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Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability?*

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Abstract

A pervasive finding in the burgeoning literature using business microdata is that firm turnover is high and that this churning process contributes substantially to aggregate (industry) productivity growth, as more productive entrants appear to displace less productive exiting businesses. A limitation of this research is that establishment-level prices are typically unobserved, resulting in within-industry price differences being embodied in productivity measures. If prices reflect idiosyncratic demand shifts or market power variation, high "productivity" businesses may not be particularly efficient. In this case, the literature's findings might be better interpreted as evidence of entering businesses displacing less *profitable*, but not necessarily less productive, exiting businesses. This distinction is important not only for the sake of understanding the positive features of selection, but the normative ones as well; whether selection is driven by efficiency or market power differences has important welfare implications. In this paper, we investigate the nature of selection using data from industries where we observe both establishment-level quantities *and* prices. We find that, as has been found in the preceding literature for revenue-based TFP measures, physical productivity and prices also exhibit considerable within-industry variation. We also show that while physical productivity shares common traits with revenue-based measures, there are important differences. These involve the productivity levels of entrants relative to incumbents and the size of the impact of net entry on productivity aggregates. Furthermore, we characterize the dimension(s) of selection and show that both idiosyncratic productivity and demand (price) conditions affect businesses' survival probabilities.

1. Introduction

A robust finding of the large and growing literature using business-level microdata is that within-industry reallocation and its associated firm turnover shape changes in industry aggregates. The effect of this churning process on aggregate productivity has received particular theoretical and empirical attention.

Models of such selection mechanisms characterize industries as collections of heterogeneous-productivity producers and link producers' productivity levels to their performance and survival in the industry (see, for example, Jovanovic (1982), Hopenhayn (1992), Ericson and Pakes (1995), and Melitz (2003)). The important mechanism driving aggregate productivity movements in these models is the reallocation of market shares to more efficient producers, either through market share shifts among incumbents or through entry and exit. Low productivity plants are less likely to survive and thrive than their more efficient counterparts, creating selection-driven aggregate (industry) productivity increases. Hence the theories point to the productivity-survival link as a crucial driver of productivity growth.

The related empirical literature has documented this mechanism as a robust feature of industry dynamics.[1] Businesses' measured productivity levels are persistent and vary significantly within industries, suggesting that productivity "types" among producers have an inherent idiosyncratic element. Reallocation, entry, and exit rates are large. Businesses with higher measured productivity levels tend to grow faster and are more likely to survive than their less productive industry cohorts. These signs all point to a selection mechanism being at work.

In reality, however, the productivity-survival link is a simplification. Selection is on profitability, not productivity (though the two are likely correlated). Producers should continue operations if the discounted sum of their future profit stream is above the opportunity cost of operating. Productivity is only one of several possible idiosyncratic factors that determine profits, however. Other idiosyncratic factors may affect survival as well. While the models cited above and their literature counterparts *do* actually construct their selection mechanism on profits, productivity is the only idiosyncratic producer characteristic. Thus producer profits are a positive monotonic function of productivity, and selection on profits is equivalent to selection on productivity.

[1] Bartelsman and Doms (2000) review much of this literature.

Given the empirical findings discussed above on the importance of productivity to survival does this theoretical simplification matter? There is reason to believe it may. A limitation of empirical research with business microdata is that establishment-level prices are typically unobserved. Previous studies have had to measure establishment output as revenue divided by a common industry-level deflator.[2] Therefore within-industry price differences are embodied in output and productivity measures. If prices reflect idiosyncratic demand shifts or market power variation rather than quality or production efficiency differences, a reasonable supposition for many industries, then high "productivity" businesses may not be particularly efficient.[3] If this is the case, the empirical literature documents the importance of selection on profits, but not necessarily productivity. Therefore the connection between productivity and survival probability, reallocation, and industry dynamics may be overstated.

Accurately characterizing the nature of the selection mechanism is important from a positive standpoint, but involves important welfare concerns as well. Holding demand structure fixed, selection on efficiency is always welfare improving: society uses fewer resources to obtain a given amount of output. This need not be the case with demand-based selection. Shifts in market share toward businesses with more market power tend to lower welfare. Indeed, if there were a high negative correlation between productivity and market power, selection might actually on net reallocate production *away from* more efficient business, lowering welfare in two ways.[4]

In this paper, we attempt to measure the separate influences of idiosyncratic productivity and demand on selection. We can explore this bifurcation systematically because, unlike most of the previous empirical work on the subject, we are able to observe both producers' physical outputs and prices. We can then measure separately both physical efficiency (physical units of

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[2] Syverson (2001), which uses physical output data as we do in this study, is an exception to this.

[3] Input price variation is another possible business-specific profitability influence that could also show up in productivity measures. Businesses enjoying idiosyncratically low input prices will look as though they are hiring fewer inputs per unit output. While we abstract from the effects of input price variation here, Katayama, Lu, and Tybout (2003) argue factor prices are potentially important. We see this area as a possible expansion point for future work.

[4] This distinction becomes even more important in models where, rather than reacting to a fixed and exogenously given profitability type, producers can actively invest in their type (e.g. Ericson and Pakes 1995). An industry equilibrium with stronger incentives to become more profitable by expending resources to increase market power rather than lowering costs opens the possibility of substantial social welfare costs as the industry evolves.

output per unit of input) and prices at the business level, and look at the contribution each one has in isolation on producer dynamics and within-industry reallocation.

Our empirical strategy is to focus on establishments that produce homogeneous products. This offers a couple advantages in interpreting our empirical results and matching them to theory. First, our physical output measures are more meaningful. For example, one might reasonably consider two plants' outputs of 1000 cubic feet of ready mixed concrete as equal outputs. This would be much harder to do for, say, two automobile assemblers producing 1000 cars each. Second, across-producer quality differences are minimized. We can then be more confident that our physical-output-based productivity measure reflects producers' true output, and that price variations indicate differences in demand levels or markups instead of quality differences.[5]

The specific products that we investigate are ready-mixed concrete, roasted coffee, and white pan bread.[6] Producers of these products make products that are among the most physically homogeneous in the manufacturing sector. In addition to product homogeneity, the set of producers is large enough (ready-mixed concrete in particular) to exhibit sufficiently rich within-industry reallocation and turnover.[7]

We are not the first to note the possible difficulties involved in using revenue-based output when using microdata. Abbott (1992) documents the extent of price dispersion within broad industries and outlines possible implications for measurement of aggregates. Klette and Griliches (1996) consider how intra-industry price fluctuations can affect production function and productivity estimates. Melitz (2000) explores this problem further and extends the analysis to consideration of multi-product producers. Katayama, Lu, and Tybout (2003), whose theme perhaps most closely matches that of this paper, demonstrate that both revenue-based output and

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[5] If prices reflect quality differences, then prices *should* enter the output measure and may actually be indicative of higher productivity levels (in terms of delivered utility per unit input). We have chosen our industries not because we think quality differences are unimportant to reallocation and selection, but rather to isolate the separate effects of production efficiency and demand without confounding the two through quality's simultaneous effect on output and prices.

[6] These products are a subset of the products that Roberts and Supina (1996, 2000) use to their advantage in their studies of establishment-level price variations. In future drafts, we plan to expand our list of products under analysis.

[7] There are a number of homogeneous-output industries with large numbers of businesses outside of the manufacturing sector. Unfortunately, the microdata for these other sectors lacks the detailed production information necessary for this study.

expenditure-based input measures can lead to productivity mismeasurement and incorrect interpretations about how heterogeneous producers respond to shocks and the associated welfare implications. Each of these papers forwards an alternative method of empirical inference that attempts to avoid the difficulties inherent in productivity analysis when business-level price data is unavailable.

This paper shares an obvious common thread with this earlier work. It departs in that, rather than trying to infer "true" productivity using alternative estimation strategies, we have the unusual opportunity to compute it with the data at hand. We can therefore directly compare revenue-based productivity measures with (arguably) true measures of productive efficiency, and show precisely the impacts of each on selection dynamics and industry evolution. We do not mean to imply that having to econometrically infer true productivity is a weakness of the earlier research. Indeed, the thrust of those papers was to seek alternate inference methods, given that revenue-based output measures are so ubiquitous. We instead seek to take advantage of observing both "standard" microdata and the much more rare quantity data in order to determine definitively (at least for our sample industries) the differences between revenue-based and quantity-based output measures. The hope is, of course, that our findings for a small subset of industries offer insight into these links in the broader economy.

To preview our findings, we find that the large and persistent within-industry dispersion observed in revenue-based productivity measures is also present in prices and productivity measures based upon physical quantity measures. Revenue-based productivity levels are positively correlated with both prices and quantity-based productivity levels across plants, while prices are negatively correlated with quantity-based productivity levels.

With regard to selection and industry evolution, we find that exiting businesses have lower productivity levels (either revenue based or physical quantity based) than incumbents. However, while entering businesses have higher productivity levels in quantity-based terms than incumbents, this is not the case for revenue-based measures because entrants charge lower prices than average. This may in part explain the empirical puzzle that entering business are not any more "productive" than incumbents. Decompositions of aggregate (industry-level) productivity growth using the alternative productivity measures suggest that the existing literature may overstate the contribution of net entry to aggregate productivity growth. (However, even with the quantity-based productivity measures, reallocation effects still account for roughly 40 percent of aggregate productivity growth, with net entry accounting for 20 percent.) Finally, as implied by the argument above and our model, we find both idiosyncratic price (demand) and productivity effects are important for survival.

The paper proceeds as follows. Section 2 provides the theoretical motivation for the paper. This section highlights the multi-dimensional nature of selection in a simple model of imperfect competition within an industry where producer profits depend not only on producers' cost/productivity levels, but also on an idiosyncratic demand draw. Section 3 describes the data and measurement issues involved in our empirical study. Basic empirical facts about productivity and price distributions in our industries are then discussed in Section 4, and the central results regarding selection dynamics are presented in Section 5. Section 6 concludes.

2. Theoretical Motivation

We now show idiosyncratic demand and productivity can jointly determine producers' long-run survival prospects in industry equilibrium. The model, while simple, holds the advantages of making the equilibrium analytically tractable and the selection mechanism straightforward. To further enhance the presentation's clarity, we assume a specific demand system for industry products. It is important to note, however, that the qualitative characteristics of the results can be obtained using other demand structures.

Industries are comprised of a continuum of producers of measure *N*. Each producer (indexed by *i*, where *I* is the set of industry producers) makes a distinct variety of the industry product. The representative industry consumer has preferences over these varieties given by

$$\begin{aligned} U &= y + \int_{i\in I}(\alpha+\delta_i)q_i\,di - \frac{1}{2}\eta\left(\int_{i\in I}q_i\,di\right)^2 - \frac{1}{2}\gamma\int_{i\in I}q_i^2\,di \\ &= y + \alpha\int_{i\in I}q_i\,di - \frac{1}{2}\left(\eta+\frac{\gamma}{N}\right)\left(\int_{i\in I}q_i\,di\right)^2 + \int_{i\in I}\delta_i q_i\,di - \frac{1}{2}\gamma\int_{i\in I}(q_i-\bar{q})^2\,di \end{aligned}, \quad (1)$$

where y is the quantity of a numeraire good, $\alpha > 0$, $\eta > 0$, and $\gamma \geq 0$.[8] The variable δ_i is a variety-specific, mean-zero taste shifter; q_i is the quantity of good i consumed; and

$$\bar{q} = \frac{1}{N}\int_{i\in I}q_i\,di .$$

[8] This modified version of the demand system used in a different context by Melitz and Ottaviano (2003).

Here, utility is a quadratic function in total consumption of the industry's output, plus a term that captures idiosyncratic tastes for particular varieties, minus a term that increases in the variance of consumption levels across varieties. This last term introduces an incentive to equate consumption levels of different varieties. The parameter γ thus embodies substitutability across varieties; an increase in γ imposes a greater utility loss from consuming idiosyncratically large or small quantities of particular q_i, therefore limiting consumer response to price differences across industry producers. As $\gamma \rightarrow 0$, substitutability becomes perfect: only the total taste-adjusted quantity of industry varieties consumed affects utility. The parameters α and η shift overall demand for the industry's output relative to the numeraire, and δ_i shifts demand for particular goods relative to the level of α.

Utility maximization implies for all goods consumed in positive quantities,

$$p_i = \alpha + \delta_i - \eta N \overline{q} - \gamma q_i . \quad (2)$$

This can be shown to imply that industry producers face the following demand function:

$$q_i = \frac{\alpha}{\eta N + \gamma} + \frac{\eta N}{\eta N + \gamma} \frac{1}{\gamma} \overline{p} + \frac{1}{\gamma} \delta_i - \frac{1}{\gamma} p_i , \quad (3)$$

where $\overline{p}$ is the average price among industry producers.

Industry producers operate at a constant marginal cost c_i that is specific to each producer. (We can define productivity in the model as some inverse function of marginal cost.) Hence there is within-industry variation in both demand (δ_i) and productivity (c_i).[9]

Producer profits are given by:

$$\pi_i = \left(\frac{\alpha}{\eta N + \gamma} + \frac{\eta N}{\eta N + \gamma} \frac{1}{\gamma} \overline{p} + \frac{1}{\gamma} \delta_i - \frac{1}{\gamma} p_i \right) (p_i - c_i) . \quad (4)$$

Profit maximization implies the producer's optimal price is

$$p_i = \frac{1}{2} \frac{\gamma \alpha}{\eta N + \gamma} + \frac{1}{2} \frac{\eta N}{\eta N + \gamma} \overline{p} + \frac{1}{2} \delta_i + \frac{1}{2} c_i . \quad (5)$$

This is intuitively increasing in the overall level of demand for the industry's output, the average price charged by industry competitors, demand for the specific producer's variety (indexed by δ_i), and decreasing in productivity levels. Notice that (5) implies the average industry price is

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[9] In this draft, we abstract from factor markets and ignore the producer's optimal hiring decisions. We plan to extend the model to include this in future work.

$$\overline{p} = \frac{\gamma\alpha}{\eta N + 2\gamma} + \frac{\eta N + \gamma}{\eta N + 2\gamma}\overline{c}, \quad (6)$$

where $\overline{c}$ is the average industry cost draw in equilibrium. This in turn implies that the deviation of any producer's price from the industry average is

$$p_i - \overline{p} = \frac{1}{2}\delta_i + \frac{1}{2}\left(c_i - \overline{c}\right). \quad (7)$$

Thus the idiosyncratic component of producer prices increases in specific demand for the variety and decreases in businesses' productivity levels relative to their competitors; the more inefficient charge higher prices. We will see both of these components acting in our empirical work below.

Combining (5) with (3) gives the producer's quantity sold at the optimal price

$$q_i = \frac{1}{2\gamma}\left(\frac{\gamma\alpha}{\eta N + \gamma} + \frac{\eta N}{\eta N + \gamma}\overline{p} + \delta_i - c_i\right). \quad (8)$$

At this point some discussion is appropriate. The above derivation does not account for the fact that, since marginal utility for any particular good is bounded at $\alpha + \delta_i$ (see (2)), some goods may not be purchased at the price given by (5). Specifically, the condition on the idiosyncratic demand and cost draws that must be met to ensure $p_i \leq \alpha + \delta_i$ is

$$\delta_i - c_i \geq \frac{\eta N}{\eta N + \gamma}\overline{p} - \frac{2\eta N + \gamma}{\eta N + \gamma}\alpha. \quad (9)$$

Further, there are also combinations of idiosyncratic draws that would imply the quantity sold given by (8) is negative. Thus to ensure $q_i > 0$, the following condition must also hold:

$$\delta_i - c_i \geq -\frac{\eta N}{\eta N + \gamma}\overline{p} - \frac{\gamma}{\eta N + \gamma}\alpha. \quad (10)$$

In order for a producer to automatically satisfy (9) by satisfying (10), it must be true that $\alpha \geq \overline{p}$. We know that this condition holds because the average marginal utility bound across varieties (and therefore the maximum average price in equilibrium) is α. Therefore any producer operating in equilibrium (i.e., satisfying $q_i > 0$) is also setting a price below the upper marginal utility bound for its good.

Using (5) and (8), maximized profits are

$$\pi_i = \frac{1}{4\gamma}\left(\frac{\gamma\alpha}{\eta N + \gamma} + \frac{\eta N}{\eta N + \gamma}\overline{p} + \delta_i - c_i\right)^2. \quad (11)$$

Define the "profitability index" of a particular producer as follows:

$$\phi_i \equiv \delta_i - c_i . \quad (12)$$

Note that this index captures both idiosyncratic demand for producer i's product and its own marginal cost level. Expression (11) implies a critical value of this index, ϕ^*, where producers with $\phi_i < \phi^*$ will not find operations profitable.[10] Solving to obtain this level explicitly gives

$$\phi^* = -\frac{\gamma\alpha}{\eta N + \gamma} - \frac{\eta N}{\eta N + \gamma}\overline{p} . \quad (13)$$

Substituting this back into (11) yields the producer's operating profits in terms of the cutoff and own profitability levels:

$$\pi_i = \frac{1}{4\gamma}(\phi_i - \phi^*)^2 . \quad (14)$$

A large pool of ex-ante identical potential entrants decide whether enter the industry as follows. They first decide whether to pay a sunk entry cost s in order to receive demand and cost/productivity draws from a joint distribution with probability density function $f(\delta,c)$. The marginal distributions of δ and c are defined respectively over $[-\delta_e, \delta_e]$ and $[0, c_u]$, where $\delta_e < \alpha$. (The values δ_e and c_u are otherwise arbitrary, and while the marginal distribution of δ need not be symmetric, we assume here for simplicity that it is.) If they choose to receive draws, they then determine after observing their draws whether to begin production and earn the corresponding operating profits as given by (14). Clearly, only those with profitability draws that yield nonnegative operating profits ($\phi_i \geq \phi^*$) will choose to produce in equilibrium. Hence the expected value of paying s is the expected value of (11) over $f(\delta,c)$, conditional upon drawing $\phi_i \geq \phi^*$. This expected value is obviously affected by the cutoff cost level ϕ^*. A free-entry condition pins down this value: ϕ^* must set the net expected value of entry into the industry V^e equal to zero. Thus ϕ^* satisfies

$$V^e = \int_0^{c_u} \int_{\phi^*+c}^{\delta_e} \frac{1}{4\gamma}(\phi_i - \phi^*)^2 f(\delta,c) d\delta dc - s = 0 . \quad (15)$$

This expression summarizes the industry equilibrium.[11] It combines the two conditions that all producers make nonnegative operating profits and that entry occurs until the expected

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[10] Note that due to the quadratic form of the profit function, while (11)(14) implies positive profits for $\phi_i < \phi^*$, this would also imply that $q_i < 0$.

value of taking demand and cost draws is zero. Notice that the equilibrium requires producers to obtain combination of demand and productivity draws high enough to meet the profitability threshold. (The particular value of this threshold is affected by the distributions of the demand and cost draws as well as industry-wide demand and technology parameters, as discussed below.) Hence the model points to both idiosyncratic features of demand and technology jointly determining the likelihood of survivorship in the industry.[12]

2.1. Comparative Statics

The model yields implications about the relationship between exogenous parameters and ϕ^*, the equilibrium cutoff profitability level. From these we can draw connections between changes in industry-wide demand or technology parameters and survivorship.

Product Substitutability. Using the implicit function theorem:

$$\frac{d\phi^*}{d\gamma} = \frac{-\partial V^e / \partial\gamma}{\partial V^e / \partial\phi^*}.$$

Rewriting (15) in terms of the separate demand and productivity draws gives

$$V^e = \int_0^{c_u}\int_{\phi^*+c}^{\delta_e} \frac{1}{4\gamma}(\delta - c - \phi^*)^2 f(\delta, c)\, d\delta dc - s = 0. \quad (15a)$$

So:

$$\frac{\partial V^e}{\partial\gamma} = \int_0^{c_u}\int_{\phi^*+c}^{\delta_e} -\frac{1}{4\gamma^2}(\delta - c - \phi^*)^2 f(\delta, c)\, d\delta dc < 0, \quad (16)$$

which is clearly negative. Further,

$$\frac{\partial V^e}{\partial\phi^*} = \int_0^{c_u}\frac{1}{4\gamma}(\phi^* + c - c - \phi^*)^2 f(\phi^* + c, c)\, dc - \int_0^{c_u}\int_{\phi^*+c}^{\delta_e}\frac{1}{2\gamma}(\delta - c - \phi^*) f(\delta, c)\, d\delta dc < 0. \quad (17)$$

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[11] The equilibrium mass of producers N is determined by α, η, γ, $\bar{c}$, and ϕ^*, and can be solved for by substituting the $\bar{p}$ implied by (5) into (13)

[12] As a two-stage entry and production model, our framework abstracts from dynamics. It can thus be interpreted as highlighting selection effects across long-run industry equilibria. However, we could augment the model to obtain dynamics by specifying evolutions for idiosyncratic demand and productivity draws, as done for productivity in Melitz (2003) or Asplund and Nocke (2003). This would explicitly specify the link between survival from one period to the next and producers' profitability types. However, it would not change the basic qualitative nature of the selection process, nor affect the directions of the comparative statics below.

The first term in this expression is zero (intuitively, letting in on the marginal a formally marginally unprofitable producer has no effect on the expected value of entry), so the expected value of entry declines when the threshold profirability level increases.

Therefore the implicit function theorem implies that $d\phi^*/d\gamma < 0$; a decrease in subsitutability (embodied in an increase in γ) leads to a lower cutoff profitability cost level. Low-product-substituability markets require lower producer demand and/or profitability draws in order to support profitable operations. This is intuitive; lower substitution possibilities for industry consumers protects producers that have less appealing products or higher costs from being driven out of business by their high-demand and/or low-cost competitors.

Sunk Entry Costs. The derivative of V^e with respect to the sunk entry cost is –1. This, combined with the results above, implies $dc^*/ds < 0$. High sunk entry costs make it easier for relatively unprofitable (low demand and/or low productivity) producers to survive in equilibrium. To understand this intuitively, imagine the sunk cost approaching zero, and suppose the number of equilibrium producers supported by the market were fixed. With very low entry costs, it is extremely cheap for potential entrants to buy profitability draws, so a large number end up doing so. The n lowest order statistics of these draws (i.e., those potential entrants that will produce in equilibrium) decrease when sunk costs fall. As a result, ϕ^* falls with s—the cutoff profitability level and sunk entry costs move in opposite direcitons.

2.2. Discussion

The model offers some insights that we can take to the data. First and foremost, it shows how selection and survival in industry equilibrium can depend on both producer-specific demand and productivity. It also implies that shifts in aggregate industry conditions interact with idiosyncratic factors to determine the margins along which selection occurs (i.e., as ϕ^* shifts). Whether such shifts "bite" harder on the demand or productivity margin depends on the joint density of the producer-specific draws $f(\delta,c)$. This question is one area of focus for the empirical work below. Furthermore, the model also shows that the producer-specific deviation from average industry price is positively affected by both idiosyncratic demand and productivity levels. This suggests, as discussed in the introduction, that revenue-based TFP measures will confound demand and productivity effects. How closely revenue-based TFP matches true productivity is an empirical matter and is an additional area of our analysis.

A note regarding the welfare implications of selection is in order. As discussed in the introduction, while selection on productivity is always efficient, selection on demand may not be. The crucial element in this latter case is whether idiosyncratic demand acts as a producer-specific demand shifter (that is, on the level of demand) or as a demand-*elasticity* shifter. A shift in the level of demand only allows a producer to sell more output and (as long as marginal costs are not rising too fast) be more profitable, but does not affect the optimal markup. Hence demand-based selection in this case does not induce additional distortions; indeed, it is welfare-enhancing because output is allocated to high-marginal-utility varieties. On the other hand, idiosyncratic demand elasticities allow producers facing relatively inelastic demands to charge higher markups. This, too, makes them more profitable and increases survival likelihoods, but it also clearly opens the possibility that demand-based selection will increase distortions and lower overall welfare. In our model, the linear nature of demand implies that shifts in δ_i act to both shift the demand curve and the demand elasticity faced by producers. Thus both welfare-enhancing and welfare-reducing forces are at work in demand-based selection. In future revisions, we will compute the implied size of these impacts.

3. Data and Measurement Issues

We explore the demand-productivity-survival linkage using establishment-level data for producers of ready-mixed concrete, roasted coffee, and white pan bread. As mentioned above, the great advantage of focusing our empirical efforts on these three products is the homogeneity of the products.

The data is from the Census of Manufactures (CM). The CM is conducted quinquenially in years ending in '2' and '7' for the universe of manufacturing plants. The CM collects information on plants' annual value of shipments by seven-digit SIC product category and shipments in physical units when feasible.[13] In addition, the CM collects information on production worker and nonproduction worker employment, production worker hours, book values of equipment and structures, cost of materials, and cost of energy usage. In each census

[13] In the case of our industries, the units are thousands of cubic yards of ready-mixed concrete, thousands of pounds of roasted coffee, and thousands of pounds of white pan bread.

year, the Census Bureau relies on administrative record data for very small establishments (typically with less than five employees). In these administrative records (AR) cases all production data except total revenues and the number of employees is imputed. On average, about one-third of CM establishments are classified AR (although because of their small size, their output and employment shares are much smaller). Due to their limited data, these administrative record cases are excluded from our analysis.

We use the revenue and physical output data to compute plants' unit prices in each year.[14] These prices are then adjusted to a common 1987 basis using the corresponding four-digit-industry-level shipments deflators from the NBER Productivity Database. In the analysis that follows, the establishment price measure that is used is the log of the establishment relative price.[15] The census years 1982, 1987, 1992, and 1997 were selected for our sample based upon the availability and quality of physical output data in the CM.[16]

We also compute two total factor productivity (TFP) values for each establishment. Both follow the typical index form

$$tfp_i = y_i - \alpha_l l_i - \alpha_k k_i - \alpha_m m_i - \alpha_e e_t ,$$

where the lower-case letters indicate logarithms of establishment-level TFP, gross output, labor hours, capital stock, materials, and energy inputs; and $\alpha_j, j = \{l,k,m,e\}$ are the factor elasticities for the corresponding inputs. Labor inputs are measured as reported production-worker hours adjusted using the method of Baily, Hulten and Campbell which involves multiplying the production-worker hours by the ratio of total payroll to payroll for production workers.[17] Capital

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[14] Because the value and quantity of production are collected as annual aggregates, unit prices are annual averages. Not every unit sold over the course of the year need be sold at a price equal to the annual average, of course. The average unit price is equivalent to a quantity-weighted average of all transaction prices charged by the plant during the year.

[15] Our products do not always fully cover the 4-digit industries from which they are drawn as discussed below. For most purposes this is not a concern for measurement and analysis of prices, since we control for product-year interactions in all of the micro analysis below. However, as will become clear, the discrepancy between products and industries causes measurement difficulties for the analysis of aggregate (industry/product) effects below.

[16] There are physical quantity data in prior years that have been successfully used by Roberts and Supina (1996, 2000). We have explored the data in prior years and discovered some anomalies. In particular, it is more difficult to identify balancing product codes in prior years (balancing codes are used to make sure the sum of value of each product does not exceed the separately reported total value of shipments). A related problem is that there are erratic time series patterns in the number of establishments reporting physical quantities. Given our focus on entry and exit, we need to investigate the source of these erratic patterns before using the data for prior years.

[17] In future drafts we plan on using the method of Davis and Haltiwanger (1991) which yields a more direct imputation of nonproduction workers hours. This method uses the plant's number of nonproduction workers multiplied by the average annual hours for nonproduction workers in the corresponding two-digit industry

inputs are the plants' reported book-value capital stocks deflated to 1987 levels using sector-specific deflators from the Bureau of Economic Analysis (using the method described in detail in Foster, Haltiwanger and Krizan (2001)). Materials and energy inputs are the reported expenditures on each deflated using the corresponding input price indices from the NBER Productivity Database. Idiosyncratic establishment-level variation in input prices will be captured here as high measured inputs and in turn low measured productivity. For some purposes, this does not pose a problem (see the discussion below) since the implications of being high cost are the same as being of low productivity but in future drafts we plan on using the establishment-level material expenditures and quantities as it would be of interest to separate out these effects.[18]

We use industry-level input cost shares for the input elasticities α_j. These are computed using reported labor, materials, and energy expenditures from the CM. We also use a capital expenditures figure constructed as the reported equipment and building stocks multiplied by their respective capital rental rates for each plant's corresponding two-digit industry.[19] We use the time series average (over our sample) of the industry cost shares in our analysis.

The difference between our two TFP indices is in the log output y_i. One index measures output as the (deflated) dollar value of shipments (adjusted for the change in inventories). This index, which we denote TFPR, corresponds to the standard revenue-based output measure used in the literature. Clearly, establishment-level prices are embodied in this productivity index. The other index, which we denote TFPQ, uses instead the physical output data described above

(calculated from Current Population Survey data). Note that prior work suggests that these alternative measures of establishment-level total hours are highly correlated.

[18] Dunne and Roberts (1992) and Roberts and Supina (1996,2000) use the materials prices and find that high materials price plants are high output price plants. Syverson (2002) uses measures of the dispersion of local materials prices and also finds this contributes to the dispersion of output prices across plants. Note that a related issue is idiosyncratic variation in labor costs and physical capital costs. Labor costs may be especially difficult to disentangle as idiosyncratic variation in wages across plants undoubtedly reflects differences in the skill mix across plants (this relationship has been well-documented in the literature). Still, we can explore local market variation in input prices including labor.

[19] Capital rental rates are from unpublished data constructed and used by the Bureau of Labor Statistics for use in computing their Multifactor Productivity series. Formulas, related methodology, and data sources are described in U.S. Bureau of Labor Statistics (1983) and Harper, Berndt, and Wood (1989).

as the output measure.[20] Given the homogeneity of our industry's outputs, we interpret TFPQ as the most accurate measure of business production efficiency.

Note that in both cases our TFP measures are log-based measures so while the levels are not directly comparable, differences across establishments and time are comparable across these measures.

3.1. Properties of the Sample

As noted above, although the CM covers the universe of manufacturing establishments, some of these establishments (the AR cases) have a more limited set of data available. These AR cases are only classified up to the 4-digit industry level. This means that total establishment counts are available at the industry level but not at the product level (our level of analysis). This distinction does not matter for ready-mixed concrete since the industry contains only one product. The distinction does matter for roasted coffee and white pan bread which are in multi-product industries. Keeping these distinctions in mind, we first provide below some summary statistics for these *industries*. We then constrain our sample to non-administrative records (non-AR) cases. Once we narrow our focus to non-AR cases, we are able to provide summary statistics for the three *products*.

Roughly 5,300 establishments are classified in the ready-mixed concrete industry (SIC 3273)) in each of the census years in our sample. There are roughly 200 establishments in the roasted coffee industry (SIC 2095) in our sample years, in two subclasses of industries: roasted coffee (20951) and concentrated coffee (20952). White pan bread is part of the "Bread and Other Bakery Products, Except Cookies and Crackers" industry (2051). There are approximately 2,500 establishments classified in this industry in each census year in our sample. This industry is generally comprised of about seven subclasses of industries: bread (20511), rolls (20512), sweet yeast goods (20513), soft cakes (20514), pies (20515), pastries (20516), and doughnuts (20517). The establishment counts for each industry are shown in detail in Table 1 (row 1 of each panel).

Narrowing our focus to producers of our three specific products (who are also non-AR cases) reduces the number of establishments under consideration. Only ready-mix concrete is an

[20] Given that producers of the products in focus also sometimes produce other products, some adjustment to this physical quantity is made as described below.

actual single 7-digit product over our entire sample, both roasted coffee and white pan bread are aggregates of a small number of 7-digit products (see Data Appendix, Table A1 for the precise definitions of these products). There are approximately 4,000 establishments producing ready-mix concrete, 100 establishments producing roasted coffee, and 400 establishments producing white pan bread over the census years in our sample (see Table 1, row 2). However, some of these plants cannot be included in our sample because they do not report the data required to compute TFPQ and unit prices. Furthermore, we impose a product specialization criterion on our sample. Recall that one of the reasons that we picked these products is it appeared that the majority of the producing establishments specialize in the production of the product (based upon the primary product specialization ratio which refers to the 5-digit product).

From a measurement standpoint, specialization is particularly important for TFPQ, since aggregating the physical outputs of multi-product plants is conceptually very difficult. Furthermore, establishment factor inputs are reported only on an establishment-wide basis, not separately by product. Thus the TFPQ value for multi-product plants must impute the share of inputs allocated for our product of interest. Using specialized plants minimizes this potential measurement error. For less than completely specialized producers, we apportion inputs by dividing the reported output of the product of interest by that product's share of establishment sales. This adjustment method in effect assumes inputs are used proportionately to each product's revenue share. For example, a plant producing 1000 cubic yards of ready-mixed concrete that accounts for 80% of its shipment revenues will have the same TFPQ value as a completely specialized plant producing 1200 cubic yards of concrete, assuming they employ the same measured inputs. Without adjusting the output, the first plant would appear less productive because the inputs it uses its other products would be instead attributed entirely to ready-mixed production.

We calculate the product specialization ratio for each establishment as the share of the total value of the product in question (e.g., ready-mixed concrete) in the sum of the total value of all of the products that the establishment produces.[21] The average share of non-AR plants' values of shipments accounted for by the corresponding product is approximately 90%, 85%, and 40% for ready-mixed concrete, roasted coffee, and white pan bread, respectively. We narrow

[21] This sum of total product values excludes administrative records products, balancing code products, and miscellaneous products (contract work, miscellaneous receipts, and resales).

our focus to only those producers for whom at least 50% of their revenue is accounted for by the product of interest.[22] Given the specialization ratios quoted above, the majority of our sample establishments in ready-mix concrete and roasted coffee are much more product-specific than this. This is not the case for white pan bread, so care must be taken in interpreting our sample of white-pan bread producers as being representative of all white-pan bread producers. Applying the specialization rule, leaves approximately 3,800 establishments in ready-mixed concrete, 100 in roasted coffee, and 100 in white pan bread (see Table 1, row 3). The data appendix provides more details about the characteristics of the establishments producing ready-mix concrete, roasted coffee, and white pan bread.

Lastly, we exclude establishments whose data appears to suffer from a reporting or recording error or is imputed. Business microdata contains reporting and recording errors that can lead to wildly mismeasured values. To minimize their influence on empirical tests, we remove a small number of gross outliers that report physical quantities implying prices greater than ten times or less than one-tenth the median price in a given year. We also exclude those non-AR plants for which the Census Bureau imputed physical quantities because they did not fully report product-level data. Unfortunately, imputed data are not explicitly identified. To distinguish and remove imputed product-level data from the sample, we use techniques similar to those employed Roberts and Supina (1996, 2000).[23]

[22] In future drafts, we plan toWe test our results for robustness to this cutoff.

[23] Identifying imputed items is difficult both because there are not reliable impute flags and also because different methods are used. A common method for imputing is to use the ratio of the variable in question to payroll at the industry level combined with the establishment-level payroll variable since the latter is typically reported and/or available from administrative data. Identifying these cases is via calculating ratios of multiple variables to payroll and finding the modal values. We eliminate plant-year observations that are identified to be imputed using this method. Another method used for imputing physical quantities is to calculate ing the average industry unit price (from establishments reporting both quantity and value data), and divide ing the establishment's reported value of production by this price. Establishment prices calculated from this imputed data will be equivalent so , cold-deck imputes can potentially be identified via are eliminated by removing plants having finding the year's the modal price for the year and other indications (via other variables) that the data are imputed. We also eliminate observations identified to be imputed using this method.The second imputation algorithm is the "hot-deck" method. This uses ratios of both plants' total value of shipments and production worker wages to payroll in order to assign imputed quantities to similar plants. We identify hot-deck imputes by finding plants with equal values of the two ratios above that also have equivalent prices. These are then removed from the sample. As noted these methods are imperfect for identifying imputed data and potentially related measurement problems. Even after removing imputed items we still find a relatively small number of outliers especially in measures of physical quantities and for this draft we trim the 1 percent tails of the distributions of prices, TFPQ and TFPR. In future drafts, we hope to make more progress identifying the sources of the outliers.

Before proceeding, it is worth noting that in most of the analysis below we control for a product-year mean effects. This implies that even though the narrow product classes that we focus on do not always cover the entire 4-digit industry from which our price deflators are drawn (for our TFPR measure for example) that by controlling for product-year mean effects that we have implicitly controlled for the appropriate product deflators (at the product level, not the establishment level). Put differently, at the micro level, our comparisons of the TFPQ and TFPR measures reflect within product variation in relative prices across establishments—precisely the effects that are the focus of this analysis.

4. Basic Facts

In this section, we provide basic facts about the business-level distributions of TFPQ, TFPR and prices for our products. Results are presented for a pooled sample (where product/year effects are controlled for) and for individual products.

4.1. Cross-Sectional Patterns

We first characterize the cross sectional distributions of TFPR, TFPQ, and prices within industries. Despite the homogeneity of the outputs, there is considerable dispersion in these values across establishments. Table 2 presents some measures of this dispersion for a pooled sample (where product/year means have been removed) and separately for each product. As can be seen, there is substantial dispersion in each of the products in TFPR, TFPQ and prices. For example, in the pooled sample the establishment at the 90th percentile of the TFPR distribution is 47 log points larger than the 10th percentile establishment (implying a 1.6:1 TFPR ratio). The equivalent difference for TFPQ is 54 log points. This pattern, greater dispersion across establishments in TFPQ than in TFPR, holds for all products. As we will see below, this stems from the negative covariance between TFPQ and prices at the establishment level.

Table 3 shows the across-establishment correlations between TFPR, TFPQ, and prices. Not surprisingly (but still reassuringly), revenue-based and quantity-based productivity measures are strongly positively correlated in our industries (all correlations are statistically different from zero). The correlations are, however, all statistically different from one. Price variations seem to be an important source of the variation in the literature-standard productivity measures. This can be seen in the positive and statistically significant correlation between establishment prices and

TFPR, which holds for all products but is especially high for white pan bread. Notice that, unlike the positive correlation prices have with TFPR, there is a negative correlation between TFPQ and prices. This makes intuitive sense; more productive establishments are lower-cost establishments. If product market competition results in lower costs being passed through as lower prices (this has been documented for ready-mixed concrete by Syverson (2002)), then we should expect to see more efficient producers charging lower prices. Note that this effect might also be capturing the influence of idiosyncratic variation in input prices. High input price plants will be measured low TFPQ plants and high input prices are likely to be associated with high output prices as emphasized in Dunne and Roberts (1992) and Roberts and Supina (1996, 2000). The different correlations of the two productivity measures with prices also highlight the importance of the distinction between the two measures and its possible effects on previous results in the literature.

4.2. Establishment Turnover

Table 4 presents simple establishment turnover rates for the pooled sample by year and for each product by year. The entry rate is defined simply as the number of entering establishments between *t-k* (*k* = 5 here given use of economic censuses) and *t* as a fraction of the total number of establishments in year *t*. The exit rate is defined as the number of exiting establishments between *t-k* and *t* as a fraction of the total number of establishments in year *t-k*. For all products, there is substantial entry and exit with establishments in the concrete industry exhibiting especially high turnover.[24] The high turnover rates observed are in accordance with findings in the business microdata literature.

4.3. Persistence

We now explore the persistence of productivity and prices at the plant level. Earlier work on (revenue-based) productivity persistence has been done by Baily, Hulten, and Campbell (1992) and Foster, Haltiwanger and Krizan (2002). Supina and Roberts (1996) explored

[24] Note that we use the universe Census files to define entry and exit. One possible concern is that our sample selection criteria (only those plants with physical quantity data, etc.) would imply sample selection problems particularly with respect to plant turnover. We need to investigate sample selection issues further but simple plant turnover rates are similar for the universe of plants and our sample of plants.

establishment-level price persistence. This preceding work has found that, conditional on survival, there is substantial persistence in TFPR and prices.

The findings reported in Table 5 are consistent with the findings in the literature. The table shows the coefficients on the respective lagged dependent variables in simple AR(1) regressions. Both TFPR and prices are persistent at the establishment level. We also characterize (for the first time in the literature, to our knowledge) the persistence in TFPQ. Interestingly, we find that TFPQ also exhibits substantial persistence that is of similar order of magnitude to that for TFPR. Persistence also varies across products (e.g., white pan bread TFPQ, TFPR, and prices all exhibit more persistence), and there tends to be greater persistence for the revenue-weighted results, implying that larger establishments tend to have more persistent idiosyncratic characteristics.[25]

5. Entry, Exit, Productivity and Prices: Selection on Productivity or Prices?

The primary focus of our analysis is the connection between entry and exit dynamics and productivity and prices. As emphasized in the theoretical model in section 2, the working hypothesis is that market selection is driven by both efficiency and demand factors. Moreover, this implies that the connections drawn between TFPR and entry and exit in the existing literature may be misleading with regard to the importance of market selection for productivity growth. That is, TFPR dynamics may not accurately reflect the dynamics of TFPQ. In this section, we characterize the relations between entry and exit and the evolution of the TFPR, TFPQ, and price distributions using a number of simple empirical exercises.

We restrict our attention here to the pooled sample and control throughout for a complete set of product/year interactions. The pooled analysis is interesting in its own right, but it is also necessitated by the relatively small sample sizes for individual product groups (especially in terms of the number of entering and exiting establishments). We recognize that this pooling has some limitations. Controlling for product-year effects does imply that we are focusing on within product variation but the nature of that within product variation likely varies by product itself (i.e., the connection between market selection, productivity and prices likely varies across these products – as discussed in the data appendix the structure of the markets for these products varies

[25] Note that we always use revenue weights for the weighted results to avoid comparability/aggregation problems across products.

considerably). While data limitations make it difficult to conduct the analysis on a product-by-product basis, in future drafts we plan to consider specifications that permit the connection between prices, productivity and market selection to vary by observable market characteristics.

5.1. Evolution of the Productivity and Price Distributions

We begin with some simple descriptive regressions using the unbalanced, pooled sample. We regress each of the key business-level measures (TFPQ, TFPR, prices) on entry and exit dummies (i.e., the entry dummy for year t equals one if the establishment enters the product group between t-k and t, and the exit dummy equals one in year t if the establishment exits sometime between t and t+k) and a complete set of product/year interactions. The product/year fixed effects capture the productivity and price evolution of continuing establishments (hereafter denoted incumbents). Thus the entry (exit) dummy measures the difference between the productivity of an entering (exiting) establishment and an incumbent within a product group.

The outcome of this exercise is reported in Table 6. The results are somewhat sensitive to weighting. For the unweighted results, we find that exiting establishments have significantly lower TFPR, TFPQ, and prices than incumbents. In contrast, entering establishments have significantly higher TFPQ but significantly lower prices than incumbents. Also, there is no significant difference between entering establishments and incumbents in TFPR levels. For the weighted results, the same general patterns hold but the magnitudes of differences between incumbents and entrants and exiters are larger. The larger magnitude of the effects with weighting suggests that these differences will be important for the aggregate dynamics.

These results shed light on an empirical puzzle. A common finding in the existing literature using TFPR is that entering establishments have productivity levels similar to (if not smaller than) incumbents. We also find this for TFPR. Many theories imply that entrants should instead be more efficient than incumbents (because of vintage capital effects, for example). The discrepancy has launched its own set of explanations, such as learning-by-doing or start-up costs keeping entrants from immediately reaching their production frontier. Notice, however, that when TFPQ is used as the productivity measure, entrants *are* significantly more efficient than incumbents. As can be seen in the price results, the puzzle exists because entrants charge lower prices than incumbents (why this is so is not obvious and could use its own theory). The lower price decreases entrants' measured TFPR levels to the point of equality with incumbents.

5.2. Implications of Entry and Exit for Aggregate (Product-Level) Productivity Growth

To gauge the implications for aggregate (product-level) productivity growth, we decompose across-CM changes in product class (output-share-weighted) average TFPR and TFPQ. The existing literature (see, e.g., Aw, Chen and Roberts (2001), Baily, Hulten, and Campbell (1992), Bartelsman and Doms (2000), and Foster, Haltiwanger, and Krizan (2002)) has found that an important fraction of productivity growth is accounted for by reallocation effects and net entry in particular. To explore these issues in this context, we calculate the relative contributions of within-plant growth, reallocation between incumbents, and entry and exit to productivity growth using the alternative measures of productivity. To do so, we utilize the decomposition of Foster, Haltiwanger, and Krizan (2002), which is given as follows:

$$\Delta P_t = \sum_{i\in C}\theta_{it-1}\Delta p_{it} + \sum_{i\in C}(p_{it-1} - P_{t-1})\Delta\theta_{it} + \sum_{i\in C}\Delta p_{it}\Delta\theta_{it}$$

$$+ \sum_{i\in N}\theta_{it}(p_{it} - P_{t-1}) - \sum_{i\in X}\theta_{it-1}(p_{it-1} - P_{t-1})$$

where P_t is the output-share-weighted average productivity for the product class (either TFPQ or TFPR, where physical quantity shares are used to weight the former and deflated revenue shares to weight the latter), p_{it} is the productivity for establishment *i*, and θ_{it} is the output share of establishment *i*. The sets *C*, *N*, and *X* respectively represent the set of continuing establishments, entering establishments, and exiting establishments. This decomposition involves four terms: a within-establishment effect, a between-establishment effect, a cross effect, and a net entry effect. We apply this decomposition for each product separately, and then average the results across products using the aggregate product revenue as weights to obtain the results reported below.[26]

Before proceeding with this analysis, it is important to emphasize a measurement limitation of this aggregate analysis that we have managed to avoid in the micro analysis discussed above. In the micro analysis above of productivity and price distributions above (and in the survival analysis below), we have always controlled for product-year effects. We cannot do that here since the product-year effects are the object of the analysis. This focus on product-

[26] There is a subtle but potentially important difference in the weighting used for this analysis and the use of the revenue weights in the regression analysis in the prior section. In the prior section, for the pooled sample regression analysis the weighted results are based upon using current year revenue weights for each establishment. In this exercise, for each product the decomposition is calculated separately where weights for the productivity using physical quantities are physical quantities (current year as appropriate). To aggregate across products, we use the average (over time) revenue weights for each product.

year effects is hampered given differences between the PPI deflators we use to deflate revenue and the aggregated establishment-level prices. In principle, productivity growth at the product level should be equal using TFPR and TFPQ if the product level deflator is equal to the appropriate weighted average of the establishment-level prices. We check this and find that the five-year changes in our aggregate of establishment-level prices exhibits similar but not exactly the same changes as the PPI deflator. This difference is likely due to several factors. For one, our products are more narrowly defined than the 4-digit industries.[27] Furthermore, the sample scheme of PPI establishment survey may be different than that for the economic census (in principle they should be the same but BLS and Census maintain separate business registers drawn from different administrative source data). The discrepancy between the PPI and the aggregate of our establishment-level prices—and in turn the differences between the aggregate growth rates of TFPR and TFPQ—suggests comparisons of the aggregate decompositions should be treated with appropriate caution.

Another measurement limitation in the aggregates is that at five-year frequencies, overall productivity growth as well as some of the key terms in the decomposition exhibit substantial cyclicality (this was noted by Foster, Haltiwanger and Krizan (2002)). That is, both overall productivity and the within component tend to be procyclical. We have applied this decomposition to our products at across different five-year periods and found this to be true for our products as well. (Although net entry contributes positively to overall productivity growth in every five year period even if overall productivity is declining.)[30] The cyclicality in within establishment productivity is interesting in its own right, but is not the focus of this analysis.

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[27] Note that for the concrete industry (SIC 3273), our product covers virtually all of the industry. In this case, we find that the PPI matches with the aggregated establishment-level prices more closely and as such the growth rates of aggregate TFPQ and TFPR for concrete match more closely as well. In future drafts, we plan on exploring these issues more fully by calculating at TFPR measure based upon the aggregated establishment-level prices. Such a TFPR measure should match more closely with the TFPQ measure at the aggregate product level and is interesting to compare with the TFPR measure based upon the PPI deflators.

[30] This positive contribution of net entry follows directly from the results reported in Table 5 showing a statistically significant difference between the productivity of entering and exiting establishments even after controlling for year effects.

With these limitations in mind, we focus our attention in this section to a five year period, 1982-87, over which aggregate productivity in each of our products is growing. Table 7 presents the above decomposition for this period for both TFPR and TFPQ.[31] As can be seen for both aggregates, the within effects are large and positive, the between components are small and negative, the cross effects are large and positive, entry's impact is large and positive, and the effect of exit is small and positive. Overall, net entry accounts for 20 percent of TFPQ growth (averaged across the products considered) over this period, while accounting for 39 percent of TFPR growth. The lower net entry contribution for TFPQ is consistent with the hypothesis that at least some of the contribution of net entry to productivity growth found in the literature reflects price effects as opposed to selection on efficiency.

While the measurement differences in growth rates suggest caution in interpretation, at face value these results suggest that the literature may have overstated the contribution of net entry to aggregate productivity growth. Still, Table 6 shows an important role for reallocation effects overall and net entry in particular for aggregate productivity growth when using physical quantity measures. About 60 percent of productivity growth is coming from the TFPQ growth within incumbents, but 27 percent is coming from the cross effect and 20 percent from net entry. The latter two effects capture important aspects of reallocation. The cross effect captures the reallocation of market shares towards continuing establishments with higher productivity growth, and as discussed above, the net entry effect reflects the contribution of more productive entrants displacing less productive exiting establishments.

5.3. Effect on Survival

The above results characterize the overall contribution of net entry to productivity growth. Here, we focus on the plant-level manifestation of producer turnover. We do so using descriptive regressions which link a producer's relative locations in the productivity and price distributions to its survival probability. An advantage of this method is that we can measure the effects of both physical productivity (i.e., TFPQ) and prices on plant survival both in isolation and jointly, testing directly whether each (or both) have a significant impact on plants' exit decisions. We also compare these findings to those found in the literature using TFPR. This

[31] In future drafts, we plan on several robustness checks on these decompositions including: (i) calculating the decomposition for TFPR for the universe Census files for our industries/products and (ii) calculating the decomposition of an alternative TFPR using the aggregated establishment-level prices as the deflator for revenue.

allows us to quantify the degree to which previous empirical work has overstated the contribution of the productivity-survival link to aggregate productivity growth. This exercise is in many ways the complementary flip side of the above analysis on the evolution of the productivity and price distributions.

Table 8 presents the results of simple (linear probability) exit regressions. The sample here again is the pooled unbalanced panel of establishments and the set of controls are the full set of product-year interactions. The results from both the weighted and unweighted specifications 1-3 indicate clearly that lower TFPR, lower TFPQ, and lower price establishments are more likely to exit. The elasticity is greater for price effects than for either productivity measure, but recall from Table 2 that productivity volatility is larger than that for prices. Using the statistics in Table 2 and the (unweighted) coefficients in Table 8, a one standard deviation increase each in TFPR, TFPQ, and price correspond respectively to declines in exit probabilities of 1.6, 0.9, and 1.5 percentage points. Given that the mean 5-year exit rate for our sample is around 25 percent, these seem to be nontrivial effects.

Specification 4 tests the argument forwarded in the introduction and demonstrated by the model that selection may be based on both idiosyncratic productivity and price (demand) components. The results indicate that this is the case. When TFPQ and price effects are included simultaneously, both higher TFPQ and higher prices are associated with a lower likelihood of exit. The unweighted coefficients imply that a one standard deviation increase in TFPQ corresponds with a 1.2 percent decline in the probability of exit, while a one standard deviation price increase yields a 1.9 decline.

It is interesting to note that for the point estimates in the unweighted case that the magnitudes of the price and productivity effects actually increase when both effects are included simultaneously. This makes intuitive sense given the negative covariance between prices and productivity (TFPQ). That is, if high-cost/low-productivity plants are high-price plants then when we include only one effect there is an implied omitted variable bias which will dampen each of the effects independently. Put differently, the key point here is that controlling for both price and productivity effects simultaneously enables us to identify the cost/productivity effects vs. the demand effects. For example, while prices in general will reflect both demand and cost/productivity factors, controlling for TFPQ, we isolate the demand effects associated with prices. Moreover, this implies when we do control for TFPQ, the magnitude of the price effect should increase, which is exactly what we find.

6. CONCLUDING REMARKS

Our main (preliminary) findings are as follows:

- A simple differentiated products model shows that market selection should be driven by both demand (price) and efficiency (productivity) factors. Much of the recent empirical literature on productivity at the micro level has focused on the latter effect by effectively assuming away within sector price dispersion.
- Within narrowly defined product classes, productivity and prices exhibit substantial and persistent dispersion across establishments. This pattern holds for productivity measures based upon deflated revenue measures of output (with industry level deflators) and productivity measures based upon physical quantity measures.
- Productivity measures based upon deflated revenue output are highly correlated with productivity measures based upon physical quantities. Productivity based upon physical quantities is negatively correlated with establishment-level prices while productivity based upon deflated revenue is positively correlated with establishment-level prices.
- Productivity measures based upon physical quantities exhibit greater dispersion than productivity measures based upon deflated revenue.
- Exiting businesses have lower prices and lower productivity (either revenue based or physical quantity based) than incumbents or entrants. These effects are larger using weighted results.
- Entering businesses have lower prices than incumbents. Entering businesses have higher productivity than incumbents when using physical quantity based measures but entering businesses do not have higher productivity than incumbents when using revenue based measures.
- Decompositions of aggregate (product-level) productivity growth using the alternative productivity measures suggests that the results in the existing literature may have overstated the contribution of net entry to aggregate productivity growth. Note, however, that even with the physical quantity based productivity measures, reallocation effects

account for roughly 40 percent of aggregate productivity growth with net entry accounting for 20 percent.

- Lower productivity establishments and lower price establishments are more likely to exit. Controlling for both price and productivity effects simultaneously shows that both factors are important for survival as implied by the theory.

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Table 1: Establishment Counts by Product

A. Ready-Mix Concrete

Number of Estabs.	1982	1987	1992	1997
In Industry	5341	5319	5257	5281
Producing Product	3953	3962	4459	4036
Primarily Producing	3741	3788	4262	3890

B. Roasted Coffee

Number of Estabs.	1982	1987	1992	1997
In Industry	150	141	172	207
Producing Product	118	101	101	111
Primarily Producing	103	95	86	98

C. White Pan Bread

Number of Estabs.	1982	1987	1992	1997
In Industry	2301	2357	2539	2753
Producing Product	466	363	364	376
Primarily Producing	151	115	102	107

Table 2: Dispersion of Productivity and Prices

Dispersion Measure	Log(TFPR)	Log(TFPQ)	Log(Price)
		Pooled	
Std. Dev	0.20	0.21	0.10
90-10 Differential	0.47	0.54	0.22
		Concrete	
Std. Dev	0.20	0.21	0.08
90-10 Differential	0.48	0.53	0.20
		Coffee	
Std. Dev	0.30	0.35	0.25
90-10 Differential	0.77	0.95	0.57
		White Pan Bread	
Std. Dev	0.27	0.31	0.27
90-10 Differential	0.68	0.82	0.67

Note: For pooled statistics, all variables have had product/year means removed. Sample includes establishments whose primary product is concrete, coffee and white pan bread for 1982, 1987, 1992 and 1997 (concrete does not include physical quantity data for 1997).

Table 3: Correlations of Productivity and Prices

Pooled	Log(TFPR)	Log(TFPQ)	Log(Price)
Log(TFPR)	1	0.70	0.16
Log(TFPQ)		1	-0.22
Log(Price)			1

Concrete	Log(TFPR)	Log(TFPQ)	Log(Price)
Log(TFPR)	1	0.74	0.10
Log(TFPQ)		1	-0.21
Log(Price)			1

Coffee	Log(TFPR)	Log(TFPQ)	Log(Price)
Log(TFPR)	1	0.63	0.29
Log(TFPQ)		1	-0.43
Log(Price)			1

White Pan Bread	Log(TFPR)	Log(TFPQ)	Log(Price)
Log(TFPR)	1	0.45	0.41
Log(TFPQ)		1	-0.22
Log(Price)			1

Note: For pooled statistics, all variables have had product/year means removed. Sample includes establishments whose primary product is concrete, coffee and white pan bread for 1982, 1987, 1992 and 1997 (concrete does not have physical quantity data for 1997).

Table 4: Entry and Exit Rates of Establishments

Year	Entry Rate(t-k,t)	Exit Rate(t-k,t)
	Pooled	
1987	0.26	0.25
1992	0.28	0.26
1997	0.12*	0.21*
	Concrete	
1987	0.27	0.26
1992	0.28	0.21
1997	N/A	N/A
	Coffee	
1987	0.10	0.15
1992	0.13	0.17
1997	0.13	0.20
	White Pan Bread	
1987	0.10	0.25
1992	0.12	0.22
1997	0.11	0.18

Note: Sample includes establishments whose primary product is concrete, coffee and white pan bread for 1982, 1987, 1992 and 1997 (concrete does not have physical quantity data for 1997).* is pooled for coffee and white pan bread only.

Table 5: Productivity and Price Persistence for Continuing Establishments, 5-yr Horizon

(Reported values are coefficients on lags of respective dependent variables.)

	Dependent Variable: Log(TFPR)	Log(TFPQ)	Log(Price)
		Pooled	
Unweighted	0.239	0.306	0.329
	(0.013)	(0.013)	(0.012)
Weighted (Revenue Weights)	0.348	0.354	0.387
	(0.014)	(0.014)	(0.011)
		Concrete	
Unweighted	0.221	0.286	0.302
	(0.013)	(0.014)	(0.012)
Weighted (Revenue Weights)	0.250	0.285	0.327
	(0.014)	(0.013)	(0.012)
		Coffee	
Unweighted	0.266	0.376	0.343
	(0.084)	(0.082)	(0.062)
Weighted (Revenue Weights)	0.338	0.278	0.400
	(0.092)	(0.088)	(0.052)
		White Pan Bread	
Unweighted	0.585	0.446	0.391
	(0.061)	(0.060)	(0.062)
Weighted (Revenue Weights)	0.558	0.464	0.367
	(0.060)	(0.062)	(0.056)

Note: For pooled results, complete set of product and year dummies interacted included as controls. For individual product results, year dummies included as controls. Sample includes establishments whose primary product is concrete, coffee and white pan bread for 1982, 1987, 1992 and 1997 (concrete does not have physical quantity data for 1997). Lagged dependent variable is five year lag. Standard errors are in parentheses.

Table 6: Evolution of Productivity and Price Distributions

Unweighted

	Dependent Variable:		
	Log(TFPR)	Log(TFPQ)	Log(Price)
Exit Dummy	-0.018	-0.013	-0.007
	(0.005)	(0.005)	(0.002)
Entry Dummy	-0.003	0.017	-0.007
	(0.004)	(0.005)	(0.002)

Weighted (Revenue Weights)

	Dependent Variable:		
	Log(TFPR)	Log(TFPQ)	Log(Price)
Exit Dummy	-0.018	-0.021	-0.034
	(0.006)	(0.007)	(0.004)
Entry Dummy	-0.002	0.044	-0.023
	(0.006)	(0.007)	(0.004)

Note: Complete set of product and year dummies interacted included as controls. Sample includes establishments whose primary product is concrete, coffee and white pan bread for 1982, 1987, 1992 and 1997 (concrete does not have physical quantity data for 1997).
Standard errors are in parentheses.

Table 7: Decomposition of Aggregate (Industry/Product) Productivity Growth, 1982-87

Measure	Total	Within	Between	Cross	Entry	Exit	Net Entry
ΔLog(TFPR)	0.067	0.31	-0.04	0.34	0.28	0.11	0.39
ΔLog(TFPQ)	0.106	0.60	-0.08	0.27	0.18	0.01	0.20

Note: Decomposition calculated for each product separately. Results reported are for average across product decompositions using average (over time) revenue weights. Other than for total, reported statistics are shares.

Table 8: Simple Selection Equations (Linear probability model of exit—dependent variable equals 1 if establishment exits by year *t*)

	Unweighted			
Initial Conditions in Year *t-k*:	Specification 1	Specification 2	Specification 3	Specification 4
Log(TFPR)	-0.082			
	(0.021)			
Log(TFPQ)		-0.041		-0.055
		(0.019)		(0.021)
Log(Price)			-0.150	-0.187
			(0.041)	(0.045)

	Weighted (Revenue Weights)			
Initial Conditions in Year *t-k*:	Specification 1	Specification 2	Specification 3	Specification 4
Log(TFPR)	-0.048			
	(0.017)			
Log(TFPQ)		-0.030		-0.058
		(0.014)		(0.015)
Log(Price)			-0.190	-0.153
			(0.021)	(0.023)

Note: Complete set of product and year dummies interacted included as controls. Sample includes establishments whose primary product is concrete, coffee and white pan bread for 1982, 1987, 1992 and 1997 (concrete does not have physical quantity data for 1997).
Standard errors are in parentheses.

DATA APPENDIX

A.1. Defining Our Products

As background to how we define our products, it is first necessary to understand the product coding scheme that Census uses. There are three types of codes that we would like to highlight. First, Census codes flags products from administrative records (AR) sources. We exclude all of these AR products from our analysis. (Including in our measures of PPSR since it is obviously not possible to assign these AR products to a single 7-digit code.) Second, Census uses balancing codes to correct cases in which the sum of the total value of shipments of reported individual products does not sum to the reported total value of shipments. Census identified these balancing codes using special suffixes for the product codes in every census year except in 1987. Where balancing codes are identified, they have been deleted. Finally, Census collects data on receipts for contract work, miscellaneous receipts, and resales of products. These products are excluded from our calculations of PPSR (again, because it is obviously not possible to assign these AR products to a single 7-digit code). As a final exclusion, we did not include any products in that have a negative value (these are presumably balancing codes).

Ready-mix concrete is defined as one 7-digit product (3273000) over our entire sample (and this code does not change over the SIC revisions). The only difficulty with this data is that some of the products coded as 3237300 in 1987 were in fact census balancing codes. These balancing codes for concrete were all deleted from our sample. Roasted coffee is the sum of whole bean (2095111), ground and extended yield (2095117 and 2095118 in 1982 and 2095115 thereafter), and ground coffee mixtures (2095121). White pan bread is a single 7-digit product until 1992 when it was split into two products white pan bread, except frozen (2051121) and frozen white pan bread (2051122). These definitions are summarized in Table A1 below.

A.2 Characteristics of Establishments

In this section we briefly characterize some of the properties of the establishments that produce concrete, coffee and white pan bread. Table A.2 shows that producers of white pan bread a far more likely to be part of a multi-unit firm than is the case for concrete or coffee (especially at the start of the sample). In terms of the share of employment, employees in white pan bread producing establishments work almost exclusively at multi-unit establishment firms. The shares of activity at multi-unit establishment firms has been rising over time for concrete and falling over time for coffee.

Table A.3 shows the average size (in terms of employment) for the establishments producing concrete, coffee and white pan bread. Table A.3 shows that concrete establishments are much smaller than average than coffee who are in turn much smaller than bread producing establishments. It is useful to note that our specialized , non-AR producers of these products tend to be larger than all establishments in the industries from which these establishments are classified (this is especially true for white pan bread).

Table A.4 shows the four-firm concentration ratio for the establishments producing concrete, coffee and white pan bread. Table A.4 shows that the concrete industry is much less concentrated than white pan bread which in turn is less concentrated than coffee. These concentration rates need to be treated with caution since the geographic concentration of the markets for these products varies considerably. As emphasized in Dunne and Roberts (1992), Roberts and Supina (1996, 2000) and Syverson (2001), concrete and white pan bread are local markets (this is evidenced by the high fraction of shipments in these industries that are shipped less than 100 miles). In contrast, roasted coffee is more of a national industry as it is less expensive to ship roasted coffee than raw, green coffee beans so coffee plants tend to be located around transportation hubs (ports).

Table A1: Defining Our Products

A. Ready-Mix Concrete

Product Code	1982	1987	1992	1997
3273000	X	X	X	X

B. Roasted Coffee

Product Code	1982	1987	1992	1997
2095111	X	X	X	X
2095115		X	X	X
2095117	X *			
2095118	X			
2095121	X	X	X	X

* This actually appears as CURPC=2095115 in the data.

C. White Pan Bread

Product Code	1982	1987	1992	1997
2051111	X	X		
2051121			X	X
2051122			X	X

Table A2: Multi-Unit Establishments (Percent of Total that are Multi-Units)

Product	1982	1987	1992	1997
		Establishments		
Ready-Mix Concrete	48	57	60	65
Roasted Coffee	62	57	61	55
White Pan Bread	81	83	76	68
		Employment		
Ready-Mix Concrete	51	56	58	61
Roasted Coffee	86	78	77	75
White Pan Bread	91	89	92	90

Table A3: Average Size of Establishments

Product	1982	1987	1992	1997
Ready-Mix Concrete	21	25	19	23
Roasted Coffee	96	98	96	88
White Pan Bread	210	237	222	214

Table A4: Four-Firm Concentration Ratios

Product	1982	1987	1992	1997
Ready-Mix Concrete	6	7	7	7
Roasted Coffee	66	65	67	60
White Pan Bread	42	41	42	53