvestment because of the costs imposed by reversing the decisions (Dixit and Pindyck (1994), Abel and Eberly (1994)). In the case of transitory fluctuations, firms tend to respond by varying their capital utilization rates.

[1] Some of the notable exceptions include Feldstein and Foot (1971), Cockburn and Frank (1992), Das (1992), Cooper and Haltiwanger (1993), Cooper, Haltiwanger and Power (1995), Caballero, Engel and Haltiwanger (1995), Abel and Eberly (1996), and Goolsbe and Gross (1997).

Firms will only change their capital stock when they expect a long-lasting change in their situation.

With this point in mind, let us consider the various reasons a firm might add to or subtract from its capital stock. Table 1 gives a categorization of the various motives and manners of changing the capital stock at the firm level. The motives presented in the table are not primary motives per se, but rather desired changes driven by underlying shocks, such as changes in product demand, investment tax credits, technological progress, etc. As the table shows, several situations tend to involve mostly additions or mostly subtractions, whereas others involve both additions and subtractions from capital. For example, the standard case of a capacity expansion or contraction typically involves either subtractions or additions, but not significant amounts of both. On the other hand, any motives connected to the heterogeneity of capital, such as vintage effects or the sectoral heterogeneity of capital, typically involve both additions and subtractions of capital.

We can make inferences about the motives behind the capital changes by studying the covariance of flows of capital into and out of the firm. Suppose, for example, that we observe a high rate of investment and a low rate of disinvestment, or vice versa. This inverse relationship corresponds to the canonical model of homogeneous capital, in which a firm's only decision is whether to increase or decrease its capital stock.

Suppose, on the other hand, we observe simultaneously high rates of investment and disinvestment. This situation should only occur if there is significant heterogeneity of capital. As shown in Table 1, a firm might undertake simultaneously high rates of investment and disinvestment if it is replacing old technology with new technology or if it is changing the sectoral mix of the products it produces, through horizontal or vertical integration. This type of expansion often takes the form of a merger or acquisition.

At this point, it is useful to discuss the economic consequences of mergers. Our case studies of some of the firms involved in mergers suggest that mergers involve more than a simple change in ownership. In fact, mergers and acquisitions are frequently used as a mechanism for changing the composition of the capital stock. Consider for example Dole Food Company, which had high rates of investment and disinvestment in the mid- 1980s. During that period, Dole merged with Flexi-Van, a container-leasing company, which added a fleet of ships to transport Dole produce. At the same time, though, Dole discontinued several lines of its fruit production operations. Thus, the merger and the accompanying high rates of investment and disinvestment were used to restructure the capital stock and the types of products Dole produced.

The firm-level analysis can also be extended to a more aggregate level. High rates of investment and disinvestment at the aggregate level suggests a substantial amount of capital reallocation and replacement. Low rates of disinvestment and high rates of investment indicate general expansion of firms.

3 Data

The basic source of data is firm-level data from the 1996 Full-Coverage Compustat tapes. While Compustat has some disadvantages to be discussed below, we consider it to be more suitable for our purposes than other sources such as the Longitudinal Research Database because it covers a longer time period and is not limited to manufacturing. The initial data base has 232,417 observations, extending from 1958 to 1996, and covering 19,508 firms.

The typical study of firm-level investment behavior follows very strict sample selection rules, deleting any firms involved in mergers, with large additions or subtractions from capital, or any other suspicious activity. If we followed this procedure, we would eliminate much of the phenomenon we wish to study. Therefore, we try to keep as many observations as possible in our sample. There are some instances, though, when we are forced to drop firms or observations. As the calculation of the vintage structure of capital for each firm is an important part of data construction, we cannot use firms with missing values for capital. Thus, there were several cases in which we had to drop firms because of missing observations. We also dropped firms we believed to be duplicates. The data appendix provides details on our sample selection procedure. After all deletions, we are left with 184,549 observations and 16,653 firms.

Our goal is to construct series on the current dollar capital stock and flows of capital into and out of firms. To do this, we begin by constructing gross historical cost, or book value, stocks and flows, and then deflate them with an appropriate deflator, based on the vintage history of the firm.

Construction of Historical Cost Stocks and Flows

Let us begin by discussing our construction of historical cost gross stocks and flows. Consider the following identity from Compustat's Schedule V variables:

(1) $$\text{Kend}_{it} = \text{Kbeg}_{it} + \text{Expenditures}_{it} - \text{Retirements}_{it} + \text{Other}_{it} + \varepsilon_{it} ,$$

Kend = Ending balance of gross book value of property, plant and equipment (Compustat variable V187)

Kbeg = Beginning balance of gross book value of property, plant and equipment (V182)

Expenditures = Capital expenditures (V30)

Retirements = Retirements (V184)

Other = Other changes in property, plant and equipment not elsewhere classified (V185)

ε = discrepancy (not a Compustat variable)

t indexes the year, and i indexes the firm

The computation of historical cost stocks and flows is simple when all of the variables in equation (1) are available. In this case, we set the historical cost capital stock to be equal to end of period capital (v187). We then define flows of capital into the firm, or "additions," and flows of capital out of the firm, or "subtractions" as:

(2a) $ADD_{it} = Expenditures_{it} + \max(0, Other_{it}) + \max(0, \varepsilon_{it})$ Firm-level additions to capital

(2b) $SUB_{it} = Retirements_{it} + \max(0, -Other_{it}) + \max(0, -\varepsilon_{it})$ Firm-level subtractions from capital

At this point, it is useful to pause to compare our definitions of capital flows to Davis and Haltiwanger's definitions of jobs flows. Davis and Haltiwanger define job creation as the *net* change in employment at expanding establishments and job destruction as the *net* change in employment at contracting establishments. Although we are working at a more aggregate level (firms instead of establishments), our data allow us to construct gross flows for the most part within our unit of analysis. The only case when some of the gross flows might be netted out is when they are combined together in "other" and "ε."

Let us now discuss five complications that arise in the construction of these additions and subtractions of capital, and how we deal with them. The first complication is data availability. Either ending period property, plant and equipment from Schedule V (v187) or an alternative measure, v7, is available for most firms for most years. Capital expenditures (v30) are also widely available. On the other hand, retirements (v184) and other changes (v185) do not become regularly available until 1969. When one or more of the flows is missing, we construct the identity so that those components become part of ε, and we construct ADD and SUB as in equation (2) above.

To ascertain the impact on our measures of ADD and SUB of constructing the identities without the data on retirements and other changes, we constructed limited information aggregate series for the entire period and compared them to the full-information series starting in 1969. We found small differences in the series from 1969 to 1974, but much larger differences in the 1980s. In order to make our series more consistent across time, we adjusted several components of the pre-1969 gross flows by the mean difference in the series during the 1969 to 1974 period. The data appendix gives the details of the adjustment.

A second issue is a few cross-year discrepancies between this period's beginning stock of capital and last period's ending stock of capital. Our analysis of the observations with a discrepancy suggests that these discrepancies were real, and are often associated with mergers and acquisitions. Thus, we add positive discrepancies to ADD and negative discrepancies to SUB.

A third issue is entry of firms into the Compustat database. Firms can enter the Compustat database for a variety of reasons, including incorporation, filing with the SEC, or divestiture of a larger company. We do not wish to count the appearance of an already existing company as an addition to capital. Several companies, however, appear to be newly formed because their net book value of capital is similar to their gross book value of capital. If the end of period gross capital is not more than 20 percent of the end of period net capital during a company's first year in the data set, we count it as a new entrant and add its capital (net of current investment) to ADD.

A fourth complication is the exit of firms from the data base. Exits are easier to address because Compustat gives reasons for exit of firms. We count exits due to mergers and bankruptcies as subtractions from capital. We do not count exits due to conversion to private companies, leveraged buyouts, or unspecified reasons as part of subtractions.

The fifth complication is the divestiture of AT&T in 1984. If we do not adjust the data, the SUB series has a huge spike in 1984, since AT&T was divested of $218.6 billion of current dollar gross capital. This amount is equal to 4.2 percent of the aggregate capital in our sample. Because this was such an unusual circumstance, and because the flow of capital was due to government policy, we decided to net out the AT&T divestiture.

Converting to Current Cost

The next stage in data construction is the conversion of the historical cost book values to current dollar values. In order to construct the deflators necessary for this step, we first must construct a vintage history of capital for each firm. Full details are given in the data appendix, but we will briefly summarize the process here. For the first observation for a firm, we estimate the vintage history based on the ratio of the firm's current flow depreciation to its accumulated depreciation and the BEA's average age of capital in that industry. After the first period, we construct a vintage history for each year using the various components of the ADD and SUB series discussed above.

We make the following assumptions about the ages of the components of ADD and SUB. We split ADD into two components based on the assumed age of the capital: ADDNEW, which includes "new" capital, and ADDAVG, which includes additions that have an average age equal to the average age of the firm's existing capital. We cannot necessarily use the investment series (v30) for the new capital component, because v30 also includes the gross book value of the property, plant, and equipment of purchased companies. Fortunately, there is another capital expenditure series (v128) from the Statement of Cash Flows, which excludes property, plant and equipment of purchased companies. When v30 is greater than v128, we include only v128 in ADDNEW and assign the rest of v30 to ADDAVG. We also assume that "other," and "ε" all have the same average age as the firm's existing capital.

We also split SUB into two categories, SUBOLD and SUBAVG. We assume a first-in first-out policy on retirements, so that the age of retirements is equal to the age of the oldest capital. SUBOLD includes these retirements. SUBAVG includes all other subtractions, and assumes these subtractions have the same average age as the firm's existing capital.

Using this vintage history of capital, we can construct deflators for converting the stock of capital and the various flows to current dollars. We combine our constructed information about the vintage structure with BEA deflators for investment by industry to produce several deflators for each firm-year observation to cover flows of varying ages.

Depreciated or Undepreciated Capital?[2]

Our intent is to measure flows of physical capital into and out of firms. Ideally, we would count the number of machines flowing in and the number of machines flowing out of firms, just as the labor studies count bodies flowing into and out of establishments. The closest we can come to counting machines with the available data is to use current dollar gross capital stocks and flows. At first glance, one might think that depreciated variables are preferable. While interesting for some cases, we believe that the depreciated flows can be misleading in other instances. Consider using the data to study a firm that is replacing one hundred 386 computers with one hundred Pentiums. If we analyzed only the depreciated flows, we would find a noticeable inflow of capital, but very little outflow of capital from this firm, since the depreciated values of the 386's would be near zero. Yet, the fact that one hundred computers are exiting this firm is useful information.

Another reason to favor the use of undepreciated measures is that we believe they involve less measurement error. The accounting data essentially gives the flow of dollars in and dollars out. Some imputation is necessary to convert the historical dollars to current dollars. Going further to depreciate the capital involves more measurement error because we must rely on industry-average depreciation. We do not feel comfortable using the accounting depreciation data because we feel they are dominated by tax and accounting considerations. The depreciation rates suggested by the accounting data are substantially above those computed by the BEA.

[2] In order to avoid hopeless confusion, we will use "net" and "gross" only when referring to flows (as in Davis and Haltiwanger). We will use "undepreciated" and "depreciated" instead of the usual net and gross terms for capital stocks.

In many cases, though we believe that studying the net flows sheds additional light. For those cases, we construct the net stocks and flows using BEA industry-specific depreciation rates and our vintage structure of capital data.

Construction of Aggregate Series

For much of our analysis, we will aggregate firm-level data to industry aggregates or economy-wide aggregates. It is important to discuss a few issues that arise in the aggregation.

The first issue is calendar years versus fiscal years. We initially thought that it would be important to convert the data from the firm fiscal years to calendar years. We constructed calendar year aggregates by using the Compustat information on end of fiscal year month to divide a firm's capital flows between calendar years. The results were so similar to those obtained when we ignored the difference between fiscal years and calendar years, that we decided to use the simpler procedure of treating the fiscal year as if it were the calendar year.

The second issue is the difference between the aggregate of the Compustat data and U.S. government data aggregates. It is important to keep in mind several ways in which the Compustat data set differs from the standard aggregate data. First, Compustat data covers only corporations that file with the SEC. Thus, sole proprietorships and partnerships are not part of the sample. Second, if a U.S. corporation sells a U.S.-located plant to a foreign firm, that plant would disappear from our data set, but would still be counted in the BEA data. Thus, the aggregate capital stock constructed from Compustat will not necessarily have the same patterns as the BEA aggregate capital stock. To determine the extent of similarities of our series to the BEA series, we compared the investment rate for new capital from the BEA to the investment rate for new capital for our data. To be specific, we compared the ratio of the BEA's current dollar nonresidential fixed investment to the BEA current dollar gross capital stock with the ratio of Compustat new capital additions (ADDNEW) to our constructed current dollar gross capital stock. Figure 1 shows the two series. While the Compustat series appear to be more volatile, the basic movements in the two series is surprisingly similar: the correlation of the two series is 0.82.

We define some of the key aggregate series we study in the following sections. The aggregate gross flows are defined as follows:

(3a) $ADDALLK = (ADDNEW + ADDAVG + NEWENT)/K_{t-1}$

(3b) $SUBALLK = (SUBAVG + SUBOLD + EXIT)/K_{t-1}$

where

ADDNEW = additions of new capital, as defined above, expressed in current dollars

ADDAVG = additions of capital with ages equal to firm's average age of capital, expressed in current dollars

NEWENT = capital stock of firms that appear to be newly formed, expressed in current dollars

SUBAVG = subtractions of capital with ages equal to firm's average age of capital, in current dollars

SUBOLD = subtractions of capital of oldest vintage, in current dollars

EXIT = capital of firms that exited due to bankruptcies and mergers.

K_{t-1} = current dollar capital at the end of period t-1.

4 Some Stylized Facts about Gross Flows of Capital

We begin by analyzing gross flows of capital at the aggregate level, using techniques similar to those used by Davis, Haltiwanger and Schuh (1996) (DHS) for job creation and job destruction. Analogous to DHS, we construct several additional variables from the basic flow data. These variables are defined as follows:

(4a) SUMK = ADDALLK + SUBALLK

(4b) NETK = ADDALLK – SUBALLK

(4c) Excess reallocation = SUMK – ABS(NETK)

DHS argue that the sum of their "pos" and "neg" can viewed as a measure of job reallocation. We follow their lead and use the sum of our "add" and "neg" to indicate capital reallocation. DHS define "excess reallocation" as the amount of reallocation over and above what is required to achieve net changes. For comparability, we also include this measure. The interpretation of "excess," though, is different in the case of capital because the physical depreciation rate of most capital is probably greater than for workers. Note finally that the NETK we define is not necessarily equal to the change in the capital stock, since we do not include all entries and exits from our data base as capital flows. For example, if a corporation disappeared from our sample because it became private, we would not include it in our SUBALLK series, even though it would decrease the capital stock aggregate.

Magnitude of gross flows

Table 2 shows summary statistics for these variables and compares them to comparable numbers regarding worker flows. The top panel presents statistics for the all industries over the period 1959 to 1995.[3] The second panel presents data for manufacturing alone, for the entire period, and the third panel presents data for manufacturing from 1973 to 1988, which is comparable to the sample analyzed by DHS. The last panel reproduces DHS's statistics for employment. All panels show both undepreciated values and depreciated values.

Consider first the undepreciated flows in the first column. Several results are noteworthy. First, the gross flows of capital are large. The statistics from the full sample imply that on average over 7 percent of the capital exited firms, and almost 10 percent was added to firms. Second, for the data most comparable to DHS, which covers manufacturing industries from 1973-1988, the flows of capital are at least as great as the flow rate of jobs. Furthermore, the capital flows are largest for this particular sub-sample. The flows imply substantial amounts of capital reallocation and excess capital reallocation.

The results based on depreciated flows and stocks also imply substantial capital flows. Addition rates appear much larger because depreciation lowers the entire denominator, but only part of the numerator. As one would expect, the capital subtraction rate is measured to be lower when we depreciate retirements. Nonetheless, the rates still imply substantial amounts of capital churning.

Figure 2a shows graphs of undepreciated addition and subtraction rates over time, and Figure 2b shows the same graphs using depreciated data. The same types of patterns emerge from both graphs. As one would expect, addition rates show substantial cyclicality, rising during booms and falling during recessions. Subtraction rates appear to be counter-cyclical, but have less amplitude than investment rates. The most noticeable pattern in subtraction rates is

[3] Our actual data extends from 1958 to 1996. Many firms had missing values for data in 1958 and 1996, which affected the aggregates, so we omitted those two years.

the clear upward trend over time. It appears that outflows of capital are rising over time, but inflows are not.

Components of Gross Flows

Figure 3a and Figure 3b break down addition and subtraction rates into their components. Table 3 reports summary statistics. In order not to produce an overwhelming number of graphs and tables, we will focus our attention on the undepreciated data. Figure 3a shows that accumulation of new capital is the most important part of gross inflows of capital. Acquisitions of existing capital become increasingly important during the 1980s though, and are as large as purchases of new capital in 1987. Entries of new firms are relatively unimportant for our sample, perhaps because of the way we defined new entries. According to Table 3, purchases of new capital become less important in the 1980s and 1990s, whereas the importance of acquisitions doubled.

Figure 3b shows that retirements are the most important component of outflows of capital. During the 1980s, though, sales of capital and exits due to mergers and bankruptcies become more important. All components trend upward over time. Table 3 shows that the 3.5 percentage rate increase in the subtraction rate from the 1970s to the 1980s came in equal parts from the three components.

Correlation of Flows

We now present the correlation of the various flows of capital with each other and with the aggregate unemployment rate, which gives a measure of business cycles. Table 4 shows the correlations for the entire sample period and for the sample from 1980 to 1995. It should be noted that the correlations for the entire sample period will include both cyclical elements as well as the obvious trends in the variables, including the unemployment rate. The trend features should be less important for the subsample.

Several features stand out. For the entire sample, NET and SUB are negatively correlated, whereas during the 1980s and 1990s they have zero correlation. ADD and SUB are positively correlated for the entire sample, but have zero correlation during the last part of the sample. For the entire sample, net capital investment has a high negative correlation with the unemployment rate, implying significant procyclicality. It is less procyclical during the last 16 years of the sample. Capital reallocation (sum), on the other hand, is somewhat countercyclical for the entire sample, but procyclical during the 1980s and 1990s.

The 1980s and 1990s are also noticeably different in the behavior of the components of capital flows. Additions of new capital become less procyclical during the 1980s and 1990s.[4] In contrast, acquisitions of existing capital and retirements are positively correlated with the unemployment rate over the entire sample but negatively correlated during the 1980s and 1990s.

Capital Churning within Firms and Industries

We now seek to quantify the extent to which the capital churning occurs within firms and industries versus across firms and industries. By capital churning, we mean the simultaneous addition and subtraction of capital that does not lead to net changes in the capital stock. To this end, we define variables which measure churning that is confined to a particular level of aggregation. Consider the following measures:

[4] This change is also true for the BEA investment rates. The correlation of investment rates with unemployment is –0.49 for the entire sample and 0.21 for the period 1980 to 1995.

Firm-level capital churning:

(5a) Firmchurn = $$\left\{\sum_{i=1}^{I} \min(addnew_{it} + addavg_{it},\ subold_{it} + subavg_{it})\right\} / \sum_{i=1}^{I} K_{it-1}$$

where i indexes the firms and I is the number of firms.

Industry-level capital churning:

(5b) Induschurn = $$\left\{\sum_{j=1}^{J} \min(addnew_{jt} + addavg_{jt},\ subold_{jt} + subavg_{jt})\right\} / \sum_{j=1}^{J} K_{jt-1}$$

where j indexes the industry.

Aggregate-level capital churning:

(5c) Aggchurn = $\min(addall, suball)/K_{t-1}$

The measure of firm-level churning sums the minimum of capital additions and subtractions, taken at the firm level. This measure gives an idea of capital that is turning over within the firm, that does not have an affect on the net capital stock. The same idea can be applied to the industry level, at various levels of aggregation. These measures indicate what part of the capital flows are due to the replacement of existing capital and what part is due to changes in the distribution of capital across firms or industries.

Figure 4 plots these churn measures for the firm level, the 4-digit industry level, the 2-digit level, and the aggregate level, and Table 5 gives summary statistics. At the aggregate level, most but not all of the minimums are the subtraction rates. The figure and table indicate that firm-level churning accounted for the majority of aggregate capital churning during the 1960s. From the 1970s through the 1990s, aggregate capital churning increased substantially, but firm-level churning increased only a moderate amount. From the 1970s to the 1980s, firm-level churning increased by only 0.6 percentage points, whereas 4-digit level churning increased by 1.8 percentage points, 2-digit level churning increased by 2.3 percentage points and aggregate level churning increased by 3 percentage points. Thus, most of the increase in capital churning in the 1980s was not due to within firm churning. Flows of capital across firms and industries became increasingly important.

Consequences of Capital Reallocation

In this section, we conduct a preliminary investigation of the consequences of capital churning. It is interesting to see whether capital reallocation has affects on variables such as employment and productivity. In this preliminary version of the paper, we investigate the relationship between employment growth based on Compustat data and the various capital flow measures. We intend to link the capital flows up with productivity and employment measures from other data sources in later versions of the paper.

To investigate the possibility of a link between employment and capital reallocation, we estimate panel regressions on two-digit manufacturing industries. We chose to limit this preliminary analysis to manufacturing because some of the nonmanufacturing industries have a very small number of firms represented in Compustat. We estimate the following type of regression:

(6) $\text{Employment growth}_{jt} = \beta_1\, NETK_{jt} + \beta_2\, SUMK_{jt} + \beta_3 FIRMCHURNK_{jt} + \text{fixed effects}$

where employment growth is calculated using Compustat employment numbers, aggregated to the industry level. Recall that NETK is the capital addition rate less the capital subtraction rate, SUMK is the sum of the two flows, and FIRMCHURN is the minimum of the two flows, applied at the firm level and summed.

If capital and firms are homogeneous and capital is allocated efficiently, only NETK, the net investment rate, should matter and the coefficient on SUMK and FIRMCHURN should be zero. If these assumptions are relaxed, then the coefficients on SUMK and FIRMCHURN can take on values other than zero. Both positive and negative values of the coefficient are possible.

The effects of capital reallocation and firm-level churning can be positive or negative, depending on the driving forces behind the reallocation and churning. If capital reallocation is the result of inefficient firm-breakups or credit restrictions, then higher capital reallocation might lead to lower employment growth. Second, if capital reallocation and firm-level churning are the result of technological updating with labor-saving capital, then higher rates of either of these variables could lead to lower employment growth (within that industry). Third, if capital reallocation is the result of sectoral shifts, and capital becomes less productive if it shifts industries, then capital reallocation might have a negative correlation with employment growth.

On the other hand, there are at least two reasons why capital reallocation or churning might have a positive effect on employment growth. First, if technological updating of capital is the source of the high capital reallocation and firm-level churning, and the technology is a complement to labor, then capital reallocation and employment growth should be positively correlated. Second, if a reorganization of capital across firms increases the efficiency of its use, then employment growth might rise as a consequence of higher capital reallocation.

Table 6 reports the results of the panel regressions. The table shows results for both undepreciated capital flows and depreciated capital flows.[5] All specifications include year fixed effects. The results shown in the first and third column also contain industry fixed effects.

The results are very similar across the specifications, and all coefficients are precisely estimated. In all cases, net capital growth is associated with a rise in employment growth, as one would expect if industries are expanding and contracting their scale. Furthermore, the estimates indicate that capital reallocation (SUM) has an independent association with employment growth. In line with the reasons discussed above for a positive relationship, the data indicate that capital reallocation has a positive effect on employment growth. On the other hand, after taking into account net capital growth and capital reallocation across firms, within firm capital churning appears to have a significant negative effect on employment growth.

These estimates indicate that the behavior of the gross flows of capital have independent effects from the net change in capital. Thus, these preliminary results support our contention that studying the gross flows underneath the net flows of capital can increase our understanding of the motives for capital accumulations, and the consequences. Furthermore, these results seem to indicate that the increased level of capital reallocation during the 1980s and 1990s may have increased labor productivity, and thus raised employment growth. The high amount of capital reallocation may have been the basis for the current run of high economic growth.

[5] The variable FIRMCHURNK is based on undepreciated data in every case.

5 Conclusions

(To be written later.)

Table 1
Motives for Changing the Level of the Capital Stock

Motive	**Method of Adding Capital**	**Method of Subtracting Capital**
Firm wishes to expand productive capacity by simple replication	- Purchases of new capital - Acquisition of existing capital from another firm	- Minimal rate of retirements
Firm wishes to adopt a new technology	Purchases of new capital	- Higher rate of retirements - Sales of capital
Firm expands vertically or horizontally	- Purchases of new capital - Acquisition of existing capital from another firm -Merger	- Possible higher rate of retirements - Possible sales of capital
Firm wishes to shrink productive capacity	No capital additions	- Higher rate of retirement - Sales of capital
Firm wishes to maintain the same capacity, simply replacing old capital	Purchases of new capital	- “Normal” rate of retirement

Table 2
Average Gross Capital Flows
Current $ Annual Flows as a Percentage of Current $ Capital Stock

	Undepreciated Capital Flows and Stocks	Depreciated Capital Flows and Stocks
Aggregate, 1959-1995		
Additions	9.7	17.3
Subtractions	7.3	4.8
Capital Reallocation	17.1	22.1
Net Investment	2.4	12.4
Excess Reallocation	14.2	9.7
Manufacturing, 1959-1995		
Additions	10.4	19.0
Subtractions	8.3	5.4
Capital Reallocation	18.6	24.4
Net Investment	2.1	13.6
Excess Reallocation	15.8	10.8
Manufacturing, 1973-1988		
Additions	11.2	20.1
Subtractions	10.0	7.0
Capital Reallocation	21.2	27.1
Net Investment	1,2	13.2
Excess Reallocation	18.9	13.9
Manufacturing, 1973-1988 From Davis, Haltiwanger, Schuh (1996) Table 2.1		
Job Creation	9.1	
Job Destruction	10.3	
Job Reallocation	19.4	
Employment Growth	-1.1	
Excess Job Reallocation	15.4	

Table 3
Components of Gross Undepreciated Capital Flows
Current $ Annual Flows as a Percentage of Current $ Capital Stock

	1959-1995	1959-1969	1970-1979	1980-1989	1990-1995
All additions to capital	9.7	9.0	9.6	10.3	10.3
New purchases	6.9	6.9	7.7	6.5	6.4
Acquisitions	2.6	2.0	1.8	3.6	3.6
New entry	0.2	0.1	0.1	0.3	0.4
All subtractions from capital	7.3	4.2	6.6	10.1	9.5
Retirements	5.2	3.5	5.0	6.3	6.6
Sales	1.5	0.6	1.0	2.4	2.1
Exit	0.7	0.1	0.6	1.4	0.8

Table 4
Correlation of Capital Flow Rates

1959-1995

	Unemp	Addall	Suball	Sum	Net	Addnew	Addavg	Subold	Subavg
Unemp	1								
Addall	-0.19	1							
Suball	0.52	0.40	1						
Sum	0.31	0.72	0.93	1					
Net	-0.67	0.14	-0.85	-0.59	1				
Addnew	-0.40	0.41	-0.20	0.02	0.45	1			
Addavg	0.26	0.55	0.77	0.82	-0.52	-0.34	1		
Subold	0.42	0.43	0.96	0.91	-0.79	-0.11	0.79	1	
Subavg	0.55	0.23	0.91	0.79	-0.86	-0.32	0.68	0.81	1

1980-1995

	Unemp	Addall	Suball	Sum	Net	Addnew	Addavg	Subold	Subavg
Unemp	1								
Addall	-0.54	1							
Suball	-0.13	-0.02	1						
Sum	-0.48	0.70	0.70	1					
Net	-0.29	0.71	-0.71	-0.00	1				
Addnew	-0.07	0.52	-0.33	0.13	0.60	1			
Addavg	-0.66	0.58	0.08	0.47	0.35	-0.22	1		
Subold	-0.47	0.24	0.78	0.73	-0.37	-0.27	0.50	1	
Subavg	0.14	-0.35	0.72	0.27	-0.75	-0.38	-0.15	0.31	1

Unemp is the aggregate unemployment rate. The other variables represent flow rates of capital.

Table 5
Capital Churning Rates by Level of Aggregation

Sample	Firm-Level Churning	4-Digit Level Churning	2-Digit Level Churning	Aggregate Capital Churning Rate
1959-1995	4.1	6.2	6.6	7.1
1959-1969	3.4	4.3	4.4	4.2
1970-1979	4.0	5.9	6.2	6.6
1980-1989	4.6	7.7	8.5	9.6
1990-1995	4.6	7.6	8.1	9.0

Firm-level churning is defined as the sum of min(add,sub) taken at the firm level, divided by the capital stock. The other churning measures are defined similarly, but the minimums are taken at difference levels of aggregation.

Table 6
Panel Regression of Employment Growth on Net Capital Growth and Reallocation
2-Digit Manufacturing Industries

Coefficient on:	Undepreciated Capital Flows		Depreciated Capital Flows	
NETK	0.328 (.027)	0.318 (.028)	0.212 (.023)	0.209 (.025)
SUMK	0.185 (.030)	0.190 (.034)	0.130 (.024)	0.135 (.028)
FIRMCHURNK	-0.305 (.110)	-0.252 (.133)	-0.203 (0.048)	-0.190 (.057)
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	No	Yes	No	Yes
R^2	0.51	0.54	0.51	0.54
Number of observations	740	740	740	740

Notes:

-Standard errors are in parenthesis.

-The years covered are 1959 to 1995.

-NETK is total additions less total subtractions of capital, divided by the capital stock.

-SUMK is total additions plus total subtractions of capital, divided by the capital stock

-FIRMCHURNK is the sum of min(add, sub) for each firm, divided by the capital stock

Figure 1: A Comparison of Compustat and NIPA Investment Rates

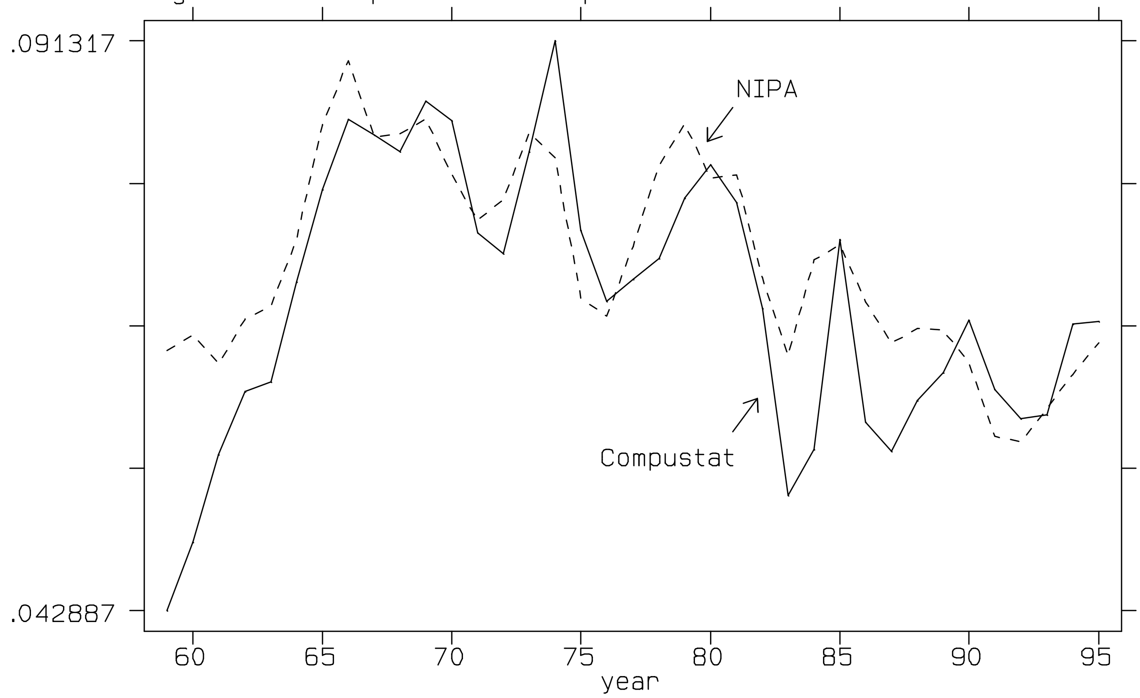


Figure 2a: Undepreciated Gross Flows of Capital

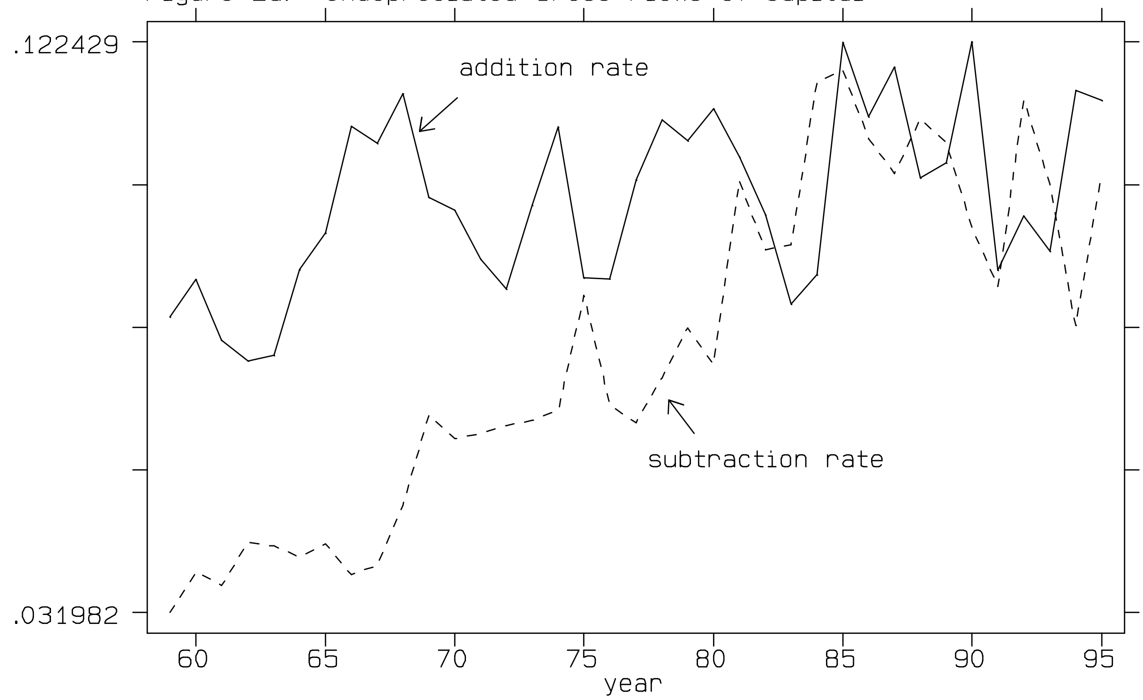


Figure 2b: Depreciated Gross Flows of Capital

Figure 3a: Undepreciated Capital Addition Rates

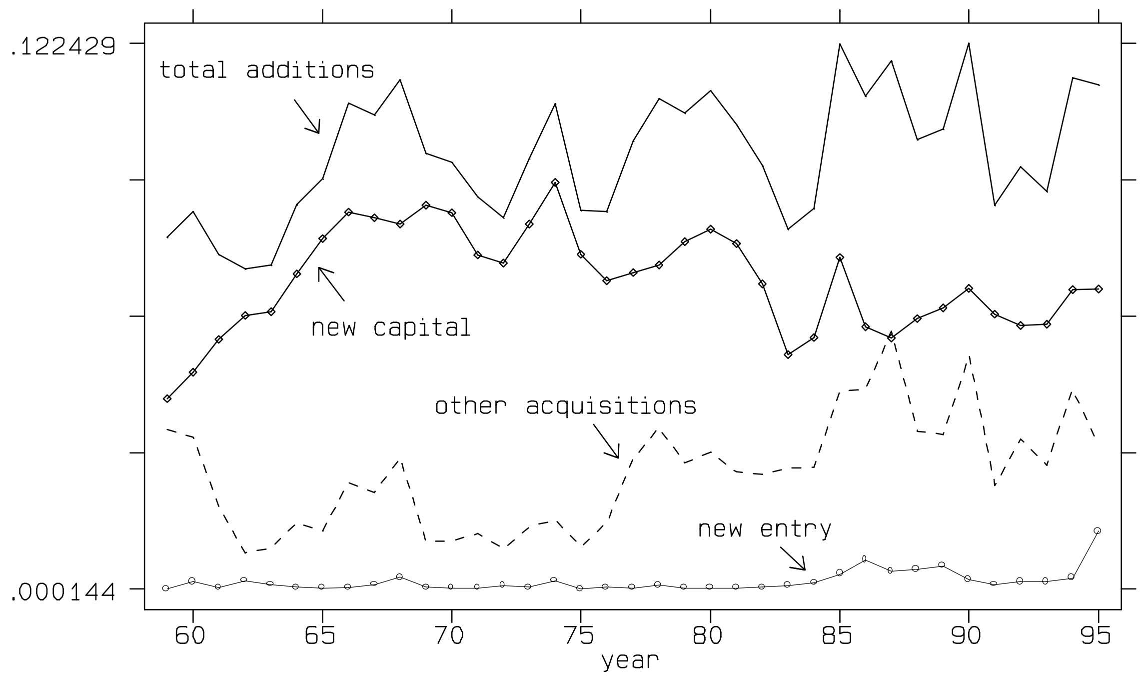
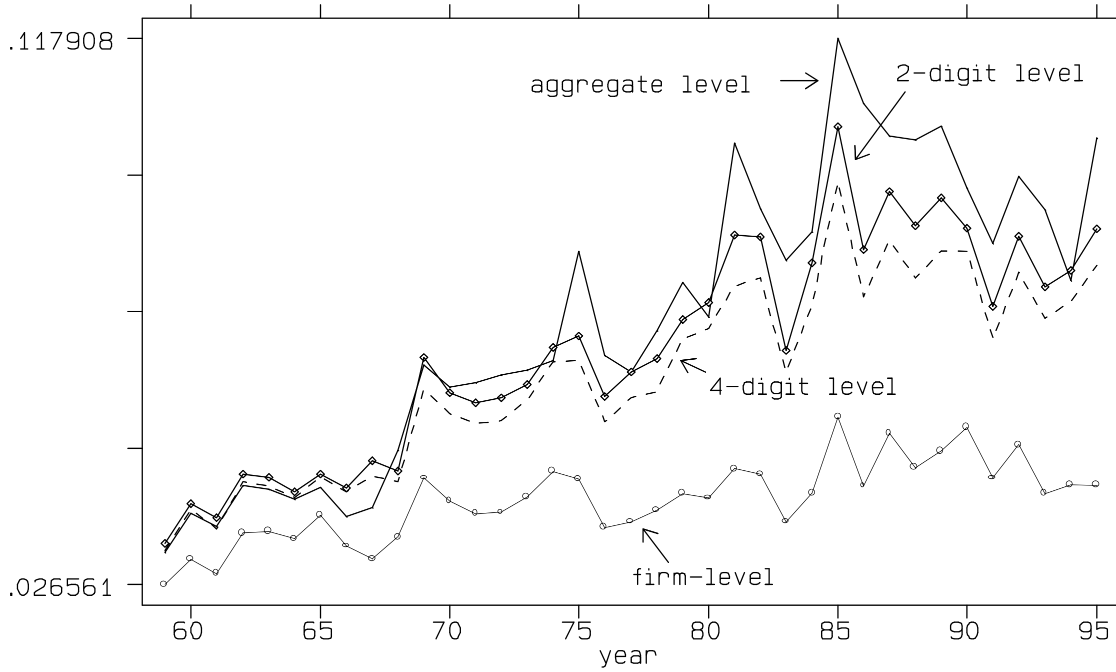


Figure 3b: Undepreciated Capital Subtraction Rates

Figure 4: Capital Churning at Various Levels of Aggregation



References

Abel, Andrew and Janice Eberly (1994), "A Unified Model of Investment Under Uncertainty," *American Economic Review,* 84, 1369-1384.

----------------- (1996), "Investment and q with Fixed Costs: An Empirical Analysis," manuscript.

Blanchard, Olivier and Peter Diamond (1989), "The Beveridge Curve," *Brookings Papers on Economic Activity,* 1: 1-60..

Blanchard, Olivier and Peter Diamond (1990), "The Cyclical Behavior of the Gross Flows of U.S. Workers," *Brookings Papers on Economic Activity* No. 2, 85-155.

Caballero, Ricardo, Eduardo Engel, and John Haltiwanger (1995), "Plant-Level Adjustment and Aggregate Investment Dynamics," *Brookings Papers on Economic Activity* 1995:2, 1-54.

Christiano, Lawrence J. and Jonas Fisher (1995), "Tobin's q and Asset Returns: Implications for Business Cycle Analysis," NBER working paper 5292.

Cockburn, Iain and Murray Frank (1992), "Market Conditions and Retirement of Physical Capital: Evidence from Oil Tankers," NBER working paper 4194.

Cooley, Thomas F., Jeremy Greenwood and Mehmet Yorukoglu (1997), "The Replacement Problem," *Journal of Monetary Economics,* 40 (December): 457-500.

Cooper, Russell and John Haltiwanger (1993), "The Macroeconomic Implications of Machine Replacement: Theory and Evidence," *American Economic Review,* 83 , 360-382.

Cooper, Russell, John Haltiwanger, and Laura Power (1995), "Machine Replacement and the Business Cycle: Lumps and Bumps," NBER working paper 5260.

Das, Sanghamitra (1992), "A Micro-Econometric Model of Capital Utilization and Retirement: A Case of the U.S. Cement Industry," *Review of Economic Studies,* 59 , 277-297.

Davis, Steven and John Haltiwanger (1992), "Gross Job Creation, Gross Job Destruction, and Employment Reallocation," *Quarterly Journal of Economics,* 107:3, 819-63.

Davis, Steven, John Haltiwanger, and Scott Schuh (1996), *Job Creation and Destruction,* Cambridge, Mass.: M.I.T. Press.

Diamond, Peter (1981), "Mobility Costs, Frictional Unemployment, and Efficiency," *Journal of Political Economy* 89(4): 798-812.

Dixit, Avinash and Robert Pindyck (1994), *Investment Under Uncertainty,* Princeton, NJ: Princeton University Press.

Feldstein, Martin S. and David K. Foot (1971), “The Other Half of Gross Investment: Replacement and Modernization Expenditures,” *The Review of Economics and Statistics*, 53 (February), 49-58.

Goolsbee, Austan and David B. Gross (1997), “Estimating Adjustment Costs with Data on Heterogeneous Capital Goods,” University of Chicago Graduate School of Business manuscript.

Hulten, Charles and Frank Wykoff (1981), “The Estimation of Economic Depreciation Using Vintage Asset Prices,” *Journal of Econometrics,* April, 367-96.

--------------------- (1996), “Issues in the Measurement of Economic Depreciation,” *Economic Inquiry,* 34:1, 10-23.

Hulten, Charles, James Robertson, and Frank Wykoff, “Energy, Obsolescence and the Productivity Slowdown,” in *Technology and Capital Formation,* ed. Dale Jorgenson and Ralph Landau, Cambridge, Mass.: M.I.T. Press, 1988, 225-58.

Ramey, Valerie A. and Matthew D. Shapiro (1998) “Displaced Capital,” March 1998 manuscript.

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Capital Churning

by Valerie Ramey and Matthew Shapiro

Appendix

In this paper, we construct estimates of the value of a firm's capital stock using a method that integrates the identities we use to analyze the gross flows into and out of the capital stock. While our procedure is designed specifically to be fully consistent with the analytic framework of this paper, it also provides a translation of book value of capital to real values that should be useful for other studies. In particular, we construct a vintage history of the book value of capital. This vintage structure, in addition to its independent interest, allows us to accurately reflate book values to estimate the current-cost and constant-cost value of the capital stock.

A.1. Gross flow identity

Our analysis of the gross flows of capital is based on the following, fundamental identity,

$$K_t = K_{t-1} + Add\_new_t + Add\_avg_t - Sub\_avg_t - Sub\_old_t \,. \qquad (*)$$

The elements of the identity are all book values. *K* is the end-of-year book value of the gross of depreciation capital stock. *Add_new* is additions of new capital, *Sub_old* is subtractions of capital of the oldest vintage, and *Add_avg* and *Sub_avg* are additions and subtractions of capital whose age structure mirrors the age structure of the existing capital of the firm. Our accounting identity expands on the traditional accumulation identity by being explicit about acquisition of capital that is not necessarily the purchase of new plant and equipment and disposal of capital that is not necessarily retirement of capital. *Add_new* and *Sub_old* correspond to investment in new capital and retirement of old capital. *Add_avg* and *Sub_avg* are additions and subtractions of capital arising from merges, acquisitions, sales of plant or divisions, and so on. These transactions drop out of the economy-wide identity, but are important for studying reallocation among firms and industries.

A.2. Vintage structure

To convert the book values in the accounting identity into current or real values, we need to know the vintage structure of the firm's capital. To do so, we need to specify a vintage structure for the initial capital stock. We also need to make assumptions about the vintage structure of the various additions and subtractions to the capital stock.

When a firm enters the data set, we have no information on past investment flows to estimate the age structure of capital. Instead, we are presented with a book value of its existing stock. Typically, firms entering the Compustat data set are not newly formed, that is, they might have a substantial history before being listed on a stock exchange. We rely on data for industry average depreciation and average age of the net stock of capital, together with the assumption that the firm is in steady state when it enters the data set, to estimate the vintage history of the first observation. These assumptions are not totally innocent. Firms entering the Compustat data set might be likely to be growing faster than the industry average. For rapidly growing firms, our procedure is largely self-correcting after several years, so it might be reasonable to drop the first few observations.[1]

The BEA provides information on the average age and depreciation rate for the current-cost stock of net capital. These data are available annually at the two-digit SIC level. Assuming that the firm is growing at rate g, has depreciation rate δ, and is in steady state, it is straightforward to show that the average age is given by the formula

$$Average\ age = (1 - \delta)/(\delta + g).$$

We use this formula, and the annual industry-level data on average age and depreciation, to impute the growth rate g for each firm prior to its entering the sample.

In constructing the vintage history, there will be a vintage of the oldest capital at any given time, denoted V_t. Initially, we set it to thirty years, although it can increase or decrease in subsequent years. Let K_t be the book value of the capital stock. It is the sum of book value of capital of different vintages, that is

$$K_t = \sum_{v=0}^{V_t} K_{t,t-v},$$

where $K_{t,t-v}$ is the book value of capital at time t of installed at date t-v.

We have an observation on newly purchased capital for the initial year of data t_0, which ties down the most recent vintage, so

[1]There are also alternative procedures. Brownyn Hall () uses accounting depreciation to estimate average age firm-by-firm. Brainard, Shapiro, and Shoven () estimate the slope of the vintage structure to fit book depreciation. We have decided that there are enough problems with interpreting accounting depreciation not to take these approaches.

$$K_{t_0,t_0} = Add\_new_{t_0}.$$

Under the assumption that the real value of the capital stock is growing at rate g, the vintage structure of the book capital stock is

$$K_{t_0,t_0-v} = \left(\frac{1}{1+g}\right)^v \frac{P_{t_0-v}}{P_{t_0}} \bar{K}$$

where P_t is the industry specific price index for new capital and $\bar{K}$ is a factor of proportionality such that the vintage history adds up. That is, the initial book value of capital is given by

$$K_{t_0} = Add\_new_{t_0} + \bar{K} \sum_{v=1}^{V_{t_0}} \left(\frac{1}{1+g}\right)^v \frac{P_{t_0-v}}{P_{t_0}}.$$

Given this initial vintage structure, we iterate forward in time. The most recent vintage is set equal to additions of new capital, that is,

$$K_{t,t} = Add\_new_t.$$

Sub_old is subtracted from the oldest vintage. If Sub_old_t exceeds the stock of the oldest vintage, $K_{t,t-V_{t-1}}$, that vintage, and any more recent vintages as necessary, as set to zero. The oldest vintage, V_t, is updated accordingly. Add_avg_t net of Sub_avg_t is distributed evenly (in real terms) over the remaining vintages.

A.3. Deflation

The calculations just discussed provide a vintage structure of the book value of gross capital consistent with identity (*). Given this vintage structure and appropriate price indexes for new capital, it is straightforward to calculate real quantities and deflators for the capital stock and flows. We use BEA deflators for new investment by industry, matched to firm according to the SIC code assigned by Compustat. Suppose that this price index P_t has a certain base year, which is 1992 for these calculations. The constant dollar stock is calculated as

$$\textit{Constant dollar capital} = \sum_{v=0}^{V_t} K_{t,t-v} \frac{1}{P_{t-v}}$$

and the current dollar stock can be calculated as

$$\textit{Current dollar capital} = \sum_{v=0}^{V_t} K_{t,t-v} \frac{P_t}{P_{t-v}}.$$

The depreciated[2] real capital stock—presuming depreciation rate δ—are similarly calculated as

$$\textit{Constant dollar depreciated capital} = \sum_{v=0}^{V_t} (1-\delta)^v K_{t,t-v} \frac{1}{P_{t-v}}$$

and

$$\textit{Current dollar depreciated capital} = \sum_{v=0}^{V_t} (1-\delta)^v K_{t,t-v} \frac{P_t}{P_{t-v}}.$$

[2]We use the term depreciated capital, instead of the standard net capital, to avoid confusion with gross versus net flows in the sense of identity (*).

Constant and current dollar depreciation is the difference of the respective undepreciated and depreciated capital stocks.

The current-dollar price index for the capital stock is the ratio of the book value to the current-dollar stock. Similarly, the constant-dollar price index is the ratio of the book value to the constant-dollar stock. These are also the deflators that are appropriate for *Add_avg* or *Sub_avg*. For *Add_new* the deflator is P_t for constant dollars and unity for current dollars. For *Sub_old*, the deflator is P_{t-V_t} for constant dollars and P_{t-V_t}/P_t for current dollars.[3]

A.4. Data on stocks and flows.

In this section of the Appendix, we describe how to map the accounting data in Compustat into the gross flow identity (*).

Book value of capital. There are two measures of the gross-of-depreciation book value of capital in Compustat. The end-of-year value of *gross property, plant, and equipment (PPE)*—Compustat variable V7—is reported for most observations. Additional data on capital stocks and flows are available on Schedule V of corporate reports. These data are available routinely only since 1969, and are less frequently reported than V7. The Schedule V data contain, however, components of identity (*), so we make use of them whenever possible. Schedule V contains the end-of-year (V187) and beginning-of-year values of gross book value of PPE (V184). Typically, V187 and V7 report the same value, but not always. To be consistent with the other data in Schedule V, of which we make extensive use, we use the value of V187 when V7 and V187

[3] When V_t gets revised forward owing to retirement of entire vintages, the deflator should be based on the average of vintages retired.

differ.[4]

Schedule V identity. Prior to availability of Schedule V, the only flow variable is investment (V30). Schedule V also contains data on retirements (V184) and other changes (V185). Together with investment, these variables form the identity,

$$V187 = V182 + V30 - V184 + V185,$$

that is, end-of-period stock equals beginning-of-period stock, plus investment, minus retirements, and plus other.[5]

Investment. Compustat variable V30 reports investment in new plant and equipment. Variable V30 also includes the book value of the PPE of acquired companies. Since the vintage of newly-purchased PPE and that of acquired companies are likely to be quite different, these additions to capital need to be separated. Making this distinction is critical for our analysis of gross flows, but it is also important for standard perpetual inventory calculations meant to derive real values of the capital stock. Moreover, our examination of a number of cases (e.g. the case of Dole, which we discuss in the main part of the paper) leads us to conclude that it is not possible to rely on the merger footnotes to signal acquisitions. Frequently, that footnote appears in a different year from when the acquisition is reflected in variable V30. Instead, we use capital expenditures from the statement of cash flows (V128) to measure investment in new PPE. If V30 is less than V128, we ignore V128 and treat all of V30 as *Add_new*. If V30 is more than V128, we treat V128 as *Add_new* and assume that V30-V128 represents the book value of acquired

[4] In some cases, V187 is clearly miscoded (typically a very small number relative to V7). In these cases we recode V187 as missing.

[5] Except for a few data-entry problems, this identity holds in the Compustat data.

capital. We make the additional assumption that the acquired capital has the same vintage structure as the capital of the acquiring company, so V30-V128 is added to *Add_avg*.

Retirements. We assume that a firm retires it oldest capital, so V184 is included in *Sub_old*.

Other. We assume that other changes, which can be additions or subtractions, come across the existing vintage structure. Accordingly, we count positive values of V185 as *Add_avg* and negative values as *Sub_avg*.

Residuals in across-year accumulation identities. When Schedule V data are available, the current year's beginning value of capital ($V182_t$) does not always equal the previous year's ending value ($V187_{t-1}$). Likewise, in the absence of Schedule V data, the standard accumulation identity $V7_t = V30_t + V7_{t-1}$ sometimes does not hold. Our examination of cases of large residuals in these identities (see again the discussion in the main text of the paper) leads us to believe that these residuals are typically not data errors, but instead are related to acquisitions and sales of companies or divisions. Accordingly, we include these across-year residuals in identity (*). Positive residuals are included in *Add_avg*. When we have data on retirements (V184), negative residuals are included in *Sub_avg*. Retirements are typically 10 times greater than negative residuals. Hence, in the absence of data on retirements, we attribute 90 percent of negative residuals to *Sub_old* and the balance to *Sub_avg*.