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Capital Liquidity, Productivity Dispersion and Market Structure*

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Abstract

We propose an industry-level index of capital liquidity – defined as the share of used capital in aggregate industry capital expenditure – that relates (inversely) to sunkenness of capital investment. We then test the effect of capital liquidity on the dispersion and mean of industry productivity distributions, as well as on industry concentration measures using data on US manufacturing industries. As predicted by a standard model of industry equilibrium with heterogeneous firms, we find that an increase in the capital liquidity index is associated with a reduction in the productivity dispersion and an increase in the mean and median of the productivity distribution. In addition, we find that increase in capital liquidity is associated with a decline in industry concentration measures. This is consistent with predictions from the standard industry equilibrium model under certain empirically plausible assumptions about the distribution of firm productivity parameters. Our results are robust to the inclusion of a number of control variables proxying for sunk costs, fixed costs, trade competition, product substitutability, advertising and R&D intensity and productivity persistence. Our results are also robust to using alternative measures of dispersion and concentration, and alternative methods of estimating total factor productivity.

JEL classification codes: L11, L60, D24

Keywords: Asset specificity, sunk costs, concentration, productivity distribution

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1 Introduction

The extent of sunkenness of investment is expected to have important consequences for behavior of economic agents in a number of different contexts. In models of industry equilibrium, the magnitude of sunk costs of entry in an industry play an important role. For instance, in standard models of industry equilibrium with heterogenous firms (e.g. Hopenhayn 1992, Melitz 2003), dispersion in productivity increases and the mean and median productivity decrease as sunk costs of entry go up. Sunk costs of entry also influence market concentration, though theoretical models explaining concentration have differing predictions about the relationship between concentration and sunk entry costs (Sutton 1991).

While the theoretical definition of sunk costs strictly exclude the resale value of investments (and hence, are affected by the liquidity 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 discussion in Sutton, 1991, p. 93-99). Typically, investments in physical capital (usually in the median plant size) are used to proxy sunk costs (e.g. Weiss 1965, Sutton 1991, Gschwandtner and Lambson 2006). While 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 upwards.

In this paper, we propose a new index of capital liquidity (drawing on Schlingemann, Stulz and Walkling 2002) at the industry level that meaningfully captures inter-industry heterogeneity in the recoverability of investments. We define the capital liquidity 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 US Census Bureau. In industries where capital is highly firm specific or where there is no active secondary market in used capital equipment, we expect the low level of capital liquidity to be reflected in a low share of used capital in total investment. Thus, our measure would capture capital liquidity, which in turn, is an inverse measure of the extent of sunkenness of capital investments.

Given the relationship between capital liquidity and sunkenness of investment, we expect capital liquidity to be related to the mean and dispersion of productivity as well as concentration across industries. To motivate our empirical tests, we present a standard model of industry equilibrium with heterogeneous firms (related to Syverson 2004, Hopenhayn 1992, and Melitz and Ottaviano 2005). We show that 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. We then examine the effect of changes in sunk costs on concentration. Consistent with results from prior studies (e.g. Hopenhayn, 1992), we find that with heterogenous firms, the effect of increase in the sunk entry costs on concentration (as measured by inverse of the mass of firms) is ambiguous. However, with certain empirically plausible assumptions about the distribution of firm productivity parameters, this model predicts an increase in concentration with an increase in sunk costs.[1]

[1]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 that suggests an increase in concentration with sunk costs,

Next, we use data from public use US Census datasets and a number of different sources to test the relationship between our capital liquidity measure (which we propose as an inverse measure of sunk costs) on different measures of three variables of interest: (i) dispersion in productivity, (ii) central tendency (mean and median) of the productivity distribution, and (iii) industry concentration. As predicted by our heterogenous firm industry equilibrium model, we find that our measure of capital liquidity is negatively correlated with productivity dispersion, and positively correlated with mean and median productivity. Also, we find that the capital liquidity 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 our theory suggests may impact 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 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 look at a specification that controls for the (five-year) survival rate of firms in the industry. We find our results on the effects of capital liquidity to be robust to the individual as well as simultaneous inclusion of each of these control variables. Another potential issue is capital mismeasurement due to variation in capital utilization. To address this issue, we check the robustness of our results to using an alternative TFP measure proposed by Basu and Kimball (1997). We also check the robustness of our results to using alternative measures of productivity dispersion and concentration, and to using a third alternative methodology to estimate productivity. We find our results robust to all these additional checks.

To our knowledge, we are the first to examine the effect of capital liquidity (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 liquidity was proposed by Schlingemann, Stulz and Walkling (2002), who use 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 2 digit SIC level (using the relatively sparse corporate transaction data), one advantage of our measure is that it uses much the richer data on capital expenditure, which allows us to estimate it at a much more disaggregated (4 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 finds that used machinery sales fetch only 20 to 50 percent of the initial price once it is installed. Similarly, Ramey and Shapiro (2001) using equipment-level data from aerospace plant closings find 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 Syverson (2004) who examined the effect of product substitutability on productivity dispersion. While we use a similar theoretical framework and control variables, our focus is on the effect of capital liquidity 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 liquidity on concentration,

and a Bertrand competition model where only one firm enters in equilibrium, for any positive level of sunk entry cost.

which is not examined by Syverson (2004). Also, our examination of the determinants of concentration is similar in spirit to Sutton (1992, 1998).

The rest of the paper is structured as follows. Section 2 presents an industry equilibrium model with heterogenous firms that relates changes in sunk costs to productivity mean and dispersion, and concentration. Section 3 discusses the definitions of variables and data sources, with Section 3.1 focusing specifically on our capital liquidity index while Section 3.2 discussing all other variables. Section 4 presents the baseline results. Various robustness tests are discussed and presented in Section 5. Section 6 concludes.

2 Theory

We adopt a standard industry equilibrium model with heterogenous firms. It is closest in spirit to the version in Syverson (2004a), which draws on ideas from Hopenhayn (1992), Melitz (2003) and Melitz and Ottaviano (2005).[2]

We will focus on factors driving productivity dispersion in the cross-section of industries in the country, and hence we abstract from the dynamics of industry equilibrium. An industry is composed of a continuum of producers of mass N. Each producer is indexed by i (I is the set of industry producers) and produces a distinct variety of the industry product. The representative industry consumer has the following preferences over varieties:

$$U = y + \alpha \int_{i \in I} q_i di - \frac{1}{2}\eta \left(\int_{i \in I} q_i di \right)^2 - \frac{1}{2}\gamma \int_{i \in I} q_i^2 di \tag{1}$$

where y is the quantity of numeraire good, q_i is the quantity of good i consumed, $\alpha > 0$, $\eta > 0$ and $\gamma \geq 0$. Note that γ captures the love for variety. With higher γ, increasing consumption of one good reduces utility derived from it, so that the consumer would buy another variety even at a higher price (thus allowing some less productive producers of another variety to survive in the equilibrium). The parameters α and η shift the demand for the industries output relative to the numeraire good. Now defining: $\bar{q} = \frac{1}{N} \int_{i \in I} q_i di$, from the maximization of the utility function in equation 1, we can derive the following demand function:

$$p_i = \alpha - \gamma q_i - \eta N \bar{q} \tag{2}$$

Output is produced using a single factor labor (l_i), and is linearly related to the productivity term (θ_i), so that the production function is:

$$q_i = \theta_i l_i \tag{3}$$

This yields the following per period profit function for producer i:

$$\Pi_i = p_i \theta_i l_i - w l_i - F_c \tag{4}$$

where w is the (exogenous) wage rate and F_c is the fixed costs of producing output per period. Substituting from demand equation 2 and production function 3, and assuming that each firm's output is very small compared to the aggregate output, we can write:

$$\Pi_i = (\alpha - \gamma \theta_i l_i - \eta N \bar{q}) \theta_i l_i - w l_i - F_c \tag{5}$$

[2] The key difference with Syversen (2004) is that we model a Cournot-Nash equilibrium, while his model looks at a Bertrand-Nash equilibrium. Also, we examine the predictions for concentration (mass of firms).

A Cournot-Nash profit maximization, where every producer maximizes profit by choosing output level (by choosing input labor level), yields optimal output level:

$$q_i^* = \frac{1}{2\gamma}\left[\alpha - \eta N\bar{q} - \frac{w}{\theta_i}\right] \tag{6}$$

Substituting back the optimal output level in equation 6 into the profit function in equation 5 yields (after some algebra):

$$\Pi_i = \frac{1}{4\gamma}\left(\alpha - \eta N\bar{q} - \frac{w}{\theta_i}\right)^2 - F_c \tag{7}$$

This equation implies that any producer who has productivity level lower than a cutoff productivity level θ_i^*, would not be able to earn positive profits. Solving for this cutoff productivity θ^* (by setting profit equation 7 =0) yields:

$$\theta^* = \frac{w}{\alpha - \eta N\bar{q} - \sqrt{4\gamma F_c}} \tag{8}$$

Substituting for $\bar{q}$ from equation 8 into equation 7 yields (after some algebra) the following expression for the profit for producer i in terms of the cutoff productivity level θ^*:

$$\Pi_i = \frac{1}{4\gamma}\left[\sqrt{4\gamma F_c} + w\left(\frac{1}{\theta *} - \frac{1}{\theta_i}\right)\right]^2 - F_c \tag{9}$$

A large pool of ex-ante identical firms have to pay a sunk entry cost s to receive a productivity draw from a known distribution $g(\theta)$. Only those receiving a productivity draw above the cutoff productivity level θ^* can produce output in equilibrium. Thus expected profit from paying sunk cost s is the expectation of equation 9 over the distribution $g(\theta)$ if $\theta \geq \theta^*$, and zero if $\theta < \theta^*$. Thus, expected gain depends on the cutoff productivity level θ^*; free entry determines this value by setting the net expected gain from entry equal to 0. Thus, in equilibrium, θ^* is such that the expected value of entry $V^e = 0$:

$$V^e = \int_{\theta^*}^{\infty}\left\{\frac{1}{4\gamma}\left[\sqrt{4\gamma F_c} + w\left(\frac{1}{\theta *} - \frac{1}{\theta}\right)\right]^2 - F_c\right\} g(\theta)d\theta - s = 0 \tag{10}$$

This expression summarizes the industry equilibrium and allows us to perform comparative statics on the equilibrium effect of various factors (such as entry costs, fixed costs of operation, etc.) on the cutoff productivity level (which in turn determines the dispersion, mean and aggregate productivity levels, assuming $g(\theta)$ is independent of the factors). The effect of any factor x on the equilibrium cutoff productivity level can be derived from the implicit function theorem by setting:

$$\frac{d\theta^*}{dx} = \frac{-\partial V^e/\partial x}{\partial V^e/\partial \theta^*} \tag{11}$$

2.1 Sunk costs and cutoff productivity

In equilibrium, we can show that an increase in sunk costs reduces the cutoff productivity level θ^*, thus leading to an increase in dispersion in productivity.

Proposition 1. *The equilibrium cutoff productivity level θ^* decreases with an increase in sunk cost of entry; i.e. $\frac{d\theta^*}{ds} < 0$. Consequently the mean and aggregate productivity goes down, and the dispersion in productivity levels increase with a relative increase in the sunk cost of entry.*

Proof. See Appendix 1. □

The intuition behind this result is that high sunk costs of entry provides a protective barrier for inefficient firms to be able to survive. More specifically, the larger the sunk entry costs, the greater should the expected value function be, which in turn requires a higher average price level to prevail in equilibrium. Since the average price level is higher, this 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 knew 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.[3]

2.2 Sunk costs and concentration

In this model in the most general case, there is no clear prediction for the effect of sunk costs on the equilibrium concentration, measured as the inverse of the mass of firms. However, under certain assumptions, it can be shown that industry concentration and sunk costs of entry will be positively related. Specifically, the following proposition holds.

Proposition 2. *Let* $h(\omega) \equiv \frac{g(\omega)}{\int_\omega^\infty g(\theta)d\theta}$ *and* $\mu = E[\theta|\theta \geq \omega]$. *Define the set* $S \subset (0, \infty)$ *s.t.* $\forall\ \omega \in S$, *one of the two following conditions hold (i)* $\omega h(\omega) \leq 1$, *(ii) if* $\omega h(\omega) > 1$, $\frac{1}{(\mu - \omega)} + \frac{1}{\omega} \geq h(\omega)$. *Then, if the cut-off productivity* $\theta^*\ \in S$, *then concentration increases with sunk costs or equivalently the mass of firms* N *decreases with sunk costs i.e.* $\frac{dN}{ds} < 0$.

Proof. See Appendix 1. □

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 θ). The increase in price level also leads to a drop in overall market demand (Q). This drop is aggregate demand and increase in output for each surviving firm suggests that the mass of firms would go down.[4] Hopenhayn (1992, page 1142) terms this the *price effect.* However the increase in the sunk costs also reduces the cutoff productivity level, bringing in a part of the $g(\theta)$ 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.*

If, however, $\theta^* \in S$, the price effect can be shown to dominate the selection effect (see appendix), and concentration increases with sunk costs. Though this condition may appear to be restrictive, appendix 2 shows (numerically) that if $g(\theta)$ is lognormal with its parameters obtained from the observed firm size, labor productivity or the TFP distribution, the probability of θ^* being in the set S is very high.[5]

[3] Interestingly, as implied by the intuition above, the impact on the cutoff productivity level is different if non-sunk fixed operating costs go up (see footnote 5).

[4] As reflected in the two positive terms within the square brackets in equation 14 in the Appendix.

[5] As in Hopenhayn 1992, a number of other results can be shown using this model. For example, the equilibrium cutoff productivity level θ^* increases with an increase in fixed operating costs; i.e. $\frac{d\theta^*}{dF_c} > 0$. Also, as in Syverson (2004), it can be shown that the equilibrium cutoff productivity level θ^* falls with a decrease in substitutability (reflected in an increase in γ); i.e. $\frac{d\theta^*}{d\gamma} < 0$.

3 Definition of variables and data sources

3.1 Capital liquidity index

We define our index of capital liquidity as the share of used capital investment in total capital investment, at the 4 digit SIC aggregate level. We propose this index as a valid measure of physical capital liquidity based on the supposition that in industries where capital expenditure incurred by firms are not firm-specific and where there is an active secondary market for physical capital, it is likely that used capital would have a relatively higher share of total investment. Thus, we expect our capital liquidity index to be an inverse measure of the degree of sunkenness of investment across industries.

To see how our measure may 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. In the stationary equilibrium the number of firms stays constant, as a fraction of firms exit and an equal number enter the market 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 liquidity index would be zero in this industry. On the other hand, if capital is completely general and if there is an active market in second hand 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 specific nature of the investment and/or the lack of an active secondary market, our capital liquidity measure would be a low number, while if capital is not specific and there is an active secondary market our capital liquidity measure would 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 the same one used by Schlingemann, Stulz and Walkling (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.[6] They cite the argument proposed by Shleifer and Vishny (1992), that a high volume of transactions in an industry is an evidence of high liquidity, to justify the use of their index. Shleifer and Vishny (1992) 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 are likely to be lower.

Our measure addresses a key weakness of using size of physical capital investment as a proxy for sunk entry costs (e.g. Sutton 1991, Syverson 2004, Gschwandtner and 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 discussed in Sutton (1991, Chapter 4), one potential weakness of such proxies is that it assumes that the proportion of initial outlays that can be recovered on exiting the

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

industry is constant across industries, or at least that the proportion of costs which 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 used in Sutton (1991) described above. It is evident that the correlation between the two measures is not very high (about -0.19). In fact, there are a number of industries that have a high sunk cost index but also potentially have 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.

One caveat to consider is that a couple of outside factors (potentiality unrelated to capital liquidity or sunkenness) could affect our measure. One such factor is cross-industry sales of used capital, which could introduce some noise into this index as a measure of industry specific sunkenness. [7] However, this measurement error is unlikely to be correlated with market structure or the mean and dispersion of productivity dispersion, and hence is only likely to bias our coefficients towards zero. 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 liquidity measure may be counter-cyclical. 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 towards zero.

To compute the proposed index of capital liquidity, we obtained data on used as well as new capital expenditure at the industry level from public use datasets at the U.S. Census Bureau, for the Census years 1987 and 1992.[8] The ASM and economic census questionnaires collect detailed information on capital expenditures from the respondents. Specifically, establishments are asked to report total capital expenditure, as well as a split 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]

Since our capital liquidity measure is inversely related to the sunkenness of capital investments, the propositions 1 and 2 imply the following predictions:

(i). Productivity dispersion is negatively correlated with capital liquidity.

(ii). The mean and median productivity are positively correlated with capital liquidity.

(iii). Concentration is negatively correlated with capital liquidity.

Summary statistics on the capital liquidity measure is presented in Table 1. The mean share of used capital in total investment is about 8.8 per cent. There is reasonable heterogeneity in the measure across

[7]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.

[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, all the analysis was restricted to 1987 and 1992.

[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.

industries, as reflected in the standard deviation of about 6.9 per cent and the interquartile (p75 - p25) difference of about 8.2 per cent. 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 10 4 digit SIC industries. The industry with the largest fraction of used equipment investment is Oil and gas field machinery and equipment, at 34.62 per cent. The lowest used capital share is zero, which is the case for Carbon black, Cellulosic manmade fiber and Fine earthenware.

3.2 Productivity, concentration and other variables

Productivity dispersion and central tendency variables are estimated using economic data from the US Census Bureau.[10] For our baseline analysis, we define 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 and 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 US Census Bureau, and are based on wage bills and materials costs reported at the firm level in the economic census datasets (See Chiang, 2004 for details). As part of robustness checks, we examine a couple of alternative TFP measures: (i) a modified Solow residual measure suggested by Basu and Kimball (1997) to adjust for variations in capacity utilization (see discussion in Section 5.7) , and (ii) as a residual from an OLS regression of revenue on inputs (see discussion in Section 5.8).

The primary productivity dispersion measures that we use include inter-quartile difference, i.e. difference between the TFP at the 75th percentile and 25th percentile 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 five different measures of concentration at the 4 digit SIC code level for the 1987 and 1992 economic census years was obtained from public-use census data from the Annual Survey of Manufactures (ASM) and the quinquennial economic censuses purchased from the US Census Bureau. The five measures of concentration are the C4 ratio (share of industry shipping accounted for by the largest 4 firms), C8 ratio (share of largest 8 firms), C20 (share of largest 20 firms), the C50 ratio (share of largest 50 firms) and the Herfindahl-Herschmann index (calculated by summing the squares of the individual company market shares for the 50 largest companies or the universe, whichever is lower). We normalize the Herfindahl-Herschmann by a factor of 1000 so that the maximum possible value, which occurs if a single firm has 100 per cent market share, is ten ($100^2/1000$).

Data on other control variables were obtained from a variety of sources. The source for each is discussed alongwith their definitions below. For a detailed discussion of how each of these variables are expected

[10] The dispersion measures and the following control variables – industry 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 (see Balasubramanian 2007).

to affect the mean and dispersion of productivity, and concentration in the industry, refer to various subsections of 5.

The industry 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. This variable was proposed by Sutton (1991) is an index of the initial setup cost, and 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 (non-production) 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 US Census Bureau's Economic Census databases for 1987 and 1992.

The share of total output exported is defined as 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 website[12]. For more detailed documentation, see Feenstra, Romalis and Schott, 2002.

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.[13] The share of output shipped < 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).[14]

The 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 for the industry.

The 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 US Census Bureau's economic census datasets. As discussed in Syverson (2004), 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 these variables were constructed using data from Compustat, a database that has financial statement

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

[12] http://cid.econ.ucdavis.edu/

[13] Refer to Syverson (2004) for a detailed description of the construction of this variable.

[14] We thank Chad Syverson for generously providing us 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.

data on all listed U.S. firms. Data on advertising and R&D in Compustat has a number of missing values, as many firms do not report advertising and R&D expenditures separately in their financial statements. Given the sparseness of data, we form these indices at the 3-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 datasets.

Table 1 presents summary statistics on the main variables used in our analysis. As discussed earlier (see footnote 8), the data we analyze comprises two cross-sections (1987 and 1992) of 4-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 320 SIC 4 digit industries for each of the two years. Throughout our analysis in the following sections, we cluster standard errors at industry level, and the number of clusters reported indicate the number of 4 digit industries for which data is available on all the variables used in the particular regression specification.

Note that the dispersion measures are scaled by central tendency measures. Specifically, the interquartile range is scaled by the median, and the variance is scaled by the mean productivity. These (scaled) dispersion measures are similar in magnitude when we compare the Solow residual based definition to the measure suggested by Basu and Kimball (1997) (see discussion in section 5.7 for a discussion of this alternative TFP measure). The mean interquartile difference in TFP is about 26.5% using the Solow measure, and about 28.4% using the Basu-Kimball measure.

4 Baseline results

In the baseline specification, we examine the effect of capital liquidity on the following six dependent variables: (i) two measures of dispersion in TFP – the interquartile range i.e. the difference between the 75th an 25th percentile of the productivity distribution within each industry (normalized by the median), and the variance (normalized by the mean); (ii) Two measures of the central tendency of the productivity distribution – the mean and the median; and (iii) Two measures of concentration – the C8 ratio i.e. the share of the largest 8 firms in total industry revenue, and the Herfindahl index.

Before turning to the regression results, Figures 2, 3 and 4 present plots of these various measures against the capital liquidity index, along with the corresponding linear fits. As predicted, capital liquidity is negatively correlated with dispersion, and positively with central tendency. Also consistent with predictions in proposition 2, concentration is strongly negatively correlated with capital liquidity.

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

Also, as predicted by the theory, variations in capital liquidity is associated positively with the central tendency measures. A one standard deviation increase in the liquidity index is associated with about 4 percent increase in both the mean and the median, which is about 14.5 percent of the standard deviation of the central tendency measures. Finally, as set out in proposition 2, the liquidity measure is strongly negatively correlated with the concentration measures. A one standard deviation increase in the liquidity index is reduces the C8 ratio by about 8.1 percent, which is about 34.9 percent of the standard deviation of the C8 ratio. Similarly a one standard deviation increase in the liquidity index is associated with a reduction in the Herfindahl index of about 32.5 per cent (0.209/0.645) of its standard deviation.

All the measured effects are highly statistically significant. (As noted earlier, all standard errors are clustered at the 4 digit industry level.)

5 Robustness checks

According to the theory set out in Section 2, a number of other factors could impact productivity mean and dispersion, as well as industry concentration. If these factors are correlated with our capital liquidity measure, the estimated effects in Section 4 may be biased due to omission of these correlated variables. In this section, we check for the robustness of the baseline analysis in Section 4 to including a number of control variables.

5.1 Sunk and fixed costs

In this subsection, we check if our capital liquidity index has any explanatory power when we include another index of industry sunk costs proposed by Sutton (1991) (see discussion in Section 3.1). 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.

The magnitude of fixed costs is another factor that could affect productivity dispersion and concentration. Theoretically, in the heterogenous firm model presented in Section 2, fixed costs of operation are expected to have an opposite effect on dispersion as sunk costs (see footnote 5). Hence, if capital liquidity were positively correlated with fixed costs, our coefficients in Table 3 would be biased towards our predictions.[15]

A good empirical proxy for the fixed costs of operation is difficult to construct. As discussed in Syverson (2004), any measure of the fixed costs of operation may inadvertently also proxy for sunk costs of entry, as the fixed costs incurred in the first few periods after entry could be considered part of the sunk entry costs. Nevertheless, we use the measure proposed by Syverson – the white collar share of total employment – as a proxy for fixed cost. The rationale behind the measure is that white collar employment is likely to represent overhead labor, and hence the overhead or fixed costs are likely to be higher in industries where this index is higher.[16]

The results from including the index of sunk costs and the index of fixed costs are presented in Table 4. While the magnitudes of the coefficients on the capital liquidity index decrease a little, they are still large and statistically very significant. The coefficients on the sunk cost index are as predicted by theory; higher the sunk cost index, the higher are the dispersion measures, the lower are the central tendency measures, and higher are the concentration measures. The effect of the fixed cost index on the central

[15]It is difficult to make a similar prediction about the bias in the concentration regressions because the effect of fixed cost on concentration is ambiguous, for the same reason as we discussed for sunk costs (see section 2.2).

[16]One drawback of this measure is that though the white collar share may be high, the overall overhead costs may be low if labor share of output itself is relatively low.

tendency measures are as predicted by theory – higher fixed cost indices are associated with higher mean and median productivity levels. However, the effect on the dispersion measures is contrary. While we do not have any explanation for this result, it potentially suggests that the stated concern about the validity of the fixed cost index may be serious.[17] There is no statistically (or economically) significant correlation between the fixed cost index and concentration.

5.2 Trade competition

Increased competition from trade could be expected to lead to lower prices and an increase in the cutoff productivity level.[18] With respect to concentration, as argued in Sutton (1991), in general an increase in the degree of competition could be expected to reduce the number of firms (or equivalently increase concentration) in equilibrium.

Table 5 presents results from adding two proxies for trade competition – the share of total output exported, as well as the the share of imports in domestic sales – to the baseline specifications. As expected, the higher the export share measure, the lower is the dispersion in TFP. Higher export share of output is however unexpectedly correlated with lower levels of mean and median of the productivity distribution. As expected, the effect of increased competition, proxied through the export share variable, on concentration is positive (statistically significant for the C8 ratio, insignificant on the Herfindahl measure).

The results on the import intensity variable are not significant when the dependent variables are TFP dispersion measures and concentration. However these results are significant with the expected sign on the central tendency measures – higher competition through higher import intensity is correlated with higher mean and median productivity levels.

In all the columns of Table 7, the coefficients on the capital liquidity index remains large and statistically very significant. In fact controlling for trade competition increases the coefficients on capital liquidity for regressions of the central tendency and concentration measures. Thus the baseline results do not appear to be driven by bias from omitted trade competition variables.

5.3 Product substitutability

Our model predicts that an increase in product substitutability increases the cutoff productivity level, thus lowering productivity dispersion and increasing the central tendency measures (see footnote 5). Syverson (2004) investigates this prediction in detail and finds strong support for this prediction. As in the case of sunk costs, our theory has no clearcut prediction for the effect of product substitutability on concentration.

To control for potential bias from omitted product substitutability, we check robustness of our results to including four different product substitutability measures used in Syverson (2004).[19] As in Syverson (2004), for the sake of brevity we report results from using the two proxies (one for geographic substitutability and one for physical product substitutability) that are least susceptible to measurement problems.[20] The proxy for geographic substitutability that we use is the dollar value per pound; the higher this measure,

[17] Incidentally these contradictory results for the effect of fixed costs on dispersion of TFP were also found in Syverson's (2004) study (see Table 5).

[18] See Melitz (2003) for demonstration of how lowering of trade barriers leads to an increase in the cutoff productivity level.

[19] One of the measures used by Syverson is advertising intensity, which we examine separately in Section 5.4. Refer to Syverson (2004) for a detailed discussion of the various product substitutability measures that we use here.

[20] Not surprisingly, these measures also have the most robust results across different specifications.

the lower transportation costs are likely to be as a fraction of the value of the goods. Hence industries with high dollar value per pound can be expected to have less segmented markets and hence greater geographic substitutability. The measure of physical product substitutability we use is the Gollop and Monahan (1991) diversification index. The larger this index, the greater would be the degree of product differentiation and hence lower the degree of substitutability between products of different firms within the industry.

The results from including these two measures of product substitutability are presented in Table 6. The dollar value per pound measure is significant only in the central tendency regressions, and has the predicted sign; as dollar value per pound (and hence product substitutability) increases, so does the mean of the productivity distribution. As predicted, we find that an increase in the diversification index (equivalent to a decrease in product substitutability) is associated with an increase in the dispersion of productivity. The coefficients in the central tendency regressions are negative as predicted, but are not statistically significant. We find that an increase in the diversification index is associated with an increase in concentration.

The results for our capital liquidity index measure remains large and significant across all specifications. Hence, we conclude that bias from omitted product substitutability variables do not affect our baseline results significantly.[21]

5.4 Advertising and R&D intensity

Sutton's (1991, 1998) work highlights the impact of endogenous sunk costs on market structure. The prediction that Sutton focusses on is related to changes in concentration with changes in market size within the industry. He shows that one of the robust predictions over a whole range of models is that in industries where endogenous sunk costs are important, there exists a non-zero lower bound to the equilibrium level of concentration in the industry, even as the market size becomes very large.

While 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. 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).

While endogenous sunk costs are not explicitly modeled in the heterogenous firm model used in Section 2, we could expect higher levels of these costs to have an effect similar to that of an increase in the entry cost parameter s. However, higher advertising and R&D intensity may proxy for higher levels of intangible capital, which could be associated with higher levels of measured TFP. This is because using only physical capital in measuring TFP leads to an upward bias in the measured TFP levels in industries where advertising and R&D are important (if higher values of these variables are correlated with higher levels of intangible capital). Advertising may build up intangible brand value capital, while R&D may contribute to an increase in intangible knowledge capital.

Also, Syverson (2004) argues that advertising intensity (defined as the advertising expenditure per

[21] Results using two other measures proposed by Syverson – a proxy for distances products are shipped (measured as the share of shipments sent within 100 miles) and the industry primary products specialization ratio – are similar to those we get here (see Appendix Table 1).

dollar of revenue) could be a plausible proxy for product differentiation. According to this view, a relatively higher level of advertising intensity would indicate lower substitutability and hence a lower productivity cutoff. Note that this is also the expected effect even if we view advertising intensity as a proxy for sunk entry costs.

The results from including advertising and R&D intensity in the baseline specifications are reported in Table 7. As expected, increase in advertising intensity leads to an increase in productivity dispersion (columns 1 and 2). The positive signs on the coefficients on advertising intensity for the central tendency regressions (columns 3 and 4) are inconsistent with advertising intensity merely being a proxy for sunk costs or product differentiation. However, as discussed above, these results may indicate that the mean TFP estimates are downward biased in high advertising intensity industries as they fail to account for intangible brand value related capital. In any case, the coefficients on advertising intensity in the central tendency regressions are not significant. Higher advertising intensity is also associated with higher concentration levels (columns 5 and 6), as expected.

The results for the R&D intensity variable are broadly similar to those for the advertising intensity variable. Higher R&D intensity is associated with higher dispersion in productivity, as well as higher central tendency measures. Higher R&D intensity also affects concentration positively, but the results here are not statistically significant.

We interpret these results as suggesting that the both higher advertising and R&D intensity indicate higher barriers to entry (akin to the sunk entry costs in the the model in Section 2), and hence lead to an increase in productivity dispersion. However both measures also reflect high levels of intangible capital and hence higher levels of mean and median TFP. These results and interpretations must be viewed with the important caveat that the data we use on advertising and R&D intensity are admittedly noisy (see discussion in Section 3.2).

Across all the specifications, the baseline results on the capital liquidity measure remain remarkably robust, both in magnitude and statistical significance. Thus the baseline results do not appear to be driven by bias from omitted endogenous sunk cost (specifically, advertising and R&D intensity) variables.

5.5 Productivity persistence

While the model we present in Section 2 abstracts from dynamics, in other heterogenous 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 across industries suggested by Syverson (2004) 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 amount of entry and exit from the industry.[22] Thus, omitted (or imperfectly

[22] 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

measured) variables (e.g. fixed costs) could be negatively correlated with productivity dispersion, and positively correlated with amount of firm turnover, and hence with the used capital measure. Since this channel of omitted variable bias works through the effect of the omitted variable on firm turnover, including the industry survival fraction (which measures firm trunover rate) provides a good way to control for this bias. In other words, if the coefficients on the capital liquidity measure are biased because they simply reflect higher firm turnover caused by omitted variables that also independently affect the dependent variable, this bias would be eliminated by the inclusion of the survival rate variable, which effectively controls for firm turnover.[23]

Table 8 presents results from inclusion of industry survival rate as a control. We find that the coefficient on the industry survival fraction is not significant in the dispersion regressions. The survival rate is negatively correlated with central tendency measures. This is consistent with Hopenhayn (1992), as any factors that drive down the cutoff productivity level (and hence the mean and median of the productivity distribution) would also cause a decrease in the turnover rate or equivalently an increase in the industry survival fraction. Also, we find that industry survival rate is positively correlated with high concentration levels (column 5 and 6).

The results on the capital liquidity index measure are similar in magnitude to the baseline specification, and remain statistically very significant.

5.6 All controls together

In Table 9, we look at the robustness of the baseline results to simultaneously including all the control variables discussed above. As seen here, the coefficients on capital liquidity index variable continue to be highly statistically significant. Also, the magnitude of the coefficients is only slightly smaller than in the baseline case discussed in Section 4.

The industry sunk cost index is significant in five out of the six cases, with the signs consistent with theoretical predictions. As in Section 5.1, 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

realization of their productivity. Also, except if productivity is perfectly persistent, the fraction of surviving firms that receive a bad enough draw that they have to exit increases as the cutoff productivity increases.

[23] 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 that a high survivor rate would be negatively correlated with turnover rate.

measured using the industry survival fraction is associated with lower central tendency measure, which is consistent with predictions of Hopenhayn (1992).

5.7 Adjusting for capacity utilization

Variable capacity utilization could lead to mismeasurement in the capital used to estimate TFP, as the capital stock may not reflect the actual amount of capital services utilized in production. If capacity utilization patterns across industries is correlated with the capital liquidity index or other relevant control variables, this could bias our results.

As in Syverson (2004), we address this potential mismeasurement issue by adopting a TFP estimation procedure suggested by Basu and Kimball (1997). If the production function is Leontief in capital and materials, under the assumption of cost minimization, they show that TFP can be defined as:

$$TFP_{it} = y_{it} - \alpha_l l_{it} - (\alpha_k + \alpha_m)m_i - \alpha_e e_i - \delta\alpha_l h_i$$

where variables are defined as in the standard TFP measure defined in Section 3.2, h_i is the log of hours per employee, and δ is a parameter which Basu and Kimball estimate as having a value of 1.06. Under the Leontief assumption, materials use is proportional to capital services flows, and therefore adding the capital's cost share to materials cost share controls for increases in capacity utilization. The log hours per employee measure captures variations in labor utilization.

The results from using this measure of TFP are presented in Table 10. While the magnitudes are somewhat lower, the coefficients on the capital liquidity index continues to be highly significant on both the dispersion measures, and on the TFP median measure. It is weakly significant (at 10 per cent level) in the TFP mean regression.

5.8 Other robustness checks

First, in Appendix Table 2, we look 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 the four largest firms in industry revenue), C20 ratio (share of the 20 largest firms) and C50 (the share of the 50 largest firms). We find the results on the capital liquidity measure are robust to looking at these alternative measures.

Second, we examine 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. The results are presented in Appendix Table 3. We find that the coefficients on the capital liquidity index in the dispersion regressions continue to be highly statistically significant in the dispersion regressions. While the sign is the same, the coefficient is not statistically significant for the mean or median regressions.

Finally, in unreported regressions, we looked at alternative ways to scale the dispersion measure (using the mean to scale the inter-quartile range and the median to scale the variance measure), and obtained very similar results.

6 Conclusion

We propose an index of physical capital liquidity, defined as the share of used capital in total capital expenditure. This is measured using annual data on used and new capital at the 4 digit SIC code level published by the U.S. Census Bureau. We argue that the variation in this measure of capital liquidity across industries would be negatively correlated with the sunkenness of entry outlays across industries. We then show theoretically and empirically that our capital liquidity measure is negatively correlated with productivity dispersion, and positively correlated with mean and median productivity. We show theoretically that, under certain conditions, sunk entry costs are positively correlated that concentration. Our empirical tests confirm that the capital liquidity measure is strongly negatively correlated with industry concentration. Our empirical results are robust to a number different checks.

Our measure of capital liquidity could be affected by two factors unrelated to capital liquidity 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 downwards, so that our coefficients may understate the true impact of capital liquidity on the dependent variables.

Based on our findings, we conclude that our capital liquidity 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 and Alchian, 1978). Specificity of capital investments also could affect rent sharing between workers and shareholders and labor contracts in general (Malcomson, 1997). Also, as discussed earlier, 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(Sibilikov, 2007).

Our results should be interpreted subject to the caveat that, as for any cross-industry study, there could be a number of sources of industry heterogeneity that may bias our results. We attempt to control for a large number of the influences identified in the theoretical and empirical literature. While some of these controls may be imperfect, the strong robustness of our results suggest that they are not severely affected by the factors that we try to control for.[24]

Finally, while our focus here is on the effect of capital liquidity, 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 (for example, the result that substitutability is negatively

[24] 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, page 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, pp6-7). 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 liquidity 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 5 year time frame would not be very meaningful. Data on used capital investments for earlier economic census years could allow us to look at long differences, but while long differences may yield more meaningful changes in the variables we examine, a longer time frame may mean that unobserved industry factors do not stay fixed.

correlated with concentration) may be of independent interest to readers.

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Appendix 1

Proof of Proposition 1:

Proof.

$$\begin{aligned}\frac{\partial V^e}{\partial \theta^*} &= \int_{\theta^*}^{\infty} \left\{ \frac{1}{2\gamma} \left[\sqrt{4\gamma F_c} + w\left(\frac{1}{\theta*} - \frac{1}{\theta}\right)\right] \left(-\frac{w}{\theta^{*2}}\right)\right\} g(\theta)d\theta \\ &\quad - \left\{ \frac{1}{4\gamma} \left[\sqrt{4\gamma F_c} + w\left(\frac{1}{\theta*} - \frac{1}{\theta^*}\right)\right]^2 - F_c \right\} g(\theta^*) < 0\end{aligned}$$

since the second term is zero,[25] and for the first term the expression under the integral is negative. Now note that

$$\frac{\partial V^e}{\partial s} = -1 < 0$$

This yields:

$$\frac{d\theta^*}{ds} = \frac{-\partial V^e/\partial s}{\partial V^e/\partial \theta^*} < 0$$

The positive impact of an increase in sunk costs on mean productivity $\bar{\theta}$ follows directly from the fact that:

$$\frac{\partial \bar{\theta}}{\partial theta^*} = \frac{\partial}{\partial \theta^*} \int_{\theta^*}^{\infty} \theta g(\theta) d\theta = -\theta^* g(\theta^*) < 0$$

□

Proof of Proposition 2:

Note that the total industry output is defined as:

$$Q \equiv \int_{i \in I} q_i di = N \cdot \bar{q} = N \cdot \int_0^{\infty} q(\theta) h(\theta) d\theta \tag{12}$$

where:

$$h(\theta) = \begin{cases} \dfrac{g(\theta)}{\int_{\theta^*}^{\infty} g(\theta)d\theta} & \text{if} \quad \theta > \theta^* \\ 0 & \text{otherwise} \end{cases}$$

Thus we get the derivative of the mass of firms N with respect to sunk costs as:

$$\frac{dN}{ds} = \frac{d\left(\frac{Q}{\bar{q}}\right)}{ds} = \frac{1}{\bar{q}}\frac{dQ}{ds} - \frac{Q}{\bar{q}^2}\frac{d\bar{q}}{ds}$$

Now from equation 8, we get that:

$$\frac{dQ}{ds} = \frac{w}{\eta {\theta^*}^2} \frac{d\theta^*}{ds}$$

Similarly, from the definition of $\bar{q}$ in equation 12 and from equation 6, we get:

$$\begin{aligned} \bar{q} &= \int_0^{\infty} q(\theta)h(\theta)d\theta = \frac{\alpha}{2\gamma} - \frac{\eta Q}{2\gamma} - \frac{w}{2\gamma P_s}\int_{\theta^*}^{\infty} \frac{1}{\theta} g(\theta)d\theta \\ \Rightarrow \frac{d\bar{q}}{ds} &= -\frac{\eta}{2\gamma}\frac{dQ}{ds} - \frac{w}{2\gamma P_s}\left(\frac{-g(\theta^*)}{\theta^*}\right)\frac{d\theta^*}{ds} - \left(\int_{\theta^*}^{\infty}\frac{1}{\theta}g(\theta)d\theta\right)\left(\frac{-w}{2\gamma P_s^2}\right)\left(-g(\theta^*)\frac{d\theta^*}{ds}\right) \\ &= -\frac{\eta}{2\gamma}\frac{dQ}{ds} - \frac{wg(\theta^*)}{2\gamma P_s}\left[\frac{1}{P_s}\left(\int_{\theta^*}^{\infty}\frac{1}{\theta}g(\theta)d\theta\right) - \frac{1}{\theta^*}\right]\frac{d\theta^*}{ds} \\ &= -\frac{w}{2\gamma {\theta^*}^2}\frac{d\theta^*}{ds} + \frac{wg(\theta^*)}{2\gamma P_s}\left[\frac{1}{\theta^*} - \frac{1}{P_s}\left(\int_{\theta^*}^{\infty}\frac{1}{\theta}g(\theta)d\theta\right)\right]\frac{d\theta^*}{ds} \end{aligned} \tag{13}$$

[25] Note that the second term denotes the change in value of entry by allowing a marginal firm to enter, which is zero.

where P_s is the probability of surviving and is defined as $P_s \equiv \int_{\theta^*}^{\infty} g(\theta)d\theta$. Writing out the full expression for $\frac{dN}{ds}$, we get:

$$\frac{dN}{ds} = \frac{w}{\bar{q}}\frac{d\theta^*}{ds}\left[\frac{1}{\theta^{*2}} + \frac{N}{2\gamma\theta^{*2}} - \frac{N}{2\gamma}\frac{g(\theta^*)}{P_s}\left(\frac{1}{\theta^*} - \frac{1}{P_s}\left(\int_{\theta^*}^{\infty}\frac{1}{\theta}g(\theta)d\theta\right)\right)\right] \tag{14}$$

In the above expression, the first two terms inside the braces is clearly positive. However since:

$$\frac{1}{\theta^*} > \frac{1}{P_s}\left(\int_{\theta^*}^{\infty}\frac{1}{\theta}g(\theta)d\theta\right)$$

the third term is negative, so that the overall sign of the term within the square braces is ambiguous. Accordingly, the overall effect of an increase in sunk costs on the equilibrium mass of firms in the industry is ambiguous.

If $\theta^* \in S$, however, the ambiguity is resolved. Specifically, consider part of the term within the square brackets i.e.

$$\begin{aligned}
\frac{N}{2\gamma\theta^{*2}} - \frac{N}{2\gamma}\frac{g(\theta^*)}{P_s}\left(\frac{1}{\theta^*} - \frac{1}{P_s}\left(\int_{\theta^*}^{\infty}\frac{1}{\theta}g(\theta)d\theta\right)\right) &> \frac{N}{2\gamma\theta^{*2}} - \frac{N}{2\gamma}\frac{g(\theta^*)}{P_s}\left(\frac{1}{\theta^*}\right) \\
&= \frac{N}{2\gamma}\left[\frac{1}{\theta^{*2}} - \frac{g(\theta^*)}{P_s}.\frac{1}{\theta^*}\right] \\
&= \frac{N}{2\gamma}\left[\frac{1}{\theta^{*2}} - \frac{h(\theta^*)}{\theta^*}\right] \text{ where } h(\theta^*) = \frac{g(\theta^*)}{\int_{\theta^*}^{\infty} g(\theta)d\theta}
\end{aligned}$$

Case 1: $\theta^* h(\theta^*) \leq 1$. Then, rewriting the above, we get

$$\frac{N}{2\gamma\theta^{*2}}\left[1 - \theta^* h(\theta^*)\right] \geq 0 \text{ since } \theta^* h(\theta^*) \leq 1$$

Case 2: $\theta^* h(\theta^*) > 1$. Consider the integral,

$$\begin{aligned}
\frac{1}{P_s}\left(\int_{\theta^*}^{\infty}\frac{1}{\theta}g(\theta)d\theta\right) &= E\left[\frac{1}{\theta}|\theta \geq \theta^*\right] \\
&\geq \frac{1}{E\left[\theta|\theta \geq \theta^*\right]} = \frac{1}{\mu} \text{ by Jensen's Inequality}
\end{aligned}$$

Since $\theta^* \in S$, and $\theta^* h(\theta^*) > 1$, by assumption, $\frac{1}{(\mu - \theta^*)} + \frac{1}{\theta^*} \geq h(\theta^*)$. Hence,

$$\begin{aligned}
\frac{1}{(\mu - \theta^*)} &\geq h(\theta^*) - \frac{1}{\theta^*} = \frac{\theta^* h(\theta^*) - 1}{\theta^*} \\
\text{which implies } \mu - \theta^* &\leq \frac{\theta^*}{\theta^* h(\theta^*) - 1} \\
\mu &\leq \frac{\theta^{*2} h(\theta^*)}{\theta^* h(\theta^*) - 1}
\end{aligned}$$

Using the first inequality above,

$$\begin{aligned}
\frac{N}{2\gamma\theta^{*2}} - \frac{N}{2\gamma}\frac{g(\theta^*)}{P_s}\left(\frac{1}{\theta^*} - \frac{1}{P_s}\left(\int_{\theta^*}^{\infty}\frac{1}{\theta}g(\theta)d\theta\right)\right) &\geq \frac{N}{2\gamma}\left[\frac{1}{\theta^{*2}} - \frac{h(\theta^*)}{\theta^*} + \frac{h(\theta^*)}{\mu}\right] \\
&\geq 0 \text{ (substituting for } \mu \text{ and solving)}
\end{aligned}$$

Hence, if $\theta^* \in S$, the term within the square braces is positive. Since $\frac{d\theta^*}{ds} < 0$, it follows that $\frac{dN}{ds} < 0$.

Appendix 2

In order to test whether the condition in Proposition 2 is likely to be empirically valid, we used the following baseline assumptions

Assumption 1. *The $g(\theta)$ distribution is lognormal.*

Assumption 2. *The mean of the distribution of $log(\theta)$ is equal to the mean of the mean TFP (Solow residual) for the various industries (1.604).*

Assumption 3. *The standard deviation of the distribution of $log(\theta)$ is equal to the mean standard deviation of the various industry TFP (Solow residual) distributions (0.326).*

Using these assumptions, the set S in 2 was computed numerically for CDF values ranging from 0.01 to 0.99. The set S covered this entire range. For CDF values from 0.01 to (approximately) 0.18, $\omega.h(\omega) < 1$. For CDF values higher than (approximately) 0.18, $\omega.h(\omega) > 1$ and $\frac{1}{(\mu - \omega)} + \frac{1}{\omega} \geq h(\omega)$. Hence, the probability that the productivity cut-off would belong to the set S was at least 0.98. We tested the robustness of these results to different parameter values. The range of CDF values that was covered by the set S under various parameter values is given in the following table.

Mean	SD	CDF Range
0.802	0.326	0.01 to 0.99
0.802	0.163	0.01 to 0.99
0.802	0.652	0.01 to 0.99
1.604	0.163	0.01 to 0.99
1.604	0.652	0.01 to 0.99
3.208	0.326	0.01 to 0.99
2.177	1.528	0.01 to 0.84
4.134	0.718	0.01 to 0.99

The first three rows use a mean value of 0.802 (half the baseline value), and differing standard deviations. Rows 4 and 5 change only the standard deviation while Row 6 doubles the mean while keeping the standard deviation at the baseline value. Row 7 uses parameters from the firm size (log number of employees) distribution obtained from another study that covered all Census years from 1977 to 1997. Finally, Row 8 uses parameters from the labor productivity (log output per employee) distribution from the same study. It is evident that the probability that the cut-off productivity would fall in the set S is very high for a fairly wide range of plausible parameter values. Hence, even though the condition in 2 appears to be restrictive at first glance, empirically, it appears to be a very plausible assumption.

Table 1: Summary statistics

See text for detailed variable definitions and data sources.

Variable	N	mean	sd	p25	p50	p75
Capital liquidity 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
TFP p10-p90 (Solow)	760	0.579	0.196	0.470	0.541	0.646
TFP p25-p75 (BK)	730	0.284	0.144	0.197	0.250	0.333
TFP variance (BK)	725	0.127	0.103	0.063	0.099	0.158
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
TFP mean (BK)	730	1.387	0.304	1.173	1.384	1.579
TFP median (BK)	730	1.324	0.309	1.113	1.314	1.516
Concentration measures						
C4 ratio	923	39.154	21.092	23.000	36.000	53.000
C8 ratio	923	51.859	23.256	34.000	51.000	69.000
C20 ratio	923	67.204	23.488	51.000	70.000	86.000
C50 ratio	923	78.250	23.608	68.000	86.000	96.000
Herfindahl index	923	0.685	0.645	0.212	0.471	0.929
Other control variables						
Industry 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
Share of output shipped < 100 miles	896	0.061	0.106	0.017	0.033	0.063
Diversification index	924	0.135	0.086	0.071	0.119	0.183
Primary product specialization ratio	760	92.219	5.891	88.191	92.024	97.688
Advertising intensity	1153	0.034	0.043	0.016	0.024	0.042
R&D intensity	1159	0.030	0.149	0.006	0.014	0.032
Industry survival fraction	750	0.543	0.137	0.453	0.546	0.638

Table 2: List of industries with high and low capital liquidity

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

SIC code	Industry description	Mean capital liquidity index
Ten industries with lowest capital liquidity 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 liquidity 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%

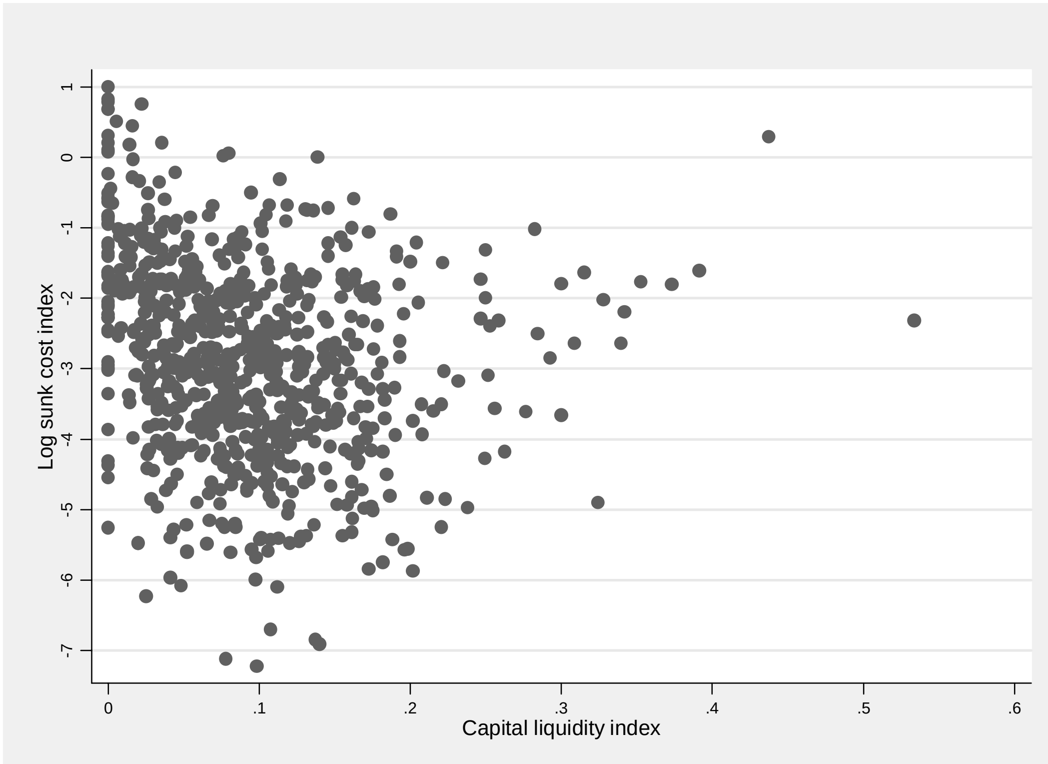

Figure 1: Sunk cost index (Sutton 1991) versus capital liquidity index

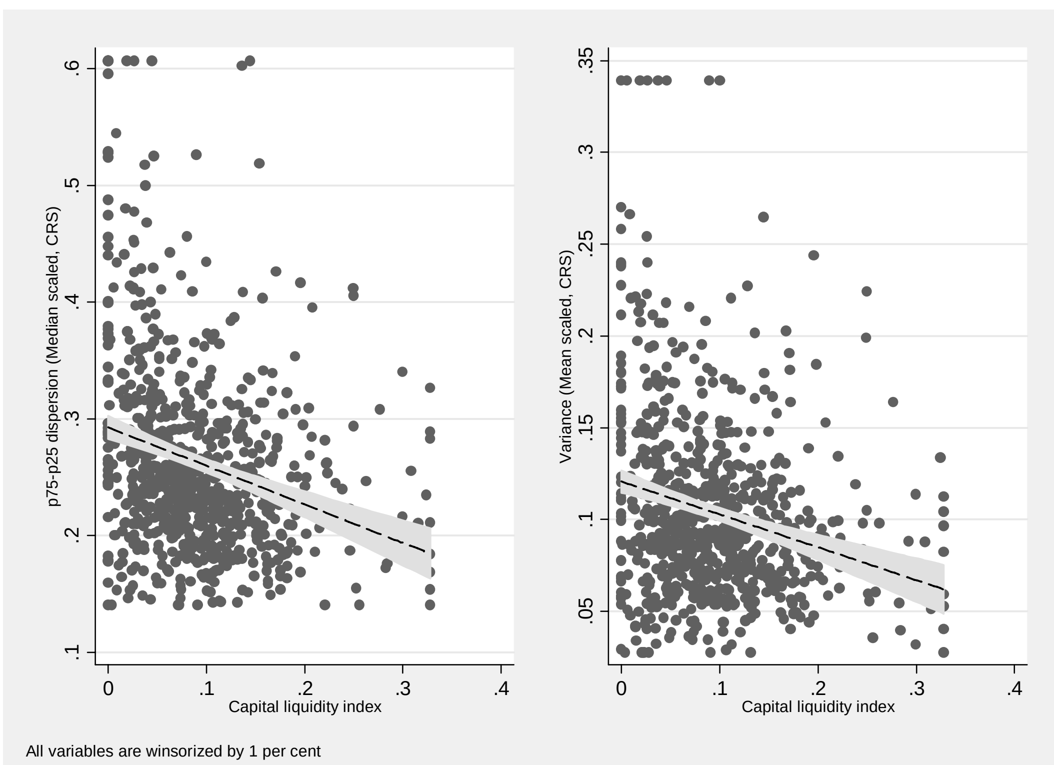

Figure 2: Productivity dispersion versus capital liquidity index

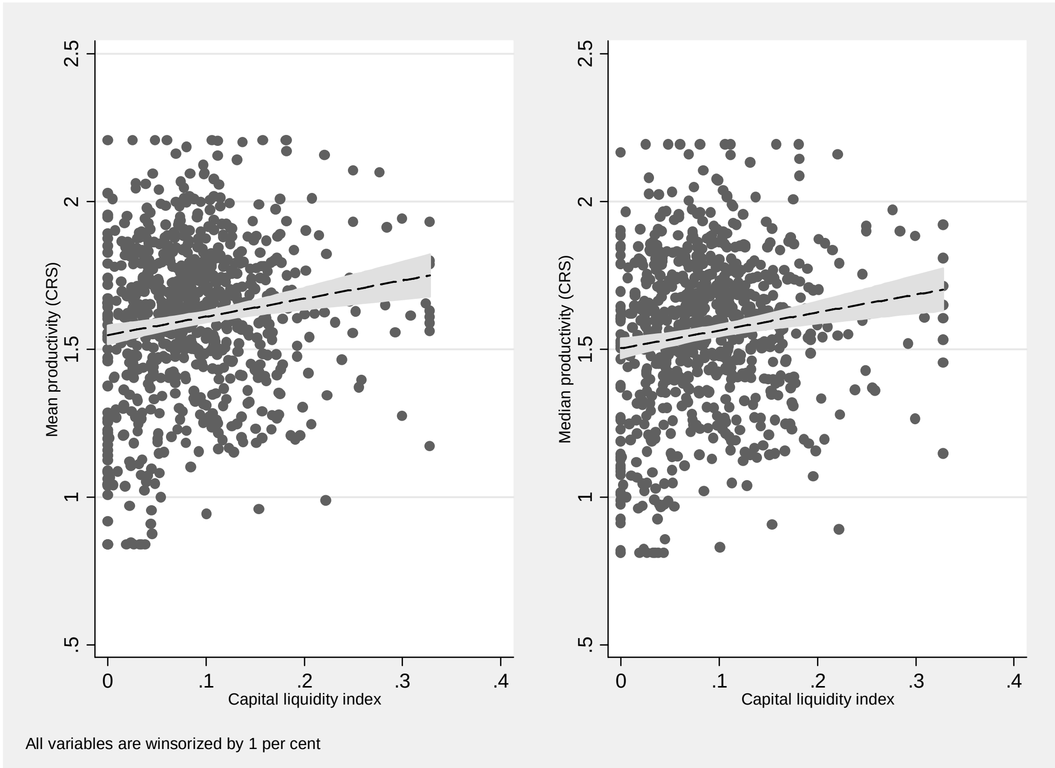

Figure 3: Productivity mean/median versus capital liquidity index

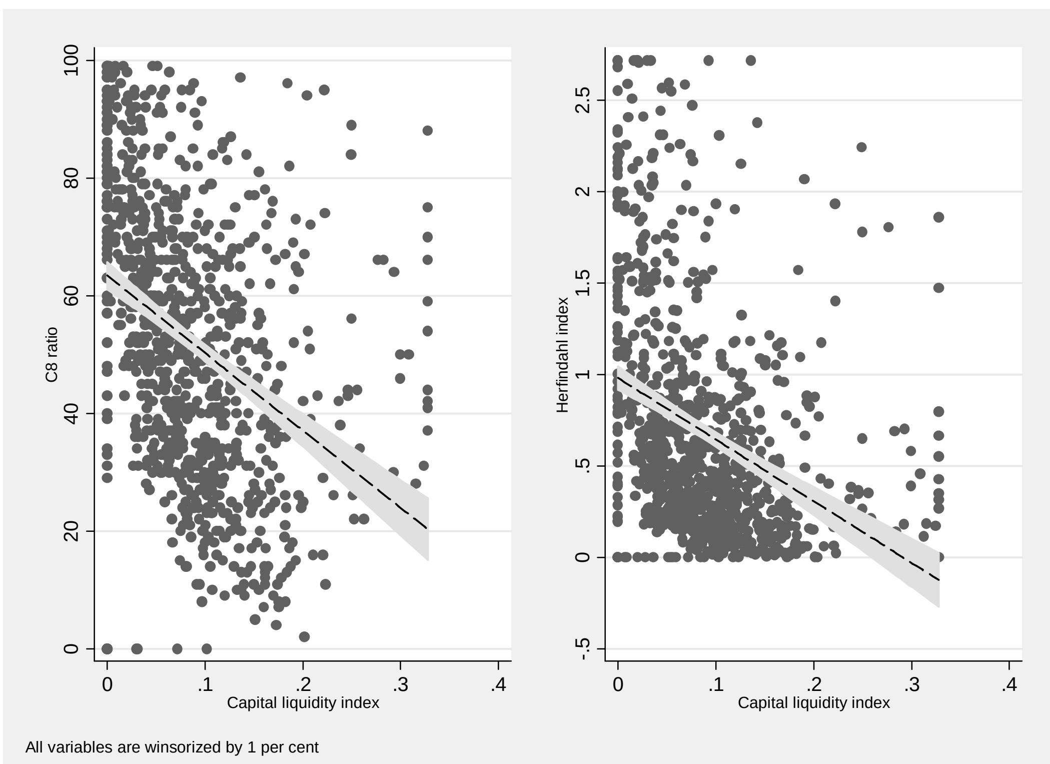

Figure 4: Concentration versus capital liquidity index

Table 3: Baseline estimates

The TFP measure is a Solow residual computed using industry average input shares. Standard errors are clustered at 4 digit industry level. + significant at 10%; * significant at 5%; ** significant at 1%.

	Dispersion		Central tendency		Concentration	
	TFP p25-p75 range	TFP variance	TFP mean	TFP median	C8 ratio	Herfindahl index
Capital liquidity 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-squared	0.06	0.04	0.02	0.02	0.12	0.11
Number of clusters	381	381	381	381	459	459

Table 4: Robustness to inclusion of sunk and fixed costs

The TFP measure is a Solow residual computed using industry average input shares. Refer table 1 for definition of other variables. Standard errors are clustered at 4 digit industry level. + significant at 10%; * significant at 5%; ** significant at 1%.

	Dispersion		Central tendency		Concentration	
	TFP p25-p75 range	TFP variance	TFP mean	TFP median	C8 ratio	Herfindahl index
Capital liquidity index	-0.269	-0.159	0.447	0.481	-95.014	-2.665
	[0.073]**	[0.042]**	[0.169]**	[0.171]**	[14.671]**	[0.435]**
Industry sunk cost index	0.064	0.009	-0.255	-0.233	26.785	0.565
	[0.019]**	[0.011]	[0.071]**	[0.072]**	[6.061]**	[0.186]**
Industry fixed cost index	0.102	0.091	0.25	0.297	8.25	0.084
	[0.035]**	[0.022]**	[0.132]+	[0.136]*	[9.523]	[0.308]
Constant	0.251	0.093	1.527	1.46	52.835	0.801
	[0.015]**	[0.009]**	[0.048]**	[0.049]**	[3.734]**	[0.113]**
Observations	760	760	760	760	760	760
R-squared	0.09	0.07	0.1	0.09	0.22	0.17
Number of clusters	381	381	381	381	381	381

Table 5: Robustness to inclusion of trade competition variables

The TFP measure is a Solow residual computed using industry average input shares. Standard errors are clustered at 4 digit industry level. + significant at 10%; * significant at 5%; ** significant at 1%.

	Dispersion		Central tendency		Concentration	
	TFP p25-p75 range	TFP variance	TFP mean	TFP median	C8 ratio	Herfindahl index
Capital liquidity index	-0.318	-0.166	0.627	0.654	-122.546	-3.314
	[0.080]**	[0.050]**	[0.176]**	[0.179]**	[15.982]**	[0.409]**
Share of total output exported	0.171	0.072	-0.38	-0.307	25.915	0.384
	[0.067]*	[0.035]*	[0.181]*	[0.185]+	[10.368]*	[0.330]
Share of imports in industry sales	-0.011	0.007	0.401	0.336	0.805	-0.02
	[0.026]	[0.015]	[0.083]**	[0.084]**	[6.417]	[0.178]
Constant	0.282	0.115	1.516	1.468	60.804	0.965
	[0.014]**	[0.009]**	[0.032]**	[0.033]**	[2.150]**	[0.065]**
Observations	643	643	643	643	787	787
R-squared	0.08	0.05	0.08	0.07	0.15	0.13
Number of clusters	324	324	324	324	393	393

Table 6: Robustness to inclusion of product substitutability variables

The TFP measure is a Solow residual computed using industry average input shares. Refer table 1 for definition of other variables. Standard errors are clustered at 4 digit industry level. + significant at 10%; * significant at 5%; ** significant at 1%.

	Dispersion		Central tendency		Concentration	
	TFP p25-p75 range	TFP variance	TFP mean	TFP median	C8 ratio	Herfindahl index
Capital liquidity index	-0.331	-0.169	0.729	0.748	-117.64	-3.17
	[0.075]**	[0.044]**	[0.176]**	[0.174]**	[16.201]**	[0.410]**
Dollar value per pound	-0.577	0.111	4.059	4.177	-33.456	0.068
	[0.426]	[0.299]	[1.127]**	[1.117]**	[71.217]	[2.493]
Diversification index	0.202	0.115	-0.205	-0.178	41.977	0.905
	[0.078]**	[0.052]*	[0.219]	[0.229]	[13.013]**	[0.366]*
Constant	0.275	0.108	1.53	1.476	57.177	0.862
	[0.011]**	[0.007]**	[0.035]**	[0.035]**	[2.942]**	[0.078]**
Observations	639	639	639	639	783	783
R-squared	0.09	0.07	0.08	0.08	0.16	0.14
Number of clusters	321	321	321	321	390	390

Table 7: Robustness to inclusion of advertising and R&D variables

The TFP measure is a Solow residual computed using industry average input shares. Standard errors are clustered at 4 digit industry level. + significant at 10%; * significant at 5%; ** significant at 1%.

	Dispersion		Central tendency		Concentration	
	TFP p25-p75 range	TFP variance	TFP mean	TFP median	C8 ratio	Herfindahl index
Capital liquidity index	-0.388	-0.206	0.77	0.803	-133.021	-3.326
	[0.096]**	[0.056]**	[0.210]**	[0.211]**	[19.564]**	[0.511]**
Advertising intensity	0.508	0.317	0.658	0.533	79.731	1.738
	[0.130]**	[0.092]**	[0.485]	[0.488]	[33.860]*	[0.947]+
R&D intensity	0.351	0.339	1.674	1.786	43.387	1.511
	[0.204]+	[0.146]*	[0.578]**	[0.601]**	[41.113]	[1.400]
Constant	0.275	0.106	1.465	1.416	59.32	0.867
	[0.015]**	[0.010]**	[0.036]**	[0.037]**	[2.733]**	[0.080]**
Observations	624	624	624	624	746	746
R-squared	0.09	0.08	0.05	0.05	0.16	0.13
Number of clusters	323	323	323	323	384	384

Table 8: Robustness to inclusion of industry survival rate

The TFP measure is a Solow residual computed using industry average input shares. Standard errors are clustered at 4 digit industry level. + significant at 10%; * significant at 5%; ** significant at 1%.

	Dispersion		Central tendency		Concentration	
	TFP p25-p75 range	TFP variance	TFP mean	TFP median	C8 ratio	Herfindahl index
Capital liquidity index	-0.352	-0.190	0.606	0.617	-121.05	-3.302
	[0.073]**	[0.044]**	[0.161]**	[0.162]**	[16.300]**	[0.425]**
Industry survival fraction	0.023	-0.027	-0.631	-0.614	25.27	0.758
	[0.031]	[0.019]	[0.095]**	[0.096]**	[6.980]**	[0.202]**
Constant	0.284	0.138	1.892	1.835	47.624	0.548
	[0.015]**	[0.009]**	[0.054]**	[0.054]**	[4.447]**	[0.121]**
Observations	748	748	748	748	748	748
R-squared	0.06	0.05	0.12	0.11	0.16	0.15
Number of clusters	381	381	381	381	381	381

Table 9: Robustness to inclusion of all controls

The TFP measure is a Solow residual computed using industry average input shares. Standard errors are clustered at 4 digit industry level. + significant at 10%; * significant at 5%; ** significant at 1%.

	Dispersion		Central tendency		Concentration	
	TFP p25-p75 range	TFP variance	TFP mean	TFP median	C8 ratio	Herfindahl index
Capital liquidity 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]**
Industry 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-squared	0.15	0.12	0.26	0.24	0.34	0.3
Number of clusters	266	266	266	266	266	266

Table 10: Robustness to capital mis-measurement -- Basu-Kimball TFP measure

The TFP measure is estimated as suggested by Basu and Kimball (1997). Standard errors are clustered at 4 digit industry level. + significant at 10%; * significant at 5%; ** significant at 1%.

	Dispersion		Central tendency	
	TFP p25-p75 range	TFP variance	TFP mean	TFP median
Capital liquidity index	-0.276	-0.166	0.388	0.479
	[0.090]**	[0.065]*	[0.200]+	[0.208]*
Industry sunk cost index	-0.013	-0.058	0.004	0.042
	[0.038]	[0.022]**	[0.077]	[0.077]
Industry fixed cost index	-0.012	-0.181	0.051	0.197
	[0.108]	[0.087]*	[0.230]	[0.234]
Share of total output exported	-0.055	0.077	-0.13	-0.152
	[0.090]	[0.106]	[0.210]	[0.217]
Share of imports in industry sales	0.157	0.037	0.21	0.15
	[0.060]**	[0.042]	[0.142]	[0.143]
Dollar value per pound	-0.549	0.06	7.495	7.335
	[0.596]	[0.364]	[2.220]**	[2.144]**
Diversification index (weighted)	0.339	0.056	-0.579	-0.536
	[0.101]**	[0.074]	[0.230]*	[0.248]*
Advertising intensity	0.476	0.32	-0.116	-0.157
	[0.260]+	[0.156]*	[0.582]	[0.599]
R&D intensity	-0.329	0.015	0.746	0.927
	[0.391]	[0.253]	[0.945]	[1.016]
Industry Fraction Survival	-0.064	-0.123	-0.239	-0.134
	[0.069]	[0.044]**	[0.136]+	[0.138]
Constant	0.282	0.238	1.475	1.302
	[0.058]**	[0.037]**	[0.114]**	[0.113]**
Observations	498	494	498	498
R-squared	0.1	0.09	0.15	0.13
Number of clusters	257	257	257	257

Appendix Table 1: Robustness to using alternative measures of product substitutability

The TFP measure is a Solow residual computed using industry average input shares. Standard errors are clustered at 4 digit industry level. + significant at 10%; * significant at 5%; ** significant at 1%.

	Dispersion		Central tendency		Concentration	
	TFP p25-p75 range	TFP variance	TFP mean	TFP median	C8 ratio	Herfindahl index
Used capital share of investment	-0.361	-0.185	0.820	0.835	-110.800	-3.208
	[0.093]**	[0.055]**	[0.193]**	[0.190]**	[17.704]**	[0.474]**
Share of shipments shipped <100 miles	0.156	0.098	-0.551	-0.577	-39.525	-0.606
	[0.094]+	[0.058]+	[0.158]**	[0.163]**	[6.757]**	[0.173]**
Primary product specialization ratio	-0.003	-0.002	0.003	0.003	-0.035	0.000
	[0.001]**	[0.000]**	[0.002]	[0.002]	[0.125]	[0.004]
Constant	0.572	0.330	1.308	1.230	66.376	1.020
	[0.048]**	[0.029]**	[0.168]**	[0.172]**	[11.311]**	[0.368]**
Observations	639	639	639	639	639	639
R-squared	0.11	0.11	0.08	0.08	0.17	0.14
Number of clusters	321	321	321	321	321	321

Appendix Table 2: Robustness to using alternative measures of dispersion and concentration

The TFP measure is a Solow residual computed using industry average input shares. Standard errors are clustered at 4 digit industry level. + significant at 10%; * significant at 5%; ** significant at 1%.

	Dispersion	Concentration		
	TFP p10-p90 range	C4 ratio	C20 ratio	C50 ratio
Capital liquidity index	-0.641	-91.458	-97.991	-66.94
	[0.184]**	[16.518]**	[17.473]**	[15.890]**
Industry sunk cost index	0.057	23.262	21.168	8.228
	[0.032]+	[5.003]**	[8.311]*	[7.841]
Industry fixed cost index	0.375	-43.961	-31.781	-4.131
	[0.120]**	[12.255]**	[14.555]*	[13.734]
Share of total output exported	0.099	27.204	40.056	39.388
	[0.152]	[13.333]*	[12.639]**	[12.175]**
Share of imports in industry sales	0.084	-10.029	12.091	24.64
	[0.066]	[7.755]	[6.921]+	[6.408]**
Dollar value per pound	-1.553	144.966	72.937	10.893
	[1.824]	[125.644]	[82.181]	[54.853]
Diversification index (weighted)	0.387	28.684	52.248	54.649
	[0.196]*	[14.221]*	[13.600]**	[12.395]**
Advertising intensity	0.7	28.637	16.185	11.522
	[0.232]**	[30.509]	[32.730]	[29.806]
R&D intensity	0.109	141.896	105.633	53.99
	[0.576]	[67.070]*	[59.300]+	[54.779]
Industry Fraction Survival	0.08	18.191	34.386	30.68
	[0.075]	[8.842]*	[8.789]**	[8.926]**
Constant	0.394	35.134	46.317	51.135
	[0.060]**	[7.506]**	[7.912]**	[7.417]**
Observations	514	514	514	514
R-squared	0.14	0.33	0.34	0.23
Number of clusters	266	266	266	266

Appendix Table 3: Robustness to alternative measure of TFP – OLS residuals

The TFP measure is defined as the residuals from an OLS regression of log real revenue on log real materials costs, log real capital stock and log employment. Standard errors are clustered at 4 digit industry level. + significant at 10%; * significant at 5%; ** significant at 1%.

	Dispersion		Central tendency	
	TFP p25-p75 range	TFP variance	TFP mean	TFP median
Used capital share of investment	-0.104	-0.061	0.278	0.316
	[0.036]**	[0.017]**	[0.222]	[0.218]
Industry sunk cost index	0.024	-0.015	-0.071	-0.046
	[0.022]	[0.011]	[0.195]	[0.191]
Industry fixed cost index	0.051	0.03	-0.074	-0.053
	[0.032]	[0.015]*	[0.275]	[0.277]
Share of total output exported	-0.011	-0.002	-0.158	-0.157
	[0.035]	[0.019]	[0.241]	[0.244]
Share of imports in industry sales	0.056	0.019	0.08	0.047
	[0.018]**	[0.009]*	[0.145]	[0.143]
Dollar value per pound	-0.272	-0.062	3.354	3.521
	[0.183]	[0.135]	[1.296]*	[1.302]**
Diversification index (Plant, weighted)	0.13	0.056	-0.918	-0.918
	[0.040]**	[0.023]*	[0.222]**	[0.219]**
Advertising intensity	0.374	0.148	0.154	0.133
	[0.107]**	[0.046]**	[0.612]	[0.603]
R&D intensity	0.268	0.116	-0.001	-0.007
	[0.183]	[0.120]	[1.011]	[1.020]
Industry survival fraction	-0.051	-0.038	-0.537	-0.528
	[0.023]*	[0.009]**	[0.157]**	[0.155]**
Constant	0.167	0.061	2.32	2.282
	[0.019]**	[0.008]**	[0.114]**	[0.113]**
Observations	459	459	459	459
R-squared	0.23	0.26	0.12	0.12
Number of clusters	239	239	239	239