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Which Firms Die?
A Look at Manufacturing Firm Exit in Ghana

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I. Introduction

How successful are markets in developing countries at driving inefficient manufacturing firms out of business? This is a particularly important question in the African context. African economies have, in general, been exceptionally poor performers over the past 3 decades. Government policy and performance, as well as historical circumstances, have been blamed for an environment where markets do not function efficiently (Collier and Gunning 1999). In such an environment, it would not be surprising if inefficient manufacturing firms were able to survive. The purpose of this article is to explore the nature of firm exit among manufacturing firms in Ghana and in particular to test whether less productive firms are more or less likely to exit than other firms.

Dysfunctional governments have been criticized for contributing to Africa's economic failure (Collier and Gunning 1999), and the failure of effective government policy and the absence of functioning markets might prop up inefficient firms where elsewhere they would be driven from business. As in other countries, Ghanaian firms face the same kinds of transaction costs, limited access to credit, and supply/demand uncertainty that is characteristic of African manufacturing (Collier and Gunning 1999). However, while the Ghanaian environment remains a challenging one for firms to operate in, the environment is more favorable than in some other African countries. Ghana was one of the first African countries to engage in an economic reform program, the Economic Recovery Programme (ERP), begun in 1983.

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Prior to the ERP, the Ghanaian economy was in disarray (Aryeetey and Harrigan [2000] in Aryeetey, Harrigan, and Nissanke [2000a]). In the 1970s, the economy was subject to a series of controls. Over the period from 1972 to 1982, the exchange rate was held constant, while import quantities were strictly controlled through the Bank of Ghana's foreign exchange allocation. Inflation was high and variable, at an average of 40% over the 1970s, and the exchange rate became increasingly overvalued. By 1982, the overvaluation was estimated to be 816% (Werlin 1994). At the same time, there were strong controls on imported inputs, which led to massive capacity underutilization (Aryeetey and Harrigan 2000, 10). Throughout the period from 1973 to 1983, the government ran a deficit fiscal policy and had a clearly lax monetary policy. The problems of inflation, large balance of payments deficits, depletion of official foreign reserves, and accumulation of external payments arrears, as well as declining real GDP per capita and emigration of skilled workers, led to a crisis in the early 1980s.

A change of government led to the IMF-sponsored ERP and resulted in dramatic changes in policy. Trade restrictions were reduced, the exchange rate was allowed to devalue, and fiscal prudence was exercised by the government. The major changes in policy occurred at the outset of the program, yielding results that were almost as immediate, with inflation dropping from 122% in 1983 to 10% in 1985 and GNP per capita growth changing from −7.1% to 1.5% over the same period (Beaudry and Sowa 1994). The relative success continued in the 1990s, with the Ghanaian per capita average annual growth rate being 1.8% over that period in comparison to the sub-Saharan African annual average of −0.2% per capita over that period.

This changing macroeconomic context obviously had a considerable effect on the industrial sector. Important benchmarks in government industrial policy date back even earlier, to the 1960s. During this period, import substitution industrialization (ISI) strategies were adopted by many developing countries, including Ghana. The state took an important and growing role in the process, with state-owned firms producing 11.8% of manufacturing output in 1962, growing to 19.5% of manufacturing output in 1966 (Steel 1972). The overall ISI strategy failed for a variety of reasons, including a lack of foreign exchange to meet the needs of imported inputs for the manufacturing sector (Steel 1972).

Therefore, the ERP in 1983 also had a strong impact on the manufacturing sector in Ghana. Steel and Webster (1992) highlight the ways in which small manufacturing firms were responding to the reform program by becoming more competitive, changing product mix, and seeking new market niches. These efforts were not without constraints as even the "dynamic" entrepreneurs in their survey cited several challenges, most notably credit and access to finance. Within these constraints, the ERP still had an impact. The previous continuous decline of the manufacturing sector was stopped and reversed, resulting in a manufacturing growth rate of 14.2% between 1984 and 1987. This growth tapered over time to a rate of 2.6% between 1988 and 1995. Asante, Nixson, and Tsikata (2000) suggest that the slowdown in growth was a result of liberalization as competitive industries continued to grow but uncompetitive industries declined or folded up in the competitive environment. Overall, then, during the time period of the current study, the early 1990s, the manufacturing sector as a whole was growing, albeit slowly. Moreover, while the overall success of the reforms has been limited for a variety of different reasons (Aryeetey, Harrigan, and Nissanke 2000b), the economy has been comparatively healthy over the 1990s, both in comparison to Ghana's early history and in relation to other African countries over the same period. This is the context in which I will explore firm exit and, in particular, address the question of whether less productive firms are in fact the ones that are more likely to go out of business.

Since the data and conclusions of this article are going to be applicable to the manufacturing sector in Ghana, it is worth situating Ghanaian manufacturing within African context. This is possible as a result of a series of surveys that were conducted in the early 1990s as part of the Regional Program on Enterprise Development, coordinated by the World Bank in several African countries. The same core information on the firms was collected in each of the countries surveyed. Using this data, Bigsten et al. (2000) compare the manufacturing sectors in Cameroon, Ghana, Kenya, Zambia, and Zimbabwe along several dimensions. They find that "Ghanaian firms are smaller, have less than a third of the capital per employee than do firms in other countries, and have a less educated work force" (Bigsten et al. 2000, 808). This fact will be important to remember in situating the scope of the conclusions of this article.

A considerable challenge in examining the efficiency of firms that are exiting involves an accurate measure of firm productivity. The major issue in the measurement of firm productivity is the problem of simultaneity bias (Griliches and Mairesse 1998). Firm productivity is often measured as a simple residual from the regression of firm output on the firm's capital and labor (and other) inputs—the usual measure of total factor productivity.[1] The simultaneity problem arises because this firm productivity, the residual in the regression, is likely to be correlated with the choice of labor input. Recent advances in

[1] This is generally preferred to, e.g., labor productivity, which does not account for changes in a firm's use of capital.

addressing this problem have included the procedure of Olley and Pakes (1996) and the recent adaptation of that procedure by Levinsohn and Petrin (2003). The Olley-Pakes procedure uses a firm's investment as a proxy for productivity, and the Levinsohn-Petrin procedure employs a firm's use of intermediate inputs as such a proxy. A recent critique of these procedures by Ackerberg and Caves (2003) demonstrates that, if one follows the expressed assumptions of the Olley-Pakes and Levinsohn-Petrin procedures to their logical conclusions, a problem of (perfect) collinearity between the productivity term and the variable inputs will arise when either the intermediate input or the investment proxy is used. In separate and concurrent work (Frazer 2004), I develop a procedure that responds to Ackerberg and Caves's critique of collinearity while working within the assumptions of the Olley-Pakes and Levinsohn-Petrin framework. For the purposes of this article, I will employ both the Levinsohn-Petrin procedure and the newer procedure (Frazer 2004), as well as ordinary least square (OLS) estimation, for the purposes of measuring productivity.

A second problem in the measurement of firm productivity arises from the limited data typically available to describe a firm's labor force. Generally, when firm total factor productivity is measured, the measure of labor used in the production function is a measure of the number of workers, or the number of worker hours, or at best the number of the skilled and unskilled (or production and nonproduction) workers at a firm or plant. The problem with such limited data is the fact that a firm that hires more educated workers would likely have higher total factor productivity in such a setup. The output in such firms is higher, after controlling for the number of workers and the size of the capital stock, than it is in other firms due to the more educated workforce. However, such a firm is not necessarily using resources more productively or efficiently as human capital (in the form of education) is a resource, and in this case, the firm is using it more intensively than other firms (and paying for its added productivity). To address this issue, characteristics that more completely capture the human capital at a firm are included in the production function in this study.

This study explores the issue of firm exit in the context of Ghana. Other studies have explored firm exit for manufacturing firms in industrialized and developing countries, and some work also exists on the exit of small and medium enterprises in Africa. The results of this article are best summarized in the context of this previous work, and therefore the next section explores this literature.

II. Literature on Firm Productivity and Exit

Models of industrial evolution are a helpful frame of reference for analyzing firm exit. Jovanovic (1982) develops a model in which firms learn about their efficiency as they operate in an industry. Firms that enter are typically smaller than the average (existing) firm. They then either grow and survive or they decline and exit, depending on their productivity. Hopenhayn (1992) develops a dynamic model in which firms differ in their productivity levels, each of which evolves according to an exogenous Markov process. Firms exit when they experience a series of adverse productivity shocks. Melitz (2003) adapts this model to monopolistic competition in a general equilibrium setting that includes trade. In each of these models, and similarly in an oligopoly model devised by Ericson and Pakes (1995), young firms tend to be smaller than average and to exit more frequently. Consistent with these models (or, in fact, inspiring these models), Dunne, Roberts, and Samuelson (1988, 1989) demonstrated, using U.S. data, that entry and exit rates are correlated and that older and larger firms are less likely to fail. These results are also confirmed in empirical work by Olley and Pakes (1996) and Bernard and Jensen (2002).

Recent empirical studies have examined firm exit in developing countries as well. A collection of studies edited by Roberts and Tybout (1996b) have examined exit rates in Chile, Colombia, and Morocco and have found annual average exit rates to be 10.8%, 11.1%, and 6.0%, respectively (Haddad, de Melo, and Horton 1996; Roberts 1996; Tybout 1996). Nevertheless, sizable exit rates do not necessarily mean that the less efficient producers are being driven out of business. For example, when the Argentine exchange rate regime collapsed in the early 1980s, it left many firms with dollar-denominated debts in serious financial trouble, and as a result, the resulting exit patterns had little to do with productive efficiency (Swanson and Tybout 1988). Still, in other studies for Chile and Colombia (Tybout 1992; Liu 1993; Liu and Tybout 1996) and for Taiwan (Aw, Chen, and Roberts 2001), measured productivity among exiting plants is much lower than it is among incumbents. Also consistent with the previous work in developed countries, most studies find that exit is concentrated in smaller and younger plants (Roberts and Tybout 1996a; Das and Srinivasan 1997).

While many studies use developing country data, firm exit has been explored for Africa only in the context of micro and small enterprises (with 50 or fewer employees) in surveys of not only manufacturing firms but also of all small businesses. Liedholm, McPherson, and Chuta (1994, 1178), in a survey from Swaziland, Botswana, Zimbabwe, Malawi, and Kenya, report that firm exit is only partly related to business reasons, broadly defined: "Only about one-half of the closures of rural enterprises in these countries were caused by business failures (i.e., the enterprise was not financially or economically viable). Approximately one-quarter of the rural enterprises closed for personal reasons, such as bad health or retirement, while others closed because better options became available or because the government forced them to close." While Liedholm et al. do not have comparable measures of firm productivity, the above conclusions by implication constrain the potential impact of productivity on firm exit. McPherson (1995) focuses more exclusively on firm exit, using data from the aforementioned survey but dropping the Kenyan data and using hazard analysis to analyze firm survival. Contrary to the previously described results for Chile, Colombia, and Morocco, McPherson finds that the size of the enterprise has no significant effect on the firm's survival chances in Swaziland or Botswana and that in Zimbabwe larger firms are actually less likely to survive. In Malawi, as in previous results, he finds that smaller firms are less likely to survive. Liedholm and Mead (1999) focus on the micro enterprises (fewer than 10 workers) in the above data. Like previous studies, Liedholm and Mead also find that young firms are more likely to exit. However, as in the McPherson study of micro and small enterprises from these data, they find that the relatively larger firms in their sample (again remembering they typically have fewer than 10 employees) are more likely to exit.

Other previous studies have explored the manufacturing sector in Ghana more broadly. Teal (1999) found no growth in technical efficiency among firms in Ghana but rather found that output growth had been matched by a commensurate growth in labor and capital inputs. He also found no evidence that smaller firms grow faster than larger firms. Söderbom and Teal (2004) found that the dispersion in technical efficiency over firms in Ghana is similar to that found in other countries. They also find that the Cobb-Douglas specification is adequate to capture the technology in use by Ghanaian manufacturing firms.

In the current study, unlike the previous work on small and medium enterprises in Swaziland, Botswana, and Zimbabwe but similar to the previous work on Malawi, I find that the larger manufacturing firms in Ghana are, in fact, less likely to exit. Contrary to the Liedholm et al. (1994) survey, I also find that the more productive firms are less likely to exit in all specifications. Furthermore, capital intensive firms are more likely to exit, as are state-owned enterprises. As did virtually all previous studies, I also find that older firms are less likely to exit, although this effect diminishes with age.

III. Data

The data set employed for this study contains data on manufacturing firms in Ghana. This survey was initially conducted as part of the Regional Program on Enterprise Development (RPED) surveys of manufacturing firms in African countries, which was coordinated by the World Bank and organized in Ghana in conjunction with Oxford University and the University of Ghana (Legon). After the RPED program ended, the survey was continued as the Ghanaian Manufacturing Enterprise Survey (GMES) and was organized by Oxford University in conjunction with the Ghana Statistical Service. The four major manufacturing industries in Ghana, namely, woodworking, metalworking, food processing, and textiles and garments, are included in the sample, and together they make up 70% of manufacturing employment in Ghana (CSAE and University of Ghana [1994]; for details on the sampling procedure, see CSAE and University of Ghana [1994]). When firms exited from the sample, they were replaced with firms of the same size category, sector, and location, so that approximately (but not exactly) 200 firms were sampled in each year.[2] The years of data used in the current study are 1991, 1993, 1995, and 1997. Given the way in which the data were recorded in the surveys, it is known whether a firm exited between 1991 and 1993, between 1993 and 1995, between 1995 and 1997, or between 1997 and 1999. Therefore, while the data on productivity will be calculated using the complete sample, the exit probits will be performed using data from the 4 years 1991, 1993, 1995, and 1997. Overall, then, the data set is an unbalanced panel. In addition, a sample of 10 workers and 10 apprentices at each firm was surveyed (or all of the firm's workers/apprentices in the case of fewer than 10 in each category), thus creating a linked employer-employee data set.

This data set has both advantages and disadvantages over previous data sets that have examined firm productivity and exit. A chief advantage is that the data set is from Africa, and the reasons for wanting to examine firm exit in

[2] Note that this method of sampling will introduce some bias in the results. Ideally, one would like to refresh the sample (as a census naturally does) with entering firms (specifically, an appropriate chosen subsample thereof). By replacing an exiting firm in the sample with another firm with similar characteristics (in particular, small size), the replacement firm is by construction more likely to exit than the firms that are surviving. The only caveat to this bias is the fact noted previously, found in other studies, that entering firms are smaller than the average firm and exiting firms are smaller than the average firm. Therefore, the replacement firm, by being relatively small (on average), as the exiting firm is, might also be more likely to be an entering firm (which are on average smaller). Unfortunately, that is the only extent to which this bias is mitigated. The magnitude of bias resulting from this fact cannot be determined a priori as we do not have any information on the pool of entering firms in Ghana.

such a context have been outlined. The disadvantages of the current survey sample are equally clear. The firms represent a sample of manufacturing firms, and they are not part of a census of manufacturing firms, as in some other studies. The limitations of a sample, as opposed to a census, are obvious. In particular, the limited number of observations will restrict the ability to find significant relationships in the data in comparison to other studies.

On the other hand, the linked employer-employee nature of the data will allow for more careful estimation of the firm productivity than has been previously possible. As outlined in the introduction, the accurate characterization of the firm's labor force will result in a more accurate measurement of firm productivity, one that accounts for a firm's use of human capital.

IV. Measuring Firm Productivity

The most important consideration in accurately estimating a production function is determining how to handle the problem of simultaneity. In short, the problem lies in the fact that firm productivity, which is observed by the firm manager but not by the econometrician, will therefore be part of the residual of a production function but will also be correlated with the variable inputs of the production function (usually labor), resulting in biased coefficients on labor (l) and capital (k). Each of the current best-practice methods that are used for handling this simultaneity (the Levinsohn-Petrin and Olley-Pakes procedures, the procedure of Ackerberg and Caves [2003], and that of Frazer [2004]) separate the residual of the production function into two components: firm productivity, ω, which is observed and acted upon by the firm manager, and ε, which is the conventional residual. A Cobb-Douglas form of this value-added production function, with each of the measures in logarithms, for firm f at time t, is

$$y_{ft} = \beta_0 + \beta_l l_{ft} + \beta_k k_{ft} + \omega_{ft} + \varepsilon_{ft}. \tag{1}$$

As Griliches and Mairesse have observed (1998, 190), the major innovation of Olley and Pakes is "to proxy for ω . . . by bringing in a new equation, the investment equation."[3] Griliches and Mairesse note that "trying to proxy for the unobserved ω (if it can be done right) has several advantages over the usual within estimators (or the more general Chamberlain and GMM type estimators): it does not assume that ω reduces to a 'fixed' (over time) firm effect; it leaves more identifying variance in x and z and hence is a less costly solution to the omitted variable and/or simultaneity problem; and it should

[3] To be consistent with Olley-Pakes and Levinsohn-Petrin, I have changed the notation to ω.

also be substantively more informative."[4] The new equation that Olley and Pakes introduce is the investment demand equation, which is

$$i_{ft} = g_t(\omega_{ft}, k_{ft}). \tag{2}$$

The investment function is indexed as a function of t, since variables such as input prices and overall demand might also affect investment within a given period. These variables are assumed to affect all firms identically within a given period, but they can vary over time. Olley and Pakes provide the conditions under which this function is strictly increasing in firm productivity, ω. Under these conditions, the function can be inverted in order to obtain the proxy for firm productivity:

$$\omega_{ft} = g_t^{-1}(i_{ft}, k_{ft}). \tag{3}$$

This expression for firm productivity can then be substituted into equation (1). While a further assumption is needed to identify the coefficients of the production function, rather than outline this for the original Olley-Pakes procedure (which I will not employ), I will outline the methodology for a modified version of the Levinsohn-Petrin procedure, which is similar and which is what I employ here.

A. Summary of Modified Levinsohn-Petrin Procedure

Levinsohn and Petrin develop their technique at least partly to cope with the reality that, in a large number of developing country data sets, investment is zero for near a majority of observations (e.g., 56% of observations in the Ghanaian data set under examination) and therefore much information would be lost in dropping these observations, as required by the Olley-Pakes technique. As a result, Levinsohn and Petrin use intermediate inputs instead of investment as the proxy, and therefore they consider the intermediate input demand function:

$$m_{ft} = f_t(\omega_{ft}, k_{ft}). \tag{4}$$

In order for intermediate inputs to be a valid proxy for productivity, the intermediate input use must be monotonically increasing in ω, as in the case of investment. Levinsohn and Petrin provide the conditions under which this is the case. Then, equation (4) can be inverted to get

$$\omega_{ft} = f_t^{-1}(m_{ft}, k_{ft}). \tag{5}$$

As in the previous case, input prices are assumed to be common across firms

[4] Here I keep Griliches and Mairesse's notation, where x refers to the variable inputs and z refers to the fixed inputs.

within a given time period, and so the intermediate input function is indexed by t. Substituting this expression into equation (1) gives

$$y_{ft} = \beta_0 + \beta_l l_{ft} + \beta_k k_{ft} + f_t^{-1}(m_{ft}, k_{ft}) + \varepsilon_{ft}. \tag{6}$$

The f^{-1} function is allowed to be a nonparametric function of m and k. As a result, initially, the coefficient β_k cannot be separately identified from the nonparametric function. Rather, for the purpose of labeling, a function ϕ is defined as $\phi_t(m_{ft}, k_{ft}) = \beta_k k_{ft} + f_t^{-1}(m_{ft}, k_{ft})$, and therefore it is a nonparametric function. Then, the first stage of estimation involves estimating the following equation:

$$y_{ft} = \beta_0 + \beta_l l_{ft} + \phi_t(m_{ft}, k_{ft}) + \varepsilon_{ft}. \tag{7}$$

This is a partially linear model, which can be estimated using any semiparametric estimation technique but in this case is estimated using Nadaraya-Watson local constant least squares regression estimators, following the method of Robinson (1988), which is also described in Levinsohn and Petrin (2003). This gives a consistent estimate of the β_l coefficient. The second stage of the estimation obtains the estimate of β_k. Here, Levinsohn and Petrin (2003) (as also Olley and Pakes 1996 and Ackerberg and Caves 2003) assume that productivity follows a first-order Markov process, so that

$$\omega_{ft} = E[\omega_{ft} | \omega_{ft-1}] + \xi_{ft}. \tag{8}$$

This assumption is more general than, for example, the assumption of a fixed effect for firm productivity. Under this assumption, capital does not immediately respond to ξ_{ft}, which is the innovation in productivity over last period's expectation (the surprise in productivity). This assumption leads directly to the following moment condition:

$$E[\xi_{ft} | k_{ft}] = 0. \tag{9}$$

Note that this assumption is not as strong as the assumption sometimes used in production function estimation that $E[\omega_{ft} + \varepsilon_{ft} | k_{ft}] = 0$, that is, that capital is mean independent of this period's unobserved residual (the productivity ω plus the noise ε). The moment condition in equation (9) states that the unexpected part of the innovation in productivity this period is independent of this period's capital stock (which was determined by the previous period's investment). This moment condition can then be used to estimate β_k through the following expression:[5]

$$\xi_{ft}(\beta_k) = \omega_{ft} - E[\omega_{ft} | \omega_{ft-1}] = (\hat{\phi}_{ft} - \beta_k k_{ft}) - \hat{\psi}(\beta_k). \tag{10}$$

[5] The notation below follows Ackerberg and Caves (2003), who provide a very clean summary of the second-stage format used by Olley-Pakes and Levinsohn-Petrin.

As already noted, the $\hat{\phi}_{ft}$ values are obtained in the first stage of estimation. The $\hat{\psi}(\beta_k)$ values are the predicted values from the nonparametric regression of $\hat{\omega}_{ft}$ on $\hat{\omega}_{ft-1}$, that is, of $(\hat{\phi}_{ft} - \beta_k k_{ft})$ on $(\hat{\phi}_{ft-1} - \beta_k k_{ft-1})$. This moment condition identifies the capital coefficient, β_k. Again, the intuition behind the strategy lies in the assumption that the current period's capital stock is determined before the surprise in the current period's productivity.

B. Summary of the Ackerberg and Caves Critique

Ackerberg and Caves (2003) outline a problem of collinearity that applies to both the Olley-Pakes (1996) and Levinsohn-Petrin (2003) approaches. They also analyze the assumptions that would be required to break this collinearity in each of the Olley-Pakes and Levinsohn-Petrin methodologies. The major problem of collinearity occurs in the first stage of the regression. Consider their critique as applied to the production function of equation (6). Ackerberg and Caves's basic point is the following. If the intermediate input variable must be only a function of the two variables, ω and k, then l should only be a function of ω and k as well, as it is also a variable input. If this is the case, then

$$l_{ft} = x_t(\omega_{ft}, k_{ft}). \tag{11}$$

Substituting equation (5) into equation (11), they get

$$l_{ft} = x_t(f_t^{-1}(m_{ft}, k_{ft}), k_{ft}) = h_t(m_{ft}, k_{ft}). \tag{12}$$

That is, the labor variable, l_{ft}, is a function of m_{ft} and k_{ft}. If this is the case, then equation (7) will not be identified—l will be collinear with the nonparametric function ϕ, defined earlier. Ackerberg and Caves also provide the conditions under which this collinearity is broken.

C. Summary of the Frazer (2004) Procedure

Frazer (2004) provides a methodology that stays within the Olley-Pakes and Levinsohn-Petrin framework but addresses the Ackerberg and Caves critique. Given the collinearity that is noted by Ackerberg and Caves, Frazer (2004) notes that we can rewrite equation (7) as

$$y_{ft} = \phi_t^1(m_{ft}, k_{ft}) + \varepsilon_{ft}, \tag{13}$$

where $\phi_t^1(m_{ft}, k_{ft}) = \phi_t(m_{ft}, k_{ft}) + h_t(m_{ft}, k_{ft})$. Therefore, in Frazer (2004), the ϕ^1 function can be estimated nonparametrically. Unlike the Levinsohn-Petrin procedure, no other coefficient will be obtained in the first stage. Therefore, in the second stage, two coefficients remain for identification, β_k and β_l. As a result, two independent moment conditions are required to identify these coefficients. As in the Levinsohn-Petrin and Olley-Pakes procedures, Frazer (2004) assumes that productivity follows a first-order Markov process, so that, as in equation (8),

$$\omega_{ft} = E[\omega_{ft}|\omega_{ft-1}] + \xi_{ft}. \tag{14}$$

The capital coefficient is identified from the same assumption as in the Olley-Pakes and Levinsohn-Petrin procedures, namely, that

$$E[\xi_{ft}|k_{ft}] = 0, \tag{15}$$

which uses the expression

$$\xi_{ft}(\beta_k, \beta_l) = \omega_{ft} - E[\omega_{ft}|\omega_{ft} - 1] = (\hat{\phi}^1_{ft} - \beta_k k_{ft} - \beta_l l_{ft}) - \hat{\psi}^1(\beta_k, \beta_l). \tag{16}$$

In this case, both the contribution of capital and the contribution of labor need to be subtracted from the ϕ^1 function in order to get ω. The ψ^1 terms are obtained as the ψ^1 terms were previously, except using ϕ^1 instead of ϕ. Now, the second moment condition follows the same approach that is used to identify other variable input coefficients in the Levinsohn-Petrin procedure,[6] namely, we assume that the surprise in productivity, ξ_{ft}, is uncorrelated with last period's labor use:

$$E[\xi_{ft}(\beta_k, \beta_l)|l_{ft-1}] = 0. \tag{17}$$

Therefore, equations (15) and (17) are the two moment conditions that are used to identify the two coefficients β_k and β_l in the Frazer (2004) model.

V. Incorporating Heterogeneous Labor into the Production Function

Therefore, when the Levinsohn-Petrin and the Frazer (2004) techniques are used to estimate productivity in this current article, the techniques used will follow those described in the previous section. However, I can make a further improvement to the aforementioned techniques, given the information in my data set. I can characterize the labor force at the firm more accurately than merely the number of workers. To develop a more careful characterization of the labor term, it is worth examining the characteristics of individuals that have been found to improve worker productivity according to the labor literature. The estimation of earnings functions in the labor literature is dominated by the human capital model of Mincer (1974). This model predicts that an individual's productivity (and therefore his earnings) will be a function

[6] Levinsohn and Petrin (2003) estimate a gross output production, while Olley and Pakes (1996) estimate a value-added production. Therefore, Levinsohn and Petrin need to estimate additional variable input coefficients. The Levinsohn-Petrin technique described in this article is modified to fit a value-added production function, as in the Olley-Pakes case.

of his education (S) and a quadratic in work experience (X) and also whether the worker is an apprentice in the position (A). In another article (Frazer 2003), I developed the unique form of the labor term in the production function that is consistent with the Mincerian earnings function. That labor term (for L workers) is

$$\sum_{i=1}^{L} e^{\beta_1+\beta_2 S_i+\beta_3 X_i+\beta_4 X_i^2+\beta_5 A_i}. \tag{18}$$

Substituting equation (18) into equation (1) and suppressing the firm and time subscripts for the moment yields

$$y = \beta_0 + \log\left(\sum_{i=1}^{L} e^{\beta_1+\beta_2 S_i+\beta_3 X_i+\beta_4 X_i^2+\beta_5 A_i}\right)^{\beta_H} + \beta_K k + \omega + \varepsilon. \tag{19}$$

Following Frazer (2003), we calculate a first-order Taylor expansion of the labor term in the above expression to get

$$\begin{aligned} y_{ft} = {} & \beta_0^* + \beta_H \log L_{ft} + \beta_H\beta_2\bar{S}_{ft} + \beta_H\beta_3\bar{X}_{ft} \\ & + \beta_H\beta_4\bar{X}_{ft}^2 + \beta_H\beta_5\bar{A}_{ft} + \beta_K k_{ft} + \omega_{ft} + \varepsilon_{ft}, \end{aligned} \tag{20}$$

where $\beta_0^* = \beta_0 + \beta_1\beta_H$, and $\bar{W} = \sum_{i=1}^{L} W_i/L$ captures the averages of the human capital variables ($W = S, X, X^2, A$) in the workforce of size L.

In order to estimate equation (20), three methods are used. First, least squares regression on each of the right-hand-side observables will be used. Second, the modified version of the Levinsohn-Petrin (2003) procedure described in the previous section will be used, with the following modification. Each of the labor characteristics ($\bar{S}, \bar{X}, \bar{X}^2, \bar{A}$) is treated as a variable input, just as the total labor variable is treated (as opposed to the capital variable, which is usually labeled quasi-fixed). Therefore, the modified version of equation (7) that is used is

$$\begin{aligned} y_{ft} = {} & \beta_0^* + \beta_H \log L_{ft} + \beta_H\beta_2\bar{S}_{ft} + \beta_H\beta_3\bar{X}_{ft} \\ & + \beta_H\beta_4\bar{X}_{ft}^2 + \beta_H\beta_5\bar{A}_{ft} + \phi_t(m_{ft}, k_{ft}) + \varepsilon_{ft}. \end{aligned} \tag{21}$$

The coefficients on each of the variable inputs ($l, \bar{S}, \bar{X}, \bar{X}^2, \bar{A}$) are identified in the first stage, using semiparametric regression. The second stage is just as described for the modified Levinsohn-Petrin procedure in the previous section. Note that, given the size of the subsample of employees collected (10) is constant across all firms, the measurement error on each of the S, X, and

X^2 variables is going to be higher in large firms than in small firms.[7] In order to handle this fact, each of these variables is going to be instrumented using an average of the leads and lags of that variable at that firm. This instrument is valid under the assumption that the measurement error is independent between periods. This instrument is not an instrument to address the issue of simultaneity, which is handled through the techniques above, but just to address the issue of measurement error.

The third technique that is used is the technique of Frazer (2004), as outlined in the previous section. In this case, the first-stage regression is

$$y_{ft} = \phi^1(m_{ft}, k_{ft}) + \varepsilon_{ft}. \tag{22}$$

In the second stage, each of the coefficients requires identification. The moment conditions used for identification are equation (15) and

$$E[\xi_{ft}|z_{ft-1}] = 0 \tag{23}$$

for $z = l, \bar{S}, \bar{X}, \bar{X}^2, \bar{A}$. Therefore, the modified version of equation (16) that is estimated is

$$\begin{aligned}\xi_{ft}(\beta_k, \beta_H, \beta_2, \beta_3, \beta_4) = (\hat{\phi}^1_{ft} - \beta_k k_{ft} - \beta_H l_{ft} - \beta_H\beta_2\bar{S}_{ft} - \beta_H\beta_3\bar{X}_{ft} \\ - \beta_H\beta_4\bar{X}^2_{ft} + \beta_H\beta_5\bar{A}_{ft} - \hat{\psi}^1(\beta_k, \beta_H, \beta_2, \beta_3, \beta_4).\end{aligned} \tag{24}$$

Although the Levinsohn-Petrin (2003) procedure is theoretically preferred to least squares as it attempts to handle the problem of simultaneity and the Frazer (2004) procedure is theoretically preferred to the Levinsohn-Petrin (2003) procedure as it addresses the Ackerberg and Caves (2003) critique, the results of each of the three procedures will be reported for comparison. The production function coefficients estimated by the three procedures are given in appendix table A1. The first column corresponds to the standard OLS results, as the IV is merely handling the issue of measurement error. Therefore, the Frazer (2004) and Levinsohn-Petrin procedures give lower estimates on the labor coefficient and higher estimates on the capital coefficient than the OLS results. This is in line with the results in the Levinsohn-Petrin (2003) and Olley-Pakes (1996) efforts to handle simultaneity, although the labor coefficient for the Levinsohn-Petrin procedure in this case is considerably below that of other studies. In general, the other variable-input coefficients are of the expected sign but are imprecisely estimated.

[7] Firms report the number of apprentices working for them, and so this variable is not calculated from the subsample.

VI. Predicting Firm Exit

The empirical approach taken in this article is consistent with a variety of different theoretical models in the industrial evolution literature. A number of these models have already been mentioned in the literature section, and their predictions have been discussed. The purpose of this article is to explore the characteristics of firms that are going out of business, as well as to compare these characteristics with previous results and the predictions of various models. The empirical approach is to use probit estimation to determine the characteristics that successfully predict a firm's exit.

As already outlined, our primary variable of interest in predicting whether or not firms exit will be the firm's productivity. The other variables that will also be examined include firm size, firm age, the size of a firm's capital stock, whether a firm exports, the fraction of a firm that is unionized, the percentage of foreign ownership in a firm, and whether a firm is a state-owned corporation. Before examining the results, let us examine the a priori predictions for each of the firm's variables.

First, firms with higher productivity should be less likely to exit. That is, firms that are efficient in their use of resources should be less likely to exit than other firms that are not as productive. This result should hold both unconditionally and controlling for other factors. However, as mentioned previously, Liedholm et al. (1994) find that, in Swaziland, Botswana, Zimbabwe, Malawi, and Kenya, firm exit is only partly related to business reasons of any kind, suggesting that productivity is only a partial explanation of firm exit in Africa.

Second, we would expect that larger firms should be less likely to exit than other firms. This is consistent with the theoretical models of Jovanovic (1982) and Ericson and Pakes (1995), noted previously, as well as a number of empirical studies (e.g., Dunne et al. 1988, 1989; Roberts and Tybout 1996a; Das and Srinivasan 1997). Simply put, in a model where firms start relatively small and then grow if they are productive and successful or decline and fail if they are not, we would expect that smaller firms are more likely to exit. On the other hand, it is worth reiterating that the majority of existing African evidence (that of the cases of Zimbabwe, Swaziland, and Botswana described in McPherson [1995]; Liedholm and Mead [1999]) has found that smaller firms are not more likely to exit within the category of micro and small enterprises. McPherson (1996) also found that larger firms grow more slowly than smaller firms within the category of micro and small enterprises in Swaziland, Botswana, Lesotho, Zimbabwe, and two townships in South Africa.

The prediction for capital intensity of firms is not completely unambiguous. On the one hand, if, as in the model of Olley and Pakes (1996), the capital intensity of the firm reveals something about its future profitability, then we would expect that more capital intensive firms would be more likely to survive. On the other hand, standard trade models would predict that exit rates might be higher in capital intensive industries. Beginning in 1983 and continuing throughout the 1990s, Ghana was undergoing a sequence of reforms to liberalize trade, including the move to a floating exchange rate regime and removal of import barriers (Oduro 2000). The bulk of these reforms happened between 1983 and 1989, but reforms were continuing throughout the 1990s. According to the standard trade models, such as Heckscher-Ohlin factor proportions theory, the trade liberalization should result in an increased production and export of those commodities that are intensive in Ghana's relatively abundant factors of production and a reduction in production and export of those commodities that are not. Given the relative capital scarcity in Ghana, in comparison to other countries, the theory would predict that capital intensive industries would shrink as a result of trade liberalization, with firms going out of business in those industries. However, given that we have industry dummies included in all specifications, the prediction from trade theory for the capital intensity variable is not clear. While the prediction from trade theory is not clear, most conventional industrial organization models would predict that capital intensive firms should be less likely to exit.

On a similar note, one would expect that older firms are less likely to exit for similar reasons. They have possessed a bundle of characteristics that have helped prevent exit in the past, and therefore they should be more likely to avoid exit this period. This stylized fact is consistent with the predictions of the theoretical models of Jovanovic (1982) and Ericson and Pakes (1995), and it is also consistent with the empirical results of a number of studies (e.g., Dunne et al. 1988, 1989; Roberts and Tybout 1996a; Das and Srinivasan 1997). On the other hand, Steel and Webster (1992) show that, in a sample of small Ghanaian firms, younger firms are performing much better and growing much faster than older firms. However, they argue that there is a contextual reason for this fact. Firms that were established after 1983, that is, after the start of the economic reform program, were "highly entrepreneurial," "better educated . . . both formally and through significant past job experience" than their predecessors, who had established firms prior to 1983 (Steel and Webster 1992, 428). They basically argue that the reform program attracted higher-quality entrepreneurs than before the reform program and that, for this reason, younger firms were more successful.

The effect of unionization on firm success is not as clear. Teal (1996) finds that unionized workers in Ghana do earn about 28% more than nonunionized workers, suggesting that unionization matters for a firm's wage bill. Hirsch

(1991) finds that unionized firms have profits that are about 10%–15% lower than those of nonunionized companies. On the other hand, Freeman and Kleiner (1999) find that unionization does not increase the insolvency of firms. Their interpretation is that unions act rationally, pushing wages high enough that the firm might expand more slowly than other firms but not so high that the firm goes out of business. Little work has been done on unionization in developing countries, and so the question is certainly an open empirical one.

Only the models of Melitz (2003) and Bernard et al. (2003) link exporting and survival.[8] For Bernard et al. (2003), more productive plants are more likely to export and also are more likely to survive, and therefore exporters are more likely to survive, but not conditional on productivity. For Melitz (2003), the most productive firms are the ones that export. In his model, either exporting firms do not die, or if they do die, then there are no nonexporting firms. Therefore, while the existing models (scarce as they may be) suggest a positive link between exporting and firm survival, this relationship may not survive after controlling for productivity. The link between productivity and export in African firms has been found empirically in the work of Söderbom and Teal (2000), who find that exporting firms are some 24% more efficient than firms that do not export.

Fortunately, in this data set, we also know the ownership structure of the firms. State-owned corporations have frequently been criticized as hampering the economic success of African nations as they frequently operate with soft budget constraints and therefore need not be as efficient as private firms. In Ghana, the state-owned corporations come from two independent "waves." The state-owned corporations in the first wave were created as state-owned corporations shortly after independence as part of the government's import-substituting industrialization strategy, described earlier. The state-owned corporations in the second wave were acquired by the military government in the late 1970s and early 1980s. In an effort to determine to which of these waves the parastatals in the current sample belong, we can examine the date at which the firms were born. One-third of the state-owned enterprises in the sample were created between 1959 and 1961. While these enterprises might not have been state owned from their inception, it is also consistent with the contemporary government policy that they were. Two-thirds were created between 1974 and 1982. While the government was also privatizing state-owned enterprises during the 1990s, it is not immediately clear what impact this would have on the exit of those parastatals that were not privatized, although this will be further discussed in the results.

[8] I am indebted to one of the referees for this fact in particular.

TABLE 1
VARIABLE SUMMARY

	Overall		Comparison of Means	
	Means	Standard Deviation	Exiting	Surviving
Productivity (Levinsohn-Petrin method)	−.044	.857	−.668	−.002 **
Productivity (OLS Method)	−.014	1.192	−.425	.013
Productivity (Frazer 2004)	−.034	.798	−.418	−.008 $^{+}$
Firm age	16.21	11.71	16.63	16.18
Size (log employment)	3.113	1.279	2.443	3.158 **
Capital intensity (log capital/labor)	12.86	2.10	12.88	12.86
State owned (dummy)	.027	.163	.067	.024
Exporter (dummy)	.154	.362	.067	.160 $^{+}$
Fraction unionized	.240	.406	.123	.248 *
Foreign ownership (dummy)	.163	.370	.133	.165
N	479		30	449

Note. *N* = sample size.
$^{+}$ Significant difference between exiting and surviving firms at the 10% level.
* Significant difference between exiting and surviving firms at the 5% level.
** Significant difference between exiting and surviving firms at the 1% level.

On the other hand, firms that have some percentage of foreign ownership might be more likely to survive than other firms. Foreign investment in a country like Ghana requires that the investor overcome considerable barriers of information and transaction costs. One would expect that foreign investors would therefore only be willing to engage in joint ventures with firms that had a higher likelihood of continued success. In particular, in the case of wholly owned subsidiaries of multinational corporations, they typically only pay the large fixed costs associated with direct investment in a country like Ghana when they expect the firm to have a high probability of profitability. Moreover, foreign ownership likely indicates access to a wider range of financial resources than that for firms that are owned domestically. Therefore, overall, we would expect firms with some percentage of foreign ownership to be less likely to exit than other firms.

VII. Results

For each of the firm characteristics described in the previous section, the prevalence of this characteristic can be compared across exiting and surviving firms, and this is done in table 1. We find a significant difference in the size, export status, unionization fraction, and productivity (by the Levinsohn-Petrin and Frazer [2004] methods) between exiting and surviving firms.

Still, these characteristics are obviously correlated with each other. For example, older firms or exporting firms might also be more productive. Therefore, we need multivariate probit results to disentangle the effects of various firm characteristics. For ease of interpretation, each of the coefficients reports the percentage change in probability of exit calculated at the mean of the variable (rather than the standard probit coefficients). The first productivity measure, employed in table 2, is that of Frazer (2004).[9] We see that, in this case, firms that are more productive are in fact less likely to exit, both unconditionally and upon including a variety of controls. The coefficient point estimate is −0.022. A 1-standard-deviation increase in productivity will result in a 1.8% decrease in the probability of exit (over the subsequent 2 years). Given that the unconditional probability of exit was 6.3%, a 1-standard-deviation increase in productivity would reduce this unconditional probability by about 29%. Table 3 shows the result using the Levinsohn-Petrin methodology. Here again, we see that the coefficient on productivity is identically −0.022 once the other controls are included, resulting in a 1.9% decrease in the probability of exit, which is 30% of the unconditional probability. While the Frazer (2004) technique should be theoretically preferred to the Levinsohn-Petrin (2003) procedure, as it responds to the Ackerberg and Caves (2003) critique, we can see that, in this case, it does not matter for the purpose of calculating productivity once the controls are introduced. On the other hand, a quick glance at the results of table 4, where productivity is calculated using standard least squares techniques, tells us that controlling for simultaneity, whether by the Frazer (2004) or the Levinsohn-Petrin (2003) methods, does appear to matter. The coefficient on firm productivity in the OLS case is −0.013, which is lower than the other results,[10] but the dispersion of the productivity measure is also greater. In sum, a 1-standard-deviation increase in firm productivity, as measured by OLS, should result in a 1.5% decrease in the probability of exit. Thus the point estimate is reduced by about 25% in the OLS case. In all specifications, more productive firms are less likely to exit.

While the average age of exiting and surviving firms was not significantly different in table 1, we find some evidence that older firms are less likely to exit in table 2. We might expect that, while older firms should be less likely to exit, this effect should be diminishing with age. Therefore, a quadratic specification for age is used. This treatment is consistent with, for example, Jovanovic (1982), where inefficient firms are most likely to exit in the first few years. Those firms that survive past the first few years are likely all to be

[9] For all productivity measures, the productivity of a firm is measured relative to the mean in its own industry in a given year. The within-year, within-industry correlation between the Frazer (2004) and the Levinsohn-Petrin measures of productivity is 0.680. The same correlation between Frazer (2004) and OLS measures of productivity is 0.625. The correlation between the Levinsohn and Petrin measure and OLS productivity is 0.559.

[10] However, this is not significantly lower than the other results once the standard errors are taken into account.

TABLE 2

PROBITS PREDICTING FIRM EXIT, USING PRODUCTIVITY MEASURE OF FRAZER (2004)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Firm productivity	−.030**	−.029**	−.028**	−.026**	−.025**	−.022**	−.022**	−.022**	−.022**
	(.011)	(.010)	(.010)	(.010)	(.009)	(.008)	(.008)	(.008)	(.008)
Firm age			−.004*	−.005*	−.003	−.003^{+}	−.003^{+}	−.003	−.003^{+}
			(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)
(Firm age)^2/100			.008*	.008*	.006*	.006*	.006*	.005*	.006*
			(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)
State owned				.132^{+}	.210*	.193*	.202*	.178*	.200*
				(.118)	(.149)	(.155)	(.156)	(.149)	(.160)
Log firm size					−.023**	−.029**	−.027**	−.027**	−.029**
					(.008)	(.009)	(.010)	(.009)	(.009)
Log capital/labor						.008*	.009*	.009*	.008^{+}
						(.004)	(.004)	(.004)	(.004)
Fraction unionized							−.009		
							(.029)		
Export dummy								−.015	
								(.017)	
Foreign ownership									.007
									(.024)
Including year and sector dummies		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log likelihood	−109.100	−101.344	−98.599	−97.355	−91.915	−89.902	−89.849	−89.657	−89.854
N	479	479	479	479	479	479	479	479	479

Note. *N* = sample size. Each of the columns above reports results for the probit of exit (= 1). In each case, instead of the standard probit coefficient, the coefficient presented is $\partial\Phi/\partial x$, the marginal change in the probability of exit associated with change in the *x* variable, calculated at the mean of the variables. For the dummy variables (state owned, export, foreign ownership), the coefficient represents the change in probability of exit associated with a change in the variable from 0 to 1. The foreign ownership variable takes a value of 1 if the firm is partially or wholly foreign-owned (and 0 otherwise). Standard errors (in parentheses) have been calculated according to White (1980) and have been corrected for repeated observations on the same firm.

$^{+}$ Significant at the 10% level.

* Significant at the 5% level.

** Significant at the 1% level.

TABLE 3

PROBITS PREDICTING FIRM EXIT, USING LEVINSOHN AND PETRIN MEASURE OF PRODUCTIVITY

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Firm productivity	−.043*	−.038*	−.035*	−.034*	−.026*	−.022*	−.022*	−.021*	−.022*
	(.010)	(.010)	(.010)	(.010)	(.009)	(.009)	(.009)	(.009)	(.009)
Firm age			−.002	−.003⁺	−.002	−.002	−.002	−.002	−.002
			(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)
(Firm age)^2/100			.005⁺	.006⁺	.005⁺	.005⁺	.005⁺	.005⁺	.005⁺
			(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)
State owned				.171⁺	.217*	.202*	.211*	.188*	.211*
				(.137)	(.154)	(.159)	(.159)	(.154)	(.164)
Log firm size					−.014*	−.020*	−.019*	−.019*	−.020*
					(.008)	(.008)	(.010)	(.009)	(.008)
Log capital/labor						.008⁺	.008⁺	.008⁺	.007⁺
						(.004)	(.004)	(.004)	(.004)
Fraction unionized							−.009		
							(.029)		
Export dummy								−.015	
								(.018)	
Foreign ownership									.009
									(.025)
Including sector and year dummies		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log likelihood	−104.830	−96.866	−95.537	−93.726	−92.182	−90.671	−90.619	−90.452	−90.602
N	479	479	479	479	479	479	479	479	479

Note. *N* = sample size. Each of the columns above reports results for the probit of exit (= 1). In each case, instead of the standard probit coefficient, the coefficient presented is $\partial\Phi/\partial x$, the marginal change in the probability of exit associated with change in the *x* variable, calculated at the mean of the variables. For the dummy variables (state owned, export, foreign ownership), the coefficient represents the change in probability of exit associated with a change in the variable from 0 to 1. The foreign ownership variable takes a value 1 if the firm is partially or wholly foreign owned (and 0 otherwise). Standard errors (in parentheses) have been calculated according to White (1980) and have been corrected for repeated observations on the same firm.

⁺ Significant at the 10% level.

* Significant at the 5% level.

** Significant at the 1% level.

TABLE 4

PROBITS PREDICTING FIRM EXIT, USING OLS MEASURE OF PRODUCTIVITY

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Firm productivity	−.016^{+}	−.017*	−.015*	−.015*	−.013*	−.013*	−.012*	−.012*	−.013*
	(.008)	(.008)	(.007)	(.007)	(.006)	(.006)	(.006)	(.006)	(.006)
Firm age			−.004*	−.005*	−.003	−.003^{+}	−.003^{+}	−.003^{+}	−.003^{+}
			(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)
(Firm age)^2/100			.008*	.008*	.006*	.006*	.006*	.006*	.006*
			(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)
State owned				.160^{+}	.245**	.223*	.234*	.207*	.231*
				(.124)	(.151)	(.159)	(.159)	(.154)	(.163)
Log firm size					−.023**	−.029**	−.027**	−.027**	−.029**
					(.008)	(.008)	(.010)	(.009)	(.009)
Log capital/labor						.009*	.009*	.009*	.009*
						(.004)	(.004)	(.004)	(.004)
Fraction unionized							−.012		
							(.029)		
Export summy								−.016	
								(.017)	
Foreign ownership									.007
									(.025)
Including sector and year dummies		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log likelihood	−110.473	−102.629	−100.107	−98.522	−93.567	−91.376	−91.294	−91.110	−91.29
N	479	479	479	479	479	479	479	479	479

Note. *N* = sample size. Each of the columns above reports results for the probit of exit (= 1). In each case, instead of the standard probit coefficient, the coefficient presented is $\partial\Phi/\partial x$, the marginal change in the probability of exit associated with change in the *x* variable, calculated at the mean of the variables. For the dummy variables (state owned, export, foreign ownership), the coefficient represents the change in probability of exit associated with a change in the variable from 0 to 1. The foreign ownership variable takes a value of 1 if the firm is partially or wholly foreign-owned (and 0 otherwise). Standard errors (in parentheses) have been calculated according to White (1980) and have been corrected for repeated observations on the same firm.

$^{+}$ Significant at the 10% level.

* Significant at the 5% level.

** Significant at the 1% level.

at least somewhat efficient and, therefore, less likely to die. That is, the aging of the firm that most affects its survival probability occurs in its first few years. The signs of the predicted coefficients in table 2 are consistent with this prediction. The linear term in the quadratic is on the edge of significance at the 10% level, and it is insignificant in some specifications.

As discussed in the previous section, we did not have a strong prediction regarding the state ownership variable. As discussed, state-owned firms were either created by the state in the 1960s or acquired by the state in the late 1970s and early 1980s. In table 1, the proportion of state-owned firms among exiting firms appears higher than among surviving firms, but the difference is not significant. However, in table 2, state-owned corporations are significantly more likely to go out of business. The Ghanaian government was willing to let state-owned businesses exit production. To see whether there is a difference between the older state-owned corporations, created between 1959 and 1961 (wave 1) and the newer state-owned corporations created between 1974 and 1982 (wave 2), I created two separate dummy variables for the state-owned firms from each of these two waves and included these controls in table 5 for each of the three productivity specifications. We see that the state-owned firms from the first wave are much more likely to go out of business than those from the second wave. I do not have a strong interpretation of this difference that does not border on speculation. Still, an overall reason why the state-owned firms might be going out of business is that the government was in general trying to rid itself of its state-owned firms over this period, more commonly through privatization. For those (typically smaller) firms that the military government had seized from their owners in the late 1970s and early 1980s, they did not formally acquire the titles to the firms and therefore they could not sell these firms as part of the government's privatization program. Therefore, in lieu of selling these firms, the government may have slowly and deliberately allowed these firms to die by avoiding new investment in them.[11]

In addition to productivity, the other coefficient that is very precisely estimated across all specifications is that of firm size. Larger firms are clearly less likely to exit. A 1-standard-deviation increase in the log (firm size) variable will result in a 3.7% decrease in the probability of exit, which is consistent with the theory. This contrasts with the previous work on micro and small enterprises that has been done in other African countries.

As discussed previously, the theory (as in, say, Olley and Pakes [1996]) suggesting that the capital intensity coefficient should be negative is clear, while the theory suggesting that the coefficient should be positive is at best

[11] I am indebted to a referee for raising this point.

TABLE 5
FURTHER SPECIFICATIONS

	Frazer (2004) (1)	OLS (2)	Levinsohn-Petrin (3)
Firm productivity	−.022**	−.013*	−.022**
	(.008)	(.006)	(.009)
Firm age	−.003⁺	−.003⁺	−.003
	(.002)	(.002)	(.002)
(Firm age)^2/100	.006*	.006*	.005+
	(.003)	(.003)	(.003)
State owned, wave 1	.255**	.308**	.298**
	(.093)	(.102)	(.100)
State owned, wave 2	.170	.187	.165
	(.215)	(.222)	(.214)
Log firm size	−.029**	−.029**	−.020**
	(.009)	(.009)	(.008)
Log capital/labor	.008*	.009*	.008⁺
	(.004)	(.004)	(.004)
Wood and furniture	.040	.037	.029
	(.034)	(.033)	(.031)
Metal working	.016	.017	.015
	(.027)	(.028)	(.027)
Textile and garments	.051⁺	.056⁺	.054⁺
	(.038)	(.039)	(.040)
Including sector and year dummies	Yes	Yes	Yes
Log likelihood	−89.869	−91.309	−90.589
N	479	479	479

Note. N = sample size. Each of the columns above reports results for the probit of exit (= 1). In each case, instead of the standard probit coefficient, the coefficient presented is $\partial\Phi/\partial x$, the marginal change in the probability of exit associated with change in the x variable, calculated at the mean of the variables. For the dummy variables, the coefficient represents the change in probability of exit associated with a change in the variable from 0 to 1. Standard errors (in parentheses) have been calculated according to White (1980) and have been corrected for repeated observations on the same firm.
⁺ Significant at the 10% level.
* Significant at the 5% level.
** Significant at the 1% level.

ambiguous. In the data, there is no difference between the capital intensity of exiting and surviving firms in table 1. However, in the multivariate probits of table 2, we see that capital intensity is a significant predictor of exit. After controlling for other factors, a 1-standard-deviation increase in the log (capital-labor) ratio results in a 1.8% increase in the firm's probability of exit. This is a result that resists quick explanation. Trade theory would predict that capital intensive industries should be shrinking during this period and, therefore, we might expect that the sectoral dummy variables for capital intensive industries would be significant predictors of exit. The most capital intensive sector in Ghana is the food-processing sector, followed by the metal-working, wood-working, and textiles and garments sectors, respectively (author calculation). I report the coefficients on the sectoral dummies in table 5. Surprisingly, from a trade theory perspective, with food processing as the omitted category, each of the other sectors has a positive coefficient, and the only coefficient that is significant (at the 10% level) is the textiles and garments sector, which is the most labor-intensive sector. Naturally, the signs on the industry dummy variables represent a number of factors, including industry-specific shocks over the period, and therefore they cannot be interpreted merely in the light of trade theory. Still, if there was to be a trade-related effect, it should be evident in the dummy variables, and not, as it is, in the capital intensity conditional on the industry effects.

Contrary to what might be expected (but consistent with the Freeman and Kleiner [1999] results), surviving firms have a significantly higher fraction of unionized employees than exiting firms, as noted in table 1. However, once other factors are controlled for (in table 2), the unionization fraction is not a significant predictor of exit as the coefficient, while negative, is not significant.[12] The coefficient on foreign ownership is also not significant, and it is virtually zero in table 2. This result is surprising, as we would have expected firms with some foreign ownership to be more likely to survive. Finally, in table 1, we noted that exporters are significantly (at the 10% level) more prevalent among surviving than exiting firms. However, in table 2, while the sign on the export dummy variable is negative as predicted, this variable is not significant. While exporting firms might still be more productive and more likely to survive than nonexporters, once productivity is controlled for in the probit regressions, exporting adds no further predictive power on firm exit.

These multivariate results are repeated in tables 3 and 4. With the exception of the productivity variable, as mentioned previously, there are no important differences in the results from those in table 2.

To further test the robustness of the results, the procedures are repeated omitting the state-owned firms. It is possible that the state-owned firms are not following the same profit maximization rules that other firms are following and, therefore, may not be undergoing the same processes as the other firms. Therefore, the univariate and multivariate probits are repeated, omitting the state-owned firms for each of the productivity methods, with the results presented in table 6. We find that the results virtually do not change.

Finally, while we have included several different characteristics in our estimation procedure, including one "unobservable" characteristic (productivity), there may still be firm characteristics that are not included (either observable but omitted or unobservable) that might result in omitted variable bias in our estimation. This might bias our parameter estimates in unpredictable ways.

[12] Similar results were obtained when a dummy variable controlling for any level of unionization (i.e., equalling 1 if any unionized employees are present) was used.

TABLE 6

PROBITS PREDICTING FIRM EXIT, DROPPING STATE-OWNED FIRMS

	Productivity Frazer (2004)		Productivity OLS		Productivity Levinsohn-Petrin	
	(2)	(6)	(2)	(6)	(2)	(6)
Firm productivity	−.028**	−.021**	−.017*	−.012*	−.038**	−.021**
	(.010)	(.008)	(.007)	(.006)	(.010)	(.008)
Firm age		−.003+		−.003+		−.002
		(.002)		(.002)		(.002)
(Firm age)^2/100		.005*		.006*		.005+
		(.002)		(.003)		(.002)
Log firm size		−.029**		−.029**		−.021**
		(.009)		(.009)		(.008)
Log capital/labor		.010*		.010*		.009*
		(.004)		(.004)		(.004)
Including sector and year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Log likelihood	−96.047	−84.924	−96.854	−86.154	−90.712	−85.418
N	466	466	466	466	466	466

Note. *N* = sample size. Each of the columns above reports results for the probit of exit (= 1). In each case, instead of the standard probit coefficients, the marginal coefficients, $\partial\Phi/\partial x$, are presented. Standard errors (in parentheses) have been calculated according to White (1980) and have been corrected for repeated observations on the same firm.

+ Significant at the 10% level.

* Significant at the 5% level.

** Significant at the 1% level.

One method that has been used to partially handle this issue in other contexts is to use firm-level fixed effects in the estimation. This would control for any time-invariant firm-specific characteristics that are currently omitted from our controls. The major problem with using fixed-effect estimation in most settings is that it exacerbates any measurement error bias that might be present, as it removes all of the between variation in the variables and any signal contained in that variation. However, in this setting, there is an even more immediate problem, in that the nonlinearity of the probit estimation makes the inclusion of fixed effects problematic. A further issue is that a number of the variables used are time invariant (either by definition, or practically in the data) and so the effect of these variables cannot be measured once fixed effects are included.

Those caveats in mind, a methodology that would enable the use of fixed effects is the linear probability model. While the probit model is preferred to the linear probability model, as the latter does not restrict the estimated probabilities to lie between 0 and 1, in practice these models frequently give similar results. Therefore, I use fixed effects with the linear probability model in order to control for any firm-specific unobservable characteristics that might affect exit.[13] Once firm-level fixed effects are included, a number of variables must be dropped from the analysis. First, time-invariant characteristics, including state ownership and foreign ownership (and, of course, the sector controls) are dropped. Similarly, the unionization variable varies little over the sample period, and so it is dropped. Including the firm age variable is also no longer sensible. In the previous results, a quadratic functional form was found to fit the data when firm ages over the entire range from 0 to 70 were included. Once firm fixed effects are included, the effect of changes in age (the maximum change in age is now 6 years) on firm exit probabilities is being measured (essentially the slope of the firm age function). However, given the quadratic specification for age, the slope of the quadratic will vary depending on the age of the firm. Therefore, firm age is dropped. Year dummies continue to be included.

The results for the linear probability model with fixed effects using the variables that remain are given in table 7. The results are consistent across the three specifications using different productivity variables. First, the pro-

[13] First, before using the fixed-effects linear probability model, I replicate the aforementioned results from the probit model using the linear probability model. The sign and significance of virtually all coefficients does not change (results not reported). Since the probit and linear probability models give similar results, this ensures that the differences that we find in the fixed-effects linear probability model results are being driven by the fixed-effects rather than by the linear probability model specification.

TABLE 7
LINEAR PROBABILITY MODEL, FIXED EFFECTS

	Frazer (2004) (1)	OLS (2)	Levinsohn-Petrin (3)
Firm productivity	−.040*	−.030*	−.045*
	(.020)	(.013)	(.022)
Log firm size	.002	.004	.020
	(.037)	(.037)	(.037)
Log capital/labor	.023	.019	.018
	(.013)	(.013)	(.013)
Export dummy	$-.095^{+}$	$-.097^{+}$	$-.093^{+}$
	(.052)	(.052)	(.052)
Includes year dummies	Yes	Yes	Yes
R-squared	.112	.116	.112
N	466	466	466

Note. *N* = sample size. Each of the columns above reports results for a linear probability model with fixed effects by firm. Standard errors (in parentheses) have been calculated according to White (1980) and have been corrected for repeated observations on the same firm.
$^{+}$ Significant at the 10% level.
* Significant at the 5% level.

ductivity variable remains significant and increases in magnitude in each case in comparison to the pooled results. This means that firms that drop in productivity are more likely to exit in the following period and that this within-firm effect is even stronger than the effect of differences in productivity between firms. A 1-standard-deviation increase in productivity (within a firm) now results in a 3.2% decrease in the probability of exit. The firm size variable, on the other hand, becomes insignificant. This might reflect the exacerbated measurement error in the differenced specification. However, in combination with the previous results, it might also be evidence that, while small firms are more likely to exit, firms are not particularly likely to shrink immediately before they exit. While the coefficient on the capital intensity variable remains positive but becomes insignificant, conclusions here are more difficult, as the *P*-value is .19 while the coefficient is larger than in the pooled results. On the other hand, the coefficient on the exporting variable, which was insignificant in the pooled results, now becomes negative and significant. Firms that switch from not exporting to exporting appear less likely to go out of business, and firms that stop exporting appear more likely to go out of business (although from the pooled results, exporters as a whole are no more or less likely to exit).

VIII. Conclusion

The goal of this study was to examine some of the determinants of firm exit in Ghana. In particular, a primary goal was to discover whether less productive firms are driven out of business in the Ghanaian economic environment. Firm productivity has been measured carefully, controlling for simultaneity in the production function as well as more carefully capturing the heterogeneity of a firm's labor, including the education and experience of the workforce. With such a definition, firms that are going out of business are found to be less productive than surviving firms, with and without a variety of controls. A 1-standard-deviation increase in firm productivity is associated with a 1.8% decrease in probability of firm exit over the subsequent 2-year period. Given that, within our sample, the average exit rates were 6.3 % over a 2-year period, this result is significant. Moreover, fixed-effect results suggest that this result is even stronger within firms. The results on firm size and firm age are generally in line with the theory and with previous results. Larger firms are less likely to exit. Older firms are also less likely to exit, although this effect decreases with age. On the other hand, capital intensive firms are more likely to go out of business, in a result that cannot be interpreted readily and that becomes insignificant with the inclusion of firm fixed effects. Contrary to what one might expect for an African country, state-owned enterprises were more likely to go out of business over the period. As discussed, this may have been the Ghanaian government's way of freeing itself of firms that it had seized from private owners but could not sell because of a lack of title, but this is of course not certain. Finally, while exporting firms overall were no more or less likely to exit than other firms, firms that switched from exporting to not exporting were more likely to exit.

How broadly can these results be generalized? Unfortunately, Ghana is far from a representative African country. It began its reforms earlier than most other African countries, and it has achieved greater economic growth than most other African countries over the last 2 decades. A number of other African countries began similar reform programs in the 1990s, including Uganda, Tanzania, Cameroon, and Benin, and these countries have generally seen increased growth rates after implementing the reform packages (World Bank 2003). Whether the results extend to these countries remains to be seen. Ghana's manufacturing sector has also been found to be different from that of other African countries. In comparison to manufacturing firms in Cameroon, Kenya, Zambia, and Zimbabwe, Ghanaian manufacturing firms are smaller and less capital intensive and have less educated employees. Whether the Ghanaian results extend to other African countries will therefore be a subject for future research.

Appendix

TABLE A1
PRODUCTION FUNCTION ESTIMATION

	IV (1)	Frazer (2004) (2)	Levinsohn-Petrin (3)
Log employment (β_H)	.776	.547	.270
	(.077)	(.127)	(.067)
Education ($\beta_H \times \beta_2$)	.144	.208	.178
	(.079)	(.165)	(.072)
Experience ($\beta_H \times \beta_3$)	.124	.268	.113
	(.090)	(.191)	(.079)
Experience^2/100 ($\beta_H \times \beta_4$)	−.211	−.585	−.159
	(.179)	(.323)	(.155)
Apprenticeship ($\beta_H \times \beta_5$)	−.414	−.413	.376
	(.521)	(1.363)	(.408)
Log capital	.132	.170	.230
	(.040)	(.053)	(.097)
N	1,301	1,301	1,301

Note. *N* = sample size. Standard errors are in parentheses. In col. 1, each of education, experience, and its square are instrumented using an average across other observations for the firm (leads and lags) as an instrument for the measurement error in these variables. In each of cols. 2 and 3, the same variables are instrumented using the same instruments, but now the standard errors are bootstrapped (b = 100). The bootstrap used is a block bootstrap, in which the bootstrap sample is created by sampling by firms. This assumes independence between the firms but not across observations within a firm.

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