CAPITAL RESALABILITY, PRODUCTIVITY DISPERSION, AND MARKET STRUCTURE

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Abstract—We propose an industry-level index of capital resalability—the share of used capital in aggregate industry capital expenditure—that relates (inversely) to sunkenness of investments. Using data from U.S. manufacturing, we then test the effect of capital resalability on industry productivity dispersion, mean productivity, and industry concentration. As predicted by standard models of industry equilibrium with heterogeneous firms, we find that increases in capital resalability are associated with a reduction in productivity dispersion, and an increase in the mean and median of the productivity distribution. Furthermore, we find that capital resalability is negatively correlated with industry concentration.

I. Introduction

The extent of sunkenness of investment has important consequences for the behavior of economic agents in a number of different contexts. In particular, in models of industry equilibrium such as Hopenhayn (1992) and Melitz (2003), the sunk costs of entry play a critical role in determining the equilibrium cutoff productivity level and, hence, the dispersion and central tendency of the equilibrium productivity distribution. Sunk costs of entry also influence market concentration, as Sutton (1991, 1998) and others have investigated.

While the theoretical definition of sunk costs strictly excludes the resale value of investments (and, hence, are affected by the resalability of investments), empirical examinations of these predictions have generally ignored this important aspect, given data limitations and other difficulties in empirically measuring sunk costs (see the discussion in Sutton, 1991, pp. 93–99). Typically, investments in physical capital (usually in the median plant size) are used to proxy sunk costs (e.g., Sutton, 1991; Gschwandtner & Lambson, 2006). Although this is a useful proxy, it assumes that the recoverability of investments is constant across industries, which is unlikely to be the case (as discussed in Sutton, 1991). Another potential bias with this proxy for sunk costs, particularly in studies of market structure, is the possibility of a spurious positive correlation between market structure and the proxy (Sutton, 1991). Concentrated industries are likely to have larger firms, and thus estimates of observed median plant size may be biased upward.

In this paper, we draw on Schlingemann, Stulz, and Walkling (2002) and propose a new index of capital resalability at the industry level that meaningfully captures interindustry heterogeneity in the recoverability of investments. We define the capital resalability index as the fraction of total capital expenditure in an industry accounted for by purchases of used (as opposed to new) capital. We construct this index using detailed data on both new and used capital expenditures collected and published by the U.S. Census Bureau. In industries where capital is highly firm specific or there is no active secondary market in used capital equipment, we expect the low level of capital resalability to be reflected in a low share of used capital in total investment. Thus, our measure would capture capital resalability, which is an inverse measure of the extent of sunkenness of capital investments.

Given the relationship between capital resalability and sunkenness of investments, we expect capital resalability to be related to the mean and dispersion of productivity as well as concentration across industries. In standard models of industry equilibrium (e.g., Hopenhayn, 1992; Melitz, 2003), an increase in sunk entry costs leads to reduction in the cutoff productivity, implying an increase in the dispersion of productivity and a decrease in the mean and median of the productivity distribution. Sunk costs of entry also influence market concentration, though the theoretical prediction about the impact of sunk costs on concentration is somewhat ambiguous in both heterogenous (Hopenhayn, 1992) and homogeneous firm models (Sutton, 1991). Thus, the relationship between resalability of capital and concentration is an interesting matter for empirical enquiry.

We use data from public use U.S. Census data sets and a number of different sources to test the relationship between our capital resalability index (an inverse measure of sunk costs) and different measures of three variables of interest: dispersion in productivity, central tendency (mean and median) of the productivity distribution, and industry concentration. As predicted by standard heterogeneous firm industry equilibrium models, we find that our measure of capital resalability is negatively correlated with productivity dispersion and positively correlated with mean and median productivity. Also, we find that the capital resalability measure is negatively correlated with measures of concentration.

We perform a number of robustness tests on these results. First, we add a number of variables that the standard theory suggests may have on impact on the productivity mean and dispersion, as well as concentration. These variables include an index of sunk costs of entry proposed by Sutton (1991), an index of fixed costs (measured as the share of white-collar workers in total employment), measures of trade competition (share of output exported and share of imports in domestic sales), measures of product substitutability (from Syverson, 2004), and measures of advertising and

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R&D intensity. To control for industry-level differences in the persistence in productivity and some sources of endogeneity of the used capital share of investment, we also add a control for the (five-year) survival rate of firms in the industry. We find our results on the effects of capital resalability to be robust to the inclusion of all of these control variables. We also find our results robust to potential capital mismeasurement, using alternative measures of productivity dispersion and concentration, excluding high R&D and advertising-intensive industries, and performing the analysis separately for each cross-section.

To our knowledge, we are the first to examine the effect of capital resalability (as an inverse proxy for sunkenness of entry costs) on productivity dispersion and market concentration across industries. In the corporate finance literature, a similarly measured index of asset resalability was proposed by Schlingemann et al. (2002), who used it to study why firms divest particular businesses. This index has subsequently been used in other contexts in the corporate finance literature (e.g., to study capital structure; Sibilikov 2007). Compared to their measure, which is defined at the two-digit SIC level (using the relatively sparse corporate transaction data), one advantage of our measure is that it uses the much richer U.S. Census data on capital expenditure, which allows us to construct it at a much more disaggregated (four-digit SIC) level.

A limited number of studies have examined specific used capital markets to understand the extent of sunkenness of capital investments in those particular contexts. Asplund (2000) looked at the salvage value of discarded metalworking machinery and found that used machinery sales fetch only 20%–50% of the initial price once it is installed. Similarly, Ramey and Shapiro (2001), using equipment-level data from aerospace plant closings, found that capital in this industry sells for a substantial discount to replacement cost, with greater discounts for more specialized equipment.

Our paper is similar in spirit to that of Syverson (2004), which examined the effect of product substitutability on productivity dispersion. We use a similar set of control variables, but our focus is on the effect of capital resalability as a (inverse) measure of the sunkenness of investment on productivity dispersion. In addition, a large part of our work looks at the effect of capital resalability on concentration, which Syverson (2004) did not examine.[1] Our examination of the determinants of concentration is similar in spirit to Sutton (1991, 1998).

The rest of the paper is structured as follows. Section II presents a brief discussion of the theoretical motivation for our empirical work. Section III discusses the definitions of variables and data sources, with section IIIA focusing specifically on our capital resalability index and section IIIB discussing all other variables. Section IV presents the baseline results. Various other robustness tests are discussed in section V. Section VI concludes.

[1] In related work, Gavazza (2007) reports higher mean and less dispersion in capacity utilization for more liquid aircraft (that are easier to resell or release).

II. Theoretical Motivation

In this paper, we examine the relationship between the capital resalability index (which we propose as an inverse measure of sunk costs) and three variables of interest: dispersion in productivity, central tendency (mean and median) of the productivity distribution, and industry concentration.

A. *Sunk Costs and Productivity Distribution*

In standard heterogeneous firm models, one of the earliest of which is Hopenhayn (1992), the equilibrium productivity distribution within an industry is pinned down by the cutoff productivity parameter (x^*). In the Hopenhayn model, an increase in the sunk costs of entry leads to a decrease in the cutoff productivity level (x^*). This in turn implies that with an increase in sunkenness of investments, the central tendency measures (mean and median) of the equilibrium distribution decline while the equilibrium spread (or dispersion) in productivity goes up.

As Hopenhayn (1992) discussed, the intuition for this result is that the sunk cost of entry acts as a barrier to entry, protecting incumbent firms. More specifically, the larger the sunk entry costs, the greater should the expected value function be, which requires a higher average price level to prevail in equilibrium. The higher average price level allows some relatively inefficient firms to cover their fixed costs. Note that these firms may not necessarily make a good return on their entry costs, which in this model they incur on entry, before they know their true productivity levels. However, having already incurred these sunk costs of entry, the inefficient firms will choose to remain in the market as they are able to cover their recurring costs at the prevailing price level.

The same predictions about the impact of sunk costs on the cutoff productivity level are obtained in other heterogeneous firm models in the literature (e.g., Syverson, 2004; Melitz, 2003; Asplund & Nocke, 2006).

B. *Sunk Costs and Concentration*

In the Hopenhayn (1992) and related models, the effect of an increase in sunk entry costs on the size distribution of firms, and hence on concentration measures, is ambiguous. The reason for the absence of a general result is that an increase in sunk entry costs leads to an increase in the overall price level in equilibrium (as the expected value of entry needs to increase to cover the extra entry costs). This causes an increase in output for every surviving firm (conditional on their productivity level). The increase in price level also leads to a drop in overall market demand. This drop in aggregate demand and increase in output for each surviving firm suggests that the mass of firms would go down. Hopenhayn (1992) terms this the *price effect.* However the increase in the sunk costs also reduces the cutoff productivity level, bringing in a part of the productivity distribution that was not within the band of survivors when the entry costs were low. Since this part of the distribution could in general have any shape, this could correspond to a large mass of small firms, causing an increase in the equilibrium number of firms. Hopenhayn terms this the *selection effect.* In theory, the net effect of sunk costs on concentration measures depends on the properties of the productivity distribution and the production function.[2]

Thus, we view the impact of entry costs on concentration as an interesting question for empirical inquiry. If we find that concentration decreases with capital resalability, this would imply that the price effect dominates the selection effect in the data.[3]

III. Definition of Variables and Data Sources

A. Capital Resalability Index

We define our index of capital resalability as the share of used capital investment in total capital investment at the four-digit SIC aggregate level. We propose this index as a valid measure of physical capital resalability based on the supposition that in industries where capital expenditure incurred by firms is not firm specific, and where there is an active secondary market for physical capital, it is likely that used capital would form a relatively higher share of total investment. Thus, we expect our capital resalability index to be an inverse measure of the degree of sunkenness of investment across industries.

To see how our measure may be a good proxy for (the inverse of) the sunkenness of investments, consider an industry in stationary long-run equilibrium with a finite number of firms. At that equilibrium, the number of firms stays constant, as a fraction of firms exit and an equal number enter the market in every period. Assume for now that capital investments are made only by entering firms. If the investments required to enter the industry are extremely specific to each firm (and hence completely "sunk"), none of the expenditure on capital equipment made by entering firms would come from the sales of capital equipment by exiting firms. Thus, our capital resalability index would be zero in this industry. On the other hand, if capital is completely general and there is an active market in used capital (so that capital investments are not "sunk"), then a large fraction of the capital investment made by entering firms would be accounted for by used capital purchased from exiting firms. Hence, if entry costs are sunk due to the specific nature of the investment or the lack of an active secondary market, our capital resalability measure will be low; if capital is not specific and there is an active secondary market, our capital resalability measure will be high. This logic can be extended to investments in expansions and asset sales by existing firms by considering these as equivalent to entry and exit into subsegments of the industry.

Another justification for using our measure as a proxy for (low) sunkenness is suggested in Schlingemann et al. (2002). They define the asset liquidity index for an industry (at the two-digit SIC code level) as the ratio of the value of the industry's corporate transactions to the value of the industry's total assets.[4] To justify the use of their index, they cite the argument, proposed by Shleifer and Vishny (1992), that a high volume of transactions in an industry is evidence of high liquidity. Shleifer and Vishny argue that in a more active market, the discounts that a seller must offer to attract buyers would be lower. This argument is also relevant for us, as it suggests that in an industry with an active secondary market (as reflected in our measure), the amount of initial capital outlays lost to discounts is likely to be lower.

Our measure addresses a key weakness of using the size of physical capital investments as a proxy for sunk entry costs (e.g., Sutton, 1991; Syverson, 2004; Gschwandtner & Lambson, 2006). Sutton (1991) defines a proxy for sunk setup cost as the product of the market share of the median plant and the industry capital-sales ratio. This measure is intended to capture the investment required to set up a new firm (as a proportion of industry sales). As Sutton (1991) discussed, one potential weakness of such a proxy is that it assumes that the proportion of initial outlays that can be recovered at exit is constant across industries, or at least that the proportion of costs that are recoverable do not vary in a systematic way with the structure of the market. Our measure specifically aims to capture the recoverability of investments required to operate in a specific industry and, hence, directly addresses the concern that recoverability may differ from industry to industry. The need to account for differing recoverabilities across industries is apparent from figure 1, which plots our measure (the share of used capital investments in total capital expenditure) against the index of sunk costs that Sutton (1991) used. It is evident that the correlation between the two measures is not very high (about -0.19). In fact, a number of industries have a high sunk cost index but also potentially a high capital recoverability, as indicated by the high share of used capital in capital investments (similarly, there are many industries with low sunk cost indices and low capital recoverabilities).

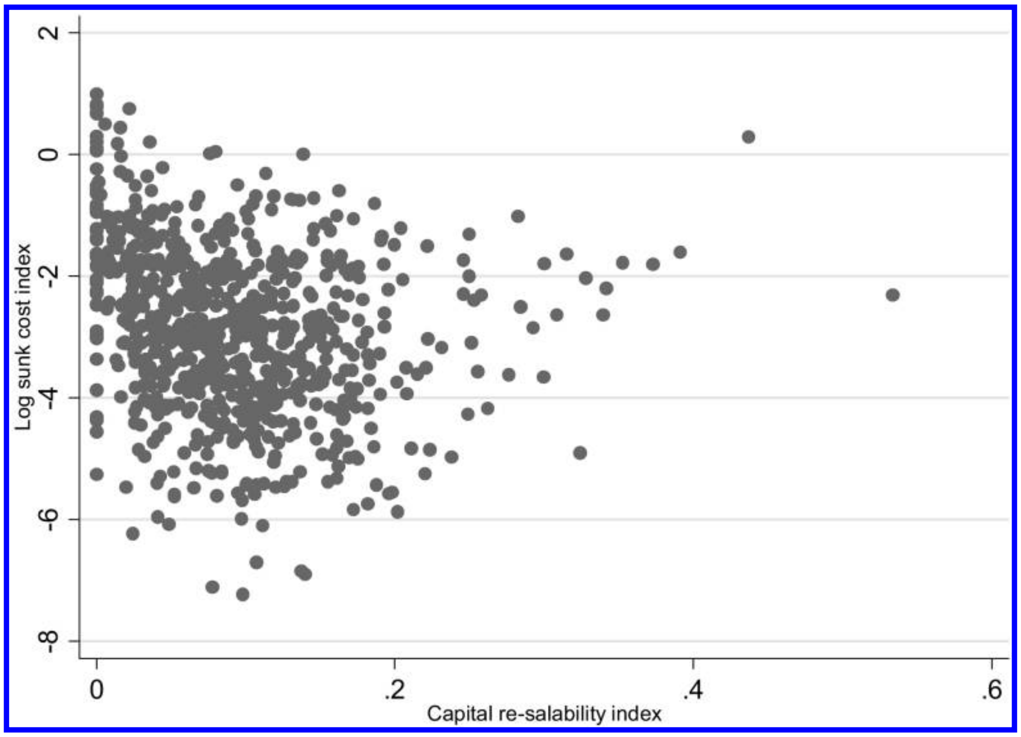
Before we turn to a description of the various variables used in the study, we discuss a couple of outside factors

[2] As Sutton (1991) discussed, even in models without firm heterogeneity, the relationship between sunk costs and concentration depends on the specifics of the model. For instance, Sutton (1991) presents a Cournot model, which suggests an increase in concentration with sunk costs, and a Bertrand competition model, where only one firm enters in equilibrium, for any positive level of sunk entry cost.

[3] In the working paper version of this paper (Balasubramanian & Sivadasan 2007), we show that under certain empirically plausible assumptions about the productivity distribution and production function, the price effect dominates the selection effect, so that concentration increases with sunk costs.

[4] While the numerator in this measure is similar to ours, we normalize our index by total investment for the year, while they use total capital stock.

Figure 1.—Sutton (1991) Sunk Cost Index Versus Capital Resalability Index



(potentially unrelated to capital resalability or sunkenness) that could affect our measure. One such factor is cross-industry sales of used capital, which could introduce some noise into this index, particularly when it is used as a measure of industry specific sunkenness.[5] However, this measurement error is unlikely to be correlated with market structure or the mean and dispersion of productivity dispersion, and hence is likely only to bias our coefficients toward 0. Another plausible source of measurement error would be cyclical changes in the share of used capital in total investment. It is possible that there is increased availability of used capital in downturns and less availability during booms. Hence, a component of our capital resalability measure may be countercyclical. Again, we expect this measurement error to be uncorrelated with our dependent variables of interest and hence likely to bias the coefficient on our index toward 0.[6]

Finally, an important point to note is that an increase in resalability of capital reduces the sunkenness of up-front investments and concurrently translates to an increase in per period fixed costs (in the form of higher opportunity costs.)[7] Interestingly, in the Hopenhayn (1992) and related models (e.g., Melitz, 2003; Syverson, 2004; Asplund & Nocke 2006), an increase in fixed cost has the same effect as a decrease in sunk entry costs. The intuition is that higher fixed costs make it difficult for inefficient firms to be profitable, leading them to exit in equilibrium. Thus, in general, the capital resalability index could be viewed as either an (inverse) measure of the sunkenness of investments or a (direct) measure of fixed costs. However, in either case, the predicted effect of changes in resalability on the mean and dispersion of productivity is the same.

To compute the proposed index of capital resalability, we obtained data on used and new capital expenditure at the industry level from public use data sets at the U.S. Census Bureau for the census years 1987 and 1992.[8] The Annual Survey of Manufactures and Economic Census questionnaires collect detailed information on capital expenditures from the respondents. Specifically, establishments are asked

[5] Note that cross-industry capital sales from industry A to industry B do not necessarily bias this measure for industry B, as this could indicate flexibility in the uses of the capital in industry B. However, such sales could bias the index for industry A, as the ability to sell capital from A to B may not be reflected in our measure.

[6] In our case, we have two annual cross-sections of data and test for robustness to looking at each cross-section separately. In other applications, where many years of data are available, users of our capital resalability index could purge cyclical factors by forming an industry mean resalability index that smoothes over different parts of the business cycle.

[7] We thank one of the referees for raising this point. Another context where reduction in sunk costs could translate to an increase in fixed costs is if improvement in capital markets leads to greater availability of outside capital. In this case, the up-front sunk equity investment would be replaced by the increased per period fixed costs of outside debt finance.

[8] This choice of years (1987 and 1992) was dictated by the fact that detailed capital expenditure data were available in electronic format only from 1987 to 1995, and 1987 and 1992 were the only two economic census years during this period. Since the productivity and concentration measures were available only for economic census years, the analysis was restricted to 1987 and 1992.

TABLE 1.—SUMMARY STATISTICS

Variable	N	Mean	s.d.	p25	p50	p75
Capital resalability index	925	0.088	0.069	0.039	0.078	0.121
Productivity dispersion measures						
TFP p25 − p75 (Solow)	760	0.265	0.100	0.209	0.246	0.296
TFP variance (Solow)	760	0.106	0.062	0.070	0.093	0.125
Central tendency measures						
TFP mean (Solow)	760	1.604	0.273	1.450	1.631	1.783
TFP median (Solow)	760	1.557	0.278	1.402	1.591	1.737
Concentration measures						
C8 ratio	923	51.859	23.256	34.000	51.000	69.000
Herfindahl index	923	0.685	0.645	0.212	0.471	0.929
Other control variables						
Sutton sunk-cost index	760	0.140	0.269	0.023	0.057	0.152
Industry fixed-cost index	760	0.288	0.103	0.217	0.267	0.341
Trade variables						
Share of total output exported	904	0.087	0.089	0.021	0.058	0.129
Share of imports in industry sales	904	0.132	0.149	0.026	0.088	0.166
Substitutability variables						
Dollar value per pound	896	0.005	0.012	0.001	0.002	0.004
Diversification index	924	0.135	0.086	0.071	0.119	0.183
Advertising intensity	1,153	0.034	0.043	0.016	0.024	0.042
R&D intensity	1,159	0.030	0.149	0.006	0.014	0.032
Industry survival fraction	750	0.543	0.137	0.453	0.546	0.638

Note: The table presents summary statistics for the variables used in this study. TFP is a Solow residual computed using industry average input shares. Sutton sunk-cost index follows the definition in Sutton (1991). Industry fixed-cost index is the share of nonproduction workers in total employment. Dollar value per pound and diversification index are taken from Syverson (2004). Advertising and R&D intensity defined as the ratio of advertising and R&D expenditures to industry sales. Industry fraction survival refers to the fraction of firms in one census year that survive until the next census year.

to report total capital expenditure, as well as a breakdown of the expenditure between new capital investment and used capital investment. Our index is defined simply as the ratio of used capital expenditure to total capital expenditure.[9]

Summary statistics on the capital resalability measure are presented in table 1. The mean share of used capital in total investment is about 8.8%. There is reasonable heterogeneity in the measure across industries, as reflected in the standard deviation of about 6.9% and the interquartile (p75 − p25) difference of about 8.2%. This is also reflected in table 2, which presents the mean used capital share (over the two years of data 1987 and 1992) for the bottom as well as top ten four-digit SIC industries. The industry with the largest fraction of used equipment investment is Oil and Gas Field Machinery and Equipment, at 34.62%. The lowest used capital share is 0, which is the case for Carbon Black, Cellulosic Manmade Fiber, Inorganic Pigments, and Fine Earthenware.

B. *Productivity, Concentration, and Other Variables*

Productivity dispersion and central tendency variables are estimated using economic data from the U.S. Census Bureau.[10] For our baseline analysis, we estimate TFP as the Solow residual defined as follows:

$$TFP_{it}^{Solow} = y_{it} - \alpha_m m_{it} - \alpha_k k_{it} - \alpha_l l_{it},$$

where y_{it} is the log revenue (in 1987 dollars) of firm i in year t, m is log material cost (in 1987 dollars), k is capital stock (in 1987 dollars), and l is the number of employees. Industry-level deflators are taken from the NBER/CES productivity database (Bartelsmann & Gray, 1996). The elasticities α_m, α_k, and α_l are defined equal to the material share, including energy and fuel (s_j^m), capital share (s_j^k), and labor share (s_j^l) of total costs in the industry j to which firm i belongs. These input shares are obtained from data at the U.S. Census Bureau and are based on wage bills and materials costs reported at the firm level in the economic census data sets (see Chiang, 2004, for details). As part of robustness checks, we examine a couple of alternative TFP measures (see the discussion in section VB).

The primary productivity dispersion measures that we use are the interquartile range, that is, the difference between the TFP at the 75th and 25th percentiles of the distribution (scaled by the industry median productivity) and the variance in TFP (scaled by the industry mean productivity). We use the mean and median as central tendency measures.

Information on different measures of concentration at the four-digit SIC code level for the 1987 and 1992 economic census years was obtained from public use census data from the ASM and the quinquennial economic censuses purchased from the U.S. Census Bureau. The two measures of concentration we use in our baseline analysis are the C8 ratio (the share of industry shipping accounted for by the largest eight firms) and the Herfindahl-Herschmann index (calculated by summing the squares of the individual company market shares for the fifty largest companies or the universe, whichever is lower). We normalize the Herfindahl-

[9] The establishments also report capital investment data separately for two subcomponents: buildings and structures, and plant and equipment. Results were somewhat similar but weaker if we used the used capital share of either subcomponent of total capital expenditure.

[10] The dispersion measures and the following control variables—the Sutton sunk cost index, fixed cost index, primary product specialization ratio, and industry fraction survival—were originally estimated using establishment-level economic census data and disclosed for public use in a separate project on the effect of learning on productivity dispersion (see Balasubramanian 2007).

TABLE 2.—INDUSTRIES WITH HIGH AND LOW CAPITAL RESALABILITY

SIC Code	Industry Description	Mean Capital Resalability Index
Ten industries with lowest capital resalability index		
2895	Carbon Black	0.00%
2823	Cellulosic Manmade Fibers	0.00
3263	Fine Earthenware (Whiteware) Table and Kitchen Articles	0.00
2816	Inorganic Pigments	0.00
2822	Synthetic Rubber	0.08
2861	Gum and Wood Chemicals	0.14
2812	Alkalies and Chlorine	0.28
2083	Malt	0.36
2044	Rice Milling	0.41
3691	Storage Batteries	0.44
Ten industries with highest capital resalability index		
3021	Rubber and Plastics Footwear	21.41
2399	Fabricated Textile Products, NEC	21.48
3549	Metalworking Machinery, NEC	21.49
2311	Men's and Boys' Suits, Coats, and Overcoats	21.55
3322	Malleable Iron Foundries	21.88
2436	Softwood Veneer and Plywood	22.35
3325	Steel Foundries, NEC	22.46
2449	Wood Containers, NEC	24.04
3412	Metal Shipping Barrels, Drums, Kegs, and Pails	24.56
2053	Frozen Bakery Products, Except Bread	24.61
3533	Oil and Gas Field Machinery and Equipment	34.62

Note: This table reports the average (over 1987 and 1992) of the capital resalability index (defined as the used capital share of investment) for the ten industries with largest and smallest capital resalability index.

Herschmann by a factor of 1,000 so that the maximum possible value, which occurs if a single firm has 100% market share, is 10 ($100^2/1,000$). We tested the robustness of our results using three alternative concentration measures: the C8 ratio (share of largest eight firms), the C20 ratio (share of largest twenty firms), and the C50 ratio (share of largest fifty firms).

Data on other control variables were obtained from a variety of sources. The source for each is discussed along with their definitions below. For a discussion of how each of these variables is expected to affect the mean and dispersion of productivity, and concentration in the industry, refer to section VA.

The Sutton sunk cost index is defined as the product of the industry capital output ratio and the market share of the median size firm in the industry. Sutton (1991) proposed this variable as an index of the initial setup cost; it is used to proxy for the capital investment (relative to the market size) required to set up a plant of minimum efficient scale (MES), assuming that the size of the median size firm approximates the MES plant.[11]

The industry fixed cost index is defined, following Syverson (2004), as the share of white-collar (nonproduction) workers in total employment. Since white-collar workers represent overhead labor, their share is expected to proxy for the relative size of production-related fixed costs. Both the sunk cost and fixed cost indices are defined as ratios to remove industry-specific scale effects. The data source for defining these variables was the U.S. Census Bureau's economic census databases for 1987 and 1992.

The share of total output exported is defined as the total value of exports of an industry divided by the total value of shipments (revenue) of the industry. Import intensity is defined as the total imports into an industry divided by the sum of industry output and imports. Data on imports and exports were obtained from Robert Feenstra's Web site.[12]

We use four variables to proxy for substitutability, based on Syverson (2004). Dollar value per pound is the log of the weighted sum of the dollar-value-to-weight ratios of all the product classes in a given four-digit industry, where the weights are the product classes' shares of the total industry tonnage shipped. The share of output shipped less than 100 miles is defined as the total value of output shipped less than 100 miles divided by the total value of shipments. These two variables depend on the magnitude of transport cost and represent proxies for geographic substitutability. These were constructed from the 1977 Commodity Transport Survey (CTS) (U.S. Bureau of the Census, 1980).[13]

The third measure (a diversification index) is a generalized Herfindahl-type measure that takes into account the number of products (defined by finer levels of SIC classification codes), the production shares of product lines within the industry, and the dissimilarity of products as measured by the input shares of various intermediate products used to make them. A relatively higher value for this index is expected to reflect a relatively greater degree of product differentiation in the industry.

The fourth, primary product specialization ratio, is the average of the share of revenue accounted for by the primary product class for the firms within each industry. This variable was constructed using data from the U.S. Census Bureau's economic census data sets. As Syverson (2004) discussed, this measure is a somewhat crude proxy for the degree of differentiation in an industry.

Advertising intensity is defined as total advertising expenditure in an industry divided by total revenue. Similarly, R&D intensity is defined as total R&D expenditure in an industry divided by total revenue. Both variables were constructed using data from Compustat, a database that has financial statement data on all listed U.S. firms. Data on advertising and R&D in Compustat have a number of missing values, as many firms do not report advertising and R&D expenditures separately in their financial statements.

[11] This measure is also used in Syverson (2004). Refer to Sutton (1991, pp. 93–99) for a detailed discussion of the pros and cons of this measure.

[12] http://cid.econ.ucdavis.edu/. For more detailed documentation, see Feenstra, Romalis, and Schott (2002).

[13] Refer to Syverson (2004) for a detailed description of the construction of the value-to-weight ratio. We thank Chad Syverson for generously providing the data to construct three of the four substitutability variables: dollar value per pound, share of output shipped by different distance categories, and the Gollop-Moynahan diversification indices.

TABLE 3.—BASELINE ESTIMATES

	Dispersion		Central tendency		Concentration	
	TFP p25 − p75	TFP Variance	TFP Mean	TFP Median	C8 Ratio	Herfindahl Index
Capital resalability index	−0.347**	−0.187**	0.587**	0.597**	−118.063**	−3.051**
	(0.072)	(0.043)	(0.173)	(0.173)	(15.437)	(0.396)
Constant	0.297**	0.123**	1.55**	1.502**	62.25**	0.953**
	(0.010)	(0.006)	(0.023)	(0.024)	(1.628)	(0.048)
Observations	756	756	756	756	923	923
R^2	0.06	0.04	0.02	0.02	0.12	0.11
Number of clusters	381	381	381	381	459	459

Note: The table presents the coefficients when measures of dispersion, central tendency, and concentration regressed on capital resalability. Standard errors are clustered at the four-digit industry level. **Significance at 1%.

Given the sparseness of data, we form these indices at the three-digit SIC level.

Finally, the industry survival fraction is defined as the fraction of firms in the 1982 and 1987 census years that still survive five years later, in the 1987 and 1992 census, respectively. This variable was constructed using U.S. Census Bureau's economic census data sets.

Table 1 presents summary statistics on the main variables used in our analysis. The data we analyze comprise two cross-sections (1987 and 1992) of four-digit SIC-level data. For each of the variables, a few industries in one or both of the years could be missing due to Census Bureau confidentiality restrictions. For most variables, we have data on about 380 SIC four-digit industries for each of the two years. Clearly, residuals could be correlated within each industry across the two cross-sections. To account for this, throughout our analysis in the following sections, we cluster standard errors at industry level; the number of clusters reported indicates the number of four-digit industries for which data are available on all the variables used in the particular regression specification.

Note that the dispersion measures are scaled by central tendency measures (following Syverson, 2004). Specifically, the interquartile range is scaled by the median, and the variance is scaled by the mean productivity. The mean interquartile range in TFP is about 26.5% using the Solow measure. We found these magnitudes to be similar across different alternative ways of measuring productivity.

IV. Baseline Results

In the baseline specification, we examine the effect of capital resalability on the following six dependent variables: (a) two measures of dispersion in TFP—the interquartile range (normalized by the median) and the variance (normalized by the mean); (b) two measures of the central tendency of the productivity distribution—the mean and the median; and (c) two measures of concentration—the C8 ratio, that is, the share of the largest eight firms in total industry revenue, and the Herfindahl index.

The regression results are summarized in table 3. We find that as predicted by the theory, our capital resalability index is highly negatively correlated with both measures of dispersion. A one standard deviation (0.069) increase in the capital resalability index is associated with a drop of 0.024 (0.069×0.347) in the interquartile range. This is about a quarter of the standard deviation in the interquartile range. Similarly a one standard deviation increase in the resalability index is associated with a reduction in the variance measure by about 21% of its standard deviation.

Also, as predicted by the theory, variations in capital resalability are associated positively with the central tendency measures. A one standard deviation increase in the resalability index is associated with about 4% increase in both the mean and the median, which is about 14.5% of the standard deviation of the central tendency measures.

Finally, the resalability measure is strongly negatively correlated with the concentration measures, suggesting that empirically, the price effect dominates the selection effect in the Hopenhayn (1992) model of industry equilibrium. A one standard deviation increase in the resalability index reduces the C8 ratio by about 8.1%, about 34.9% of the standard deviation of the C8 ratio. Similarly, a one standard deviation increase in the resalability index is associated with a reduction in the Herfindahl index of about 32.5% of its standard deviation.

All the measured effects are highly statistically significant. As noted earlier, all standard errors are clustered at the four-digit industry level.

V. Robustness Checks

A. *Robustness to Inclusion of Other Variables*

Standard heterogeneous firm industry equilibrium models such as those of Hopenhayn (1992) suggest that a number of other factors could affect productivity mean and dispersion, and potentially industry concentration. If these factors are correlated with our capital resalability measure, the estimated effects in section IV may be biased due to omission of these variables. In this section, we check for the robustness of the baseline analysis in section IV to including a number of control variables.

First, we include another index of industry sunk costs proposed by Sutton (1991; see the discussion in section IIIA). Analogous to our inverse measure, we expect this measure to be positively correlated with dispersion, negatively correlated with central tendency, and positively correlated with concentration.

Second, the magnitude of fixed costs is another factor that could affect productivity dispersion and concentration; fixed costs of operation are expected to have an opposite effect on dispersion as sunk costs (Hopenhayn, 1992). As discussed in section IIIA, a reduction in sunk costs may directly lead to an increase in fixed (opportunity) costs, and therefore the capital resalability index can be interpreted as a measure of relative levels of fixed costs. However, we would like to control for other sources of differences in fixed costs across industries. Unfortunately, as discussed in Syverson (2004), a good empirical proxy for the fixed costs of operation is difficult to construct. Nevertheless, we use a proxy for fixed cost that Syverson (2004) proposed—the white-collar share of total employment—as it is likely to represent overhead labor, which is related to fixed costs.

Third, increased competition from trade could be expected to lead to lower prices and an increase in the cutoff productivity level (Melitz, 2003). With respect to concentration, in general an increase in the degree of competition could be expected to reduce the number of firms (or equivalently increase concentration) in equilibrium (Sutton, 1991).

Fourth, Syverson (2004) shows that an increase in product substitutability increases the cutoff productivity level, thus lowering productivity dispersion and increasing the central tendency measures. To control for potential bias from omitted product substitutability, we checked the robustness of our results to including four different product substitutability measures used in Syverson (2004).[14] As in Syverson (2004), for the sake of brevity, we focus on results from using the two proxies (one for geographic substitutability and one for physical product substitutability) that are least susceptible to measurement problems. The proxy for geographic substitutability that we use is the dollar value per pound; the higher this measure is, the lower transportation costs are likely to be as a fraction of the value of the goods. Hence, industries with a high dollar value per pound can be expected to have less segmented markets and therefore greater geographic substitutability. The measure of physical product substitutability we use is the Gollop and Monahan (1991) diversification index. The larger this index is, the greater would be the degree of product differentiation and, hence, the lower would be the degree of substitutability between products of different firms within the industry.

Fifth, Sutton's (1991, 1998) work highlights the impact of endogenous sunk costs on market structure. Although there is no robust cross-sectional prediction across different classes of models, the differences in relative levels of endogenous sunk costs could be expected to affect equilibrium concentration.[15] Hence, we check for the robustness of our baseline results to the inclusion of two common types of endogenous sunk costs: advertising and R&D expenses. These variables are measured as the ratio of expenses to revenue to normalize for industry scale effects. Although endogenous sunk costs are not explicitly modeled in standard heterogeneous firm models, we could expect higher levels of these costs to have an effect similar to that of an increase in the sunk entry cost parameter. However, higher advertising and R&D intensity may proxy for higher levels of unmeasured intangible capital, which could be associated with higher levels of measured TFP.[16]

Finally, heterogeneous firm models such as Asplund and Nocke (2006) and Melitz (2003) show that an increase in the persistence of the productivity shocks increases the cutoff productivity level. One way to control for potential differences in the persistence of productivity that Syverson (2004) suggested is to use the industry survival rate (defined for convenience as the fraction of firms in an industry five years ago—i.e., in the previous census year—that survives today). If productivity shocks are persistent, this would be reflected in a higher survival rate.

We have an additional motivation for using the industry survival rate as a control variable. It could be argued that a used capital market is likely to be better developed for industries that see a lot of firm turnover (entry and exit). In the Hopenhayn (1992) model, an increase in the cutoff productivity level would also lead to greater turnover.[17] Thus, omitted (or imperfectly measured) variables (e.g., fixed costs) could be negatively correlated with productivity dispersion and positively correlated with amount of firm turnover and, hence, with our capital resalability index. Since this channel of bias works through firm turnover, including the industry survival fraction (which measures firm turnover rate) provides a good way to control for this bias.[18]

In table 4, we look at the robustness of the baseline results to including all the control variables discussed above. As seen here, the coefficients on capital resalability index variable continue to be highly statistically significant. Also,

[14] One of the measures Syverson used is advertising intensity, which we examine separately. Refer to Syverson (2004) for a detailed discussion of the various product substitutability measures that we use here.

[15] Sutton focuses on the robust (across different classes of models) prediction that in industries where endogenous sunk costs are important, there exists a nonzero lower bound to the equilibrium level of concentration in the industry, even as the market size becomes very large.

[16] Also, Syverson (2004) argues that advertising intensity (defined as the advertising expenditure per dollar of revenue) could be a plausible proxy for product differentiation. Accordingly, a relatively higher level of advertising intensity would indicate lower substitutability and hence a lower productivity cutoff.

[17] The intuition behind this is that with a higher cutoff, a lot of the firms that pay the entry costs are forced to exit on realization of their productivity. Also, the fraction of surviving firms that receive a bad enough draw that they have to exit increases as the cutoff productivity increases.

[18] In a stationary equilibrium (i.e., with a constant total number of firms over time), the industry survival fraction would be negatively correlated with the industry firm turnover rate, defined as the fraction of firms entering and exiting the market. Empirically, industry exit and entry rates are indeed highly correlated, so a high survivor rate would be negatively correlated with turnover rate.

TABLE 4.—ROBUSTNESS TO INCLUSION OF OTHER CONTROLS

	Dispersion		Central Tendency		Concentration	
	TFP p25 − p75 Range	TFP Variance	TFP Mean	TFP Median	C8 Ratio	Herfindahl Index
Capital resalability index	−0.314**	−0.188***	0.547***	0.613***	−102.057***	−2.717**
	(0.094)	(0.057)	(0.178)	(0.181)	(17.988)	(0.485)
Sutton sunk-cost index	0.05***	0.01	−0.175***	−0.162***	24.451***	0.636***
	(0.017)	(0.012)	(0.062)	(0.064)	(7.577)	(0.229)
Industry fixed-cost index	0.13**	0.133***	−0.05	−0.023	−42.99***	−1.311***
	(0.062)	(0.034)	(0.208)	(0.221)	(14.483)	(0.372)
Share of total output exported	0.11	0.013	−0.42**	−0.352**	31.417**	0.579
	(0.081)	(0.048)	(0.191)	(0.206)	(13.827)	(0.416)
Share of imports in industry sales	0.017	0.028	0.269***	0.207*	3.185	−0.245
	(0.033)	(0.021)	(0.101)	(0.106)	(7.534)	(0.226)
Dollar value per pound	−0.506	0.033	3.59	3.707**	145.306	6.204
	(0.822)	(0.644)	(2.206)	(2.155)	(108.911)	(5.941)
Diversification index	0.215**	0.116*	−0.517**	−0.527**	44.709***	1.145***
	(0.093)	(0.062)	(0.213)	(0.223)	(14.613)	(0.440)
Advertising intensity	0.408**	0.236**	0.448	0.408	14.978	0.766
	(0.111)	(0.090)	(0.463)	(0.480)	(32.841)	(0.904)
R&D intensity	−0.004	−0.065	1.123	1.185	126.679*	4.949*
	(0.294)	(0.204)	(0.763)	(0.822)	(66.128)	(2.518)
Industry survival fraction	0.031	0.006	−0.566***	−0.555***	23.904***	0.706**
	(0.038)	(0.023)	(0.128)	(0.130)	(9.133)	(0.341)
Constant	0.183***	0.055***	1.904***	1.837***	41.787***	0.466**
	(0.033)	(0.019)	(0.096)	(0.098)	(8.126)	(0.230)
Observations	514	514	514	514	514	514
R^2	0.15	0.12	0.26	0.24	0.34	0.3
Number of clusters	266	266	266	266	266	266

Note: This table presents coefficients when other control variables are added to the regressions in table 3. Standard errors are clustered at the four-digit industry level. *Significant at 10%. **Significant at 5%. ***Significance at 1%.

the magnitude of the coefficients is only slightly smaller than in the baseline case discussed in section IV.

The Sutton sunk cost index is significant in five out of the six cases, with the signs consistent with theoretical predictions. The fixed cost index is positively correlated with dispersion, which is contradictory to the predicted effect and suggests that this index may not be a good proxy for the theoretical fixed cost parameter. The fixed cost index is also negatively correlated with concentration.

The share of exports is generally insignificant, except for a negative coefficient in the central tendency regressions, and a positive correlation with one of the concentration measures. Share of imports is positively correlated with mean and median productivity (as expected). The dollar value per pound is generally not significant except for a positive coefficient in the median TFP regressions (consistent with theory). The diversification index is significant in all columns and has the predicted sign for the TFP dispersion and central tendency regressions. Diversification is positively correlated with concentration. Advertising intensity is significantly positively correlated with dispersion, which is consistent with viewing it as increasing the barrier to entry. R&D intensity is significant only in the concentration regressions: higher R&D intensity is associated with more concentrated industries. Higher productivity persistence measured using the industry survival fraction is associated with a lower central tendency measure, which is consistent with predictions of Hopenhayn (1992).

B. *Other Robustness Checks*

We undertook a number of other robustness checks, the results of which are available on request from the authors.[19] First, as in Syverson (2004), we addressed potential mismeasurement in capital due to capacity utilization by adopting a TFP estimation procedure that Basu and Kimball (1997) suggested. We found our results robust to using the Basu-Kimball measure of TFP.

Second, we looked at an alternative measure of dispersion—the difference between the 90th percentile and the 10th percentile of the (Solow) TFP measure—as well as three alternative measures of concentration: the C4 ratio (share of the 4 largest firms in industry revenue), the C20 ratio (share of the 20 largest firms), and the C50 ratio (the share of the 50 largest firms). We found that the results on the capital resalability measure are robust to looking at these alternative measures.

Third, we examined an alternative TFP measure, defined as the residual from the regression of log real revenue on log real material costs, log real capital stock, and log employment. We found that the coefficients on the capital resalability index in the dispersion regressions continue to be highly statistically significant. While the sign was the same

[19] Many of the results are reported in an earlier working paper version of this paper (Balasubramanian & Sivadasan, 2007), available at http://webuser.bus.umich.edu/jagadees/.

as in the baseline regressions, the coefficient was not statistically significant for the mean or median regressions.

Fourth, we looked at alternative ways to scale the dispersion measure (using the mean to scale the interquartile range and the median to scale the variance measure), and obtained very similar results to those in table 4. Fifth, though we control for within-industry correlation by clustering the standard errors at the industry level, we checked for robustness of our results to running the regressions separately for each cross-section (1987 and 1992). We found our results robust, which is not surprising given that most of our variables are highly correlated between the two cross-sections.

Finally, to rule out potential biases from including endogenous sunk-cost intensive industries, we ran the regressions excluding the top quartile of R&D-intensive and advertising-intensive industries and found our results to be robust to this check.

VI. Conclusion

We propose an index of physical capital resalability, defined as the share of used capital in total capital expenditure. This is measured using annual data on used and new capital at the four-digit SIC code level published by the U.S. Census Bureau. We argue that the variation in this measure of capital resalability across industries would be negatively correlated with the sunkenness of entry outlays across industries. As predicted by theory (Hopenhayn, 2002; Melitz, 2003), we find that our capital resalability measure is negatively correlated with productivity dispersion and positively correlated with mean and median productivity. In theory, the impact of sunk entry costs on concentration is ambiguous, and hence is an empirical question. Our tests indicate that the capital resalability measure is strongly negatively correlated with industry concentration. We find our empirical results robust to a number of different checks.

As discussed earlier, our measure of capital resalability could be affected by two factors unrelated to capital resalability or sunkenness: cross-industry sales of equipment and business cycle factors. We do not expect either of these potential sources of measurement error to be systematically related to the mean or median or dispersion of productivity or to concentration. Hence, we expect these factors to bias our results downward, so that our coefficients may understate the true impact of capital resalability.

Based on our findings, we conclude that our capital resalability measure is a useful proxy for the (inverse of) sunk costs. Hence, our measure could be of use in a number of contexts where the sunk costs of investment play an important role. For example, in the literature on the theory of the firm, asset specificity plays an important role in vertical integration decisions (Williamson, 1975; Klein, Crawford, & Alchian 1978). Specificity of capital investments also could affect rent sharing between workers and shareholders and labor contracts in general (Malcomson, 1997). Also, a measure similar to ours has been used in the corporate finance literature to study why firms divest (Schlingemann et al., 2002) and to examine capital structure choices (Sibilkov, 2007).[20]

Our results should be interpreted subject to the caveat that as for any other cross-industry study, there could be a number of sources of industry heterogeneity that may bias our results. We attempt to control for many of the influences identified in the theoretical and empirical literature. While some of these controls may be imperfect, the strong robustness of our results suggests that they are not severely affected by the factors that we try to control for.[21]

Finally, while our focus here is on the effect of capital resalability, our empirical tests also document some interesting regularities in the relationship between some of the other control variables and the dependent variables. The results for these control variables (e.g., the result that substitutability is negatively correlated with concentration) may be of independent interest to readers.

[20] A lowering of sunk costs due to an increase in resalability translates to higher per-period fixed (opportunity) costs of operating in the industry; hence the resalability index can alternatively be interpreted as (direct) measure of fixed costs.

[21] Given the concerns about valid proxies for theoretical parameters and potential omitted variables, some researchers have expressed "skepticism about the value of searching for statistical regularities that hold across a broad run of industries" (Sutton 1991, p. 6). We agree with Sutton that "this view is unduly pessimistic" and risks abandoning "a central part of the traditional agenda of [industrial organization], which concerns the investigation of regularities of behavior that hold across the general run of industries" (Sutton, 1991, pp. 6–7). Two approaches to deal with the issue of unobserved industry heterogeneity are to either examine industries across countries (as in Sutton, 1991) or to look at changes within industries over time. Unfortunately, data limitations preclude serious use of either approach. Looking at within-industry changes over time could control for a number of industry-level factors that are constant over time. A limited test regressing changes in the capital resalability measure between 1987 and 1992 on changes in dispersion, productivity mean, and concentration did yield results consistent with our results here, but these are not significant once we include changes in control variables. This is not surprising. Most of the variables we examine are slow moving, and hence the changes in the short five-year time frame would not be very meaningful.

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