Comparing Productivity when Products Differ in Quality:
China Manufacturing Growth 1998-2013

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Abstract

We measure and compare productivity when products and inputs are heterogeneous in quality, analyzing productivity growth in China manufacturing 1998-2013. Growth was mostly based on the introduction and development of new products, in particular by entrants. Not controlling for quality, measured productivity is lower than gross productivity by the amount of the quality dimension of production, and greater by the effect of the higher quality of the inputs. To control for input quality we specify the inputs of the production function in the form of standarized quantities. To identify the effect of quality on production and productivity we use the demand for the product (set of products) of the firm, assuming that the firm sets optimally the unobserved level of quality by equating (appropriately weighted) the marginal impact of quality in revenue and the marginal impact of quality on productivity (that is also, by duality, the impact on cost).

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1. INTRODUCTION

Everything else being equal, the level of demand for two substitute products may differ in two ways linked to differentiation. First, with the products sold at the same price each product meets specific tastes/needs of different segments of consumers. We say that the product demands differ because product characteristics that belong to horizontal differentiation. Second, one product has characteristics preferred by all consumers. In this case we say that the good has higher quality and demands differ according to a pattern of vertical differentiation. It is natural to assume that the product with superior quality will be more costly to produce and its price will be higher. Some consumers will buy the inferior variety because the additional utility brought by the superior doesn’t compensate the utility sacrifice implied by the higher price. We observe market equilibria in which consumers have sorted themselves between the products, weighting both their preferences and the marginal utility effects of their budget constraints.

Productivity in the production of products that differ in quality is hard to compare. The usual regret of many economists, that would like to have data on physical quantities of the products for productivity analyses, losses here any bite. Quantities of goods of different quality are not comparable, so we face a problem that starts with the numerator of any productivity measure. On the other hand, the inputs used in the production of goods of different quality are likely to be of different quality as well. For instance, it is standard to have quantities of labor in the form of number of workers or hours of work. However, this is not the appropriate measure if the labor employed in each production has different levels of quality (level of skills). So the problem continues with the denominator of any measure of productivity, even simple labor productivity.

The production function, the tool that is customarily used to measure the relationship between output and inputs, implicitly assumes that the products and inputs of all firms for which we compare productivity are homogeneous. This is the very foundation of productivity analysis. Productivity is taken as the (usually neutral) shift in the envelop representing maximum outputs given input quantities. This frontier is assumed the same for all firms.
except for its distance to the origin.¹

Economic theory and applied analysis have developed, however, ways to integrate quality in the framework of the production function. With respect to the quality of the output, a natural way to introduce quality is to consider that the output of the production function is multidimensional (see the recent microdata example of Grieco and McDevitt, 2017). One dimension of the output is quantity and another dimension is quality.² With respect to the quality of the inputs, there is an extensive literature that has studied the way to measure the inputs in comparable terms taking into account their quality differences (see, for example, the initial works of Griliches, 1957, and Jorgenson and Griliches, 1967)³. High skilled workers, for example, can be measured in equivalent numbers of workers of standard quality. A production function in terms of normalized or standardized quantities of inputs retains in principle all properties of traditional production functions in homogeneous inputs across firms.

More formally, dropping for simplicity firm and time subindices, the production function that is relevant for the analysis of productivity of firms in a product differentiated industry with quality differences is

$$h(Y, \alpha(\delta_Q)) = F(X^*(X, \theta)) \exp(\omega^* + \epsilon),$$

where $Y$ is output quantity, $\alpha(\delta_Q)$ is the production-relevant index of quality which depends of the $\delta_Q$ index of quality, $X^*$ is a vector of standardized quantities of inputs which is a vectorial function of the quantities $X$ and the vector of quality indices $\theta$, $\omega^*$ represents productivity and $\epsilon$ is an uncorrelated error of observation. Solving for quantity, under some

¹The recent literature on estimating production functions with varying coefficients, however, relaxes this framework. See Balat, Bramvilia and Sasaki (2015); Fox, Hadal, Holderlin, Petrin and Sherman (2016), and Kasahara, Schimpf and Suzuki (2016).

²We understand by quality an index summarizing the relevant product attributes that make the product preferable.

³Recently De Loecker, Goldberg, Khandelval and Pavnik, 2016, have proposed a control function approach to address the problem.
simplifying conditions we can approximate the result by

\[ Y = F(X) \exp(\omega^* - \alpha(\delta_Q) + \theta \beta + \epsilon) = F(X) \exp(\omega + \epsilon), \]

where \( \beta \) is a vector of input elasticities and now the production function \( F(\cdot) \) has input quantities as arguments.

In the last equality \( \omega = \omega^* - \alpha(\delta_Q) + \theta \beta \). This expression tells us that, in the absence of a specification that controls for input and output quality, measured productivity differs from gross productivity \( \omega^* \). Measured productivity is lower than gross productivity by the amount of the quality dimension of production, and greater than gross productivity by the effect of the higher quality of the inputs. In general we do not know which productivity (gross or measured) is greater, but nothing indicates that the two effects compensate each other.

Our analysis is motivated by the interest in measuring gross productivity \( \omega^* \). First, it is a measure of the real productive efficiency of the firm, that can be understood previous to the decision to allocate or not part of it to the production of quality. Second, it is convenient to have a measure of the efficiency of the firm separated of the degree of quality of the inputs, in particular the skills of the labor force. Separating the components of "apparent" productivity we possibilitate a deeper analysis of the decisions of the firms. For example, we can measure the relative amount of efficiency that firms sacrifice for quality or quality improvements. And we can get insights on this decision: is this relative amount correlated with the degree of pure efficiency shown by the firm? On the other hand, we can ask how correlated are output and input quality and if input quality is a prerequisite of output quality. As we will see later, all these questions have policy implications.

In this paper we separately measure gross productivity \( \omega^* \), the effect of quality \( \alpha(\delta) \) on productivity, and the effect of worker skills (we have not data enough to assess the effect of the quality of materials). To control for input quality we specify the inputs of the production function in the form of standarized quantities, what amounts to use the expenditures on each input divided by the appropriate price of a standard unit of the input. In the case of labor, for example, we use the wage bill divided by the average industry wage. As we
also have the number of workers, in this case we are able to identify separately both the standardized quantity and the index of quality (the average firm-level wage divided by the average industry wage).

To identify the effect of quality on production and productivity we use the demand for the product (set of products) of the firm. We assume that the quality attributes of the product are represented by the unobservable $\delta_Q$, that makes the price at which the firm can sell a given quantity higher given the values of the observable shifters (age, location, sales effort).\(^4\) Our identification assumption is just that quality has an effect $\alpha(\delta_Q)$ on productivity. In setting the optimal level of quality the firm equates (appropriately weighted) the marginal impact of quality in revenue and the marginal impact of quality on cost (the impact on productivity is passed on, by duality, to cost). We are working with different versions of this optimality condition (static, dynamic) and different ways to approximate the effect of it.

Our aim is to measure and compare firm-level productivities robust to quality, as well as the evolution of quality, in China manufacturing 1998-2013. During this period, China manufacturing experienced a huge growth. Firms' sales increased at a high pace both domestically and in the market for exports. This growth was based on an intense product turnover. Only a limited proportion of the firms alive at the beginning of the period survives, and hence the most important part of the huge increase of sales is made of the start of economic activity (entry) and growth of new firms, which contribute and develop new products. Jaumandreu and Yin (2016) shows how demand heterogeneity of all firms, and in particular of the new firms, is as dispersed as the differences in productive efficiency. In addition, Jaumandreu and Yin (2016) shows how demand advantages and measured productivity are negatively correlated, what strongly suggests the presence of pervasive effects of quality. To properly compare productivity of all kind of firms (incumbents and entrants, state owned and private firms, exporters and non-exporters, firms with and without R&D activities), and to assess the strenghts and weaknesses of all this growth, we dramatically

\(^4\)Notice that $\delta_C$ is different, in fact only part, of the demand heterogeneity specified as $\delta$ in Jaumandreu and Yin (2016).
need to measure separately gross productivity, quality and skills improvement.

There is a literature that has documented Chinese productivity growth and evaluated its determinants. Young (2003) used macro-level data, adjusting for some potential sources of measurement error in capital, labor, inflation, etc., and found that productivity growth of Chinese nonagricultural economy during 1978-1998 was 1.4 percent per year, a number "respectable but not outstanding". Brandt, Van Biesebroeck, and Zhang (2012) used microdata on manufacturing firms (from the same source than ours) to estimate manufacturing productivity during 1998-2007. They specified firms production as carried out by means of a gross production function. They concluded that the yearly growth rate was 2.85\%, the highest compared to other contemporary growths. They also stress the "dynamic force of creative destruction," with net entry being one of the engines of productivity growth during the period. Hsieh and Klenow (2009) used the same microdata to estimate allocation efficiency in China. They find significant marginal cost differences among firms that they take as a sign of "price distortions" and hence misallocation. Jaumandreu and Yin (2016) provide a description of productivity growth which agrees with the numbers by Brandt, Van Biesebroeck and Zhang (2012). However, without denying the possibility of some misallocation, they find evidence for product heterogeneity as the main source of cost differences.

The ultimate goal of this paper is to measure and compare firm-level productivities robust to quality, as well as the evolution of quality. In what follows, however, we develop the framework and only engage in a very preliminary exercise. The results, however, are highly encouraging. Our estimates show that main engines of growth were the new firms, growing very fast after entry, during a presumably stage of learning-by-doing, converging later to the average productivity growth. Our preliminary estimates are already robust to input quality but still not necessarily to product differentiation. Next steps of this research will involve more explicit controls and check of the role of vertical and horizontal differentiation.

The rest of this paper is organized as follows. In the next section, we set out a general framework with input and output quality heterogeneity and start to discuss how to estimate it. The third section sets out a preliminary model to explore the data. The forth section is
dedicated to introduce the data and comment on the main facts about Chinese manufacturing during the period. Section 5 reports estimation results, describes productivity growth and comments on its sources. Section 6 concludes with some remarks. Appendix A defines the employed variables, and Appendix B discusses a framework of dynamic quality decision.

2. A MODEL WITH HETEROGENEOUS OUTPUT AND INPUTS.

Demand

Consider a monopolistically competitive industry, where firm \( i \) produces a different product than the product of its competitors. Let’s first discuss the product demand for the firm. Assume for the moment that there are not other determinants of heterogeneity than price and embodied product attributes (i.e. assume that indirect product characteristics like age, location and sales effort are the same for all firms). The product can be different because meets the specific tastes/needs of a different group of consumers (horizontal differentiation) or because its quality (at the same price all consumers would choose the highest quality product). We adopt an specification of the firm specific demand that is a first order approximation (in logs) to any demand:

\[
y_{it} = \alpha_0 - \eta(p_{it} - \delta_{Qt}) + \delta_{Hit},
\]

where \( y_{it} \) stands for the demanded quantity of the product and \( p_{it} \) for its price (we use lowercase letters to denote the logs of the variables). The elasticity of demand is here common for simplicity but we later generalize the model to firm and time specific elasticities. The unobservables \( \delta_{Qt} \) and \( \delta_{Hit} \) account for differences in demand linked to horizontal and vertical differentiation of the product respectively.

The demand for the product has an expectation independent from the unobservables when \( p_{it} - \delta_{Qt} = \bar{p}_t \) and \( \delta_{Hit} = 0 \), where \( \bar{p}_t \) represents the industry average price. In this case \( E(y_{it} | p_{it} - \delta_{Qt}, \delta_{Hit}) = E(y_{it} | \bar{p}_t, 0) = \alpha_0 - \eta \bar{p}_t \). But in practice we observe the sales of the firms differing from this value according to two dimensions. If its product is exclusively horizontally differentiated, a particular firm \( i \) can be sell more (less) at the average price \( \bar{p}_t \) because its relative demand advantage embodied in \( \delta_{Hit} \). If the product
is exclusively vertically differentiated, firm $i$ can still sell the same quantity while setting a higher price than the average as long as the relative advantage embodied in $\delta Q_{it}$ is such that $p_{it} - \delta Q_{it} = p_i$.

Inverting the equation for the price, adding $y_{it}$ to each side to have a relationship in terms of revenue, and generalizing to a possible firm and time specific elasticity, we have the relationship

$$r_{it} = \frac{\alpha_0}{\eta_{it}} + (1 - \frac{1}{\eta_{it}})y_{it} + \delta Q_{it} + \frac{\delta H_{it}}{\eta_{it}},$$

where $r_{it}$ represents log of revenue. If in the original demand relationship we assume now that there is a vector of $z_{it}$ observed characteristics with an effect $z_{it}\alpha$, where $\alpha$ is a vector of parameters, the previous equation can be written as

$$r_{it} = \frac{\alpha_0}{\eta_{it}} + (1 - \frac{1}{\eta_{it}})y_{it} + z_{it}\alpha/\eta_{it} + \delta Q_{it} + \frac{\delta H_{it}}{\eta_{it}}. \quad (1)$$

**Production function**

Firm $i$ produces the output quantity $y_{it}$ using capital, labor and materials. Capital is given and labor and materials are freely variable. There are two important peculiarities to take into account in the specification of this production function. First, outputs differ in quality. We take this into account assuming that the inputs of the firm can ensure different combinations of quantity and quality reflected by a transformation function $h(\cdot)$. Let’s specify the output dimension quality as an unknown function $\alpha(\cdot)$ of the index of quality that shifts demand. Hence the multidimensional output of this production function is $h(y_{it}, \alpha(\delta Q_{it}))$.

Second, to get outputs of different quality firms may use either different quantities of the same inputs or similar quantities of inputs of different quality. We measure the inputs in standarized quantities by dividing the expenditure on the input by an index of the price of a unit of standard input (see Jaumandreu, 2016). We assume that input markets are

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5 Alternatively we can add $p_{it}$ to each side of our basic demand relationship, once we have included $z_{it}\alpha$, and arrive at

$$r_{it} = \alpha_0 - (\eta_{it} - 1)p_{it} + z_{it}\alpha + \eta_{it}\delta Q_{it} + \delta H_{it}.$$
competitive. Then, expenditure divided by the unit price equals quantity of the input times an index of quality, and this product is what we call standardized quantity. Let’s use asterisk for the standardized quantities. The production function can be written as

\[ h(y_{it}, \alpha(\delta_{Qt})) = F(K^*, L^*, M^*) \exp(\omega_{it} + e_{it}), \]

where \( e_{it} \) is an observational uncorrelated error.

Assuming \( h(y_{it}, \alpha(\delta_{Qt})) = y_{it} \exp(\alpha(\delta_{Qt})) \) and that the production function is Cobb-Douglas (a Cobb-Douglas production function can be also considered a first order approximation in logs to any production function), taking logs we have

\[ y_{it} = \beta_0 + \beta_K k^* + \beta_L l^* + \beta_M m^* + \omega_{it} - \alpha(\delta_{Qt}) + e_{it}. \quad (2) \]

**Combining the demand and production function**

Equations (1) and (2) represent the relevant system of demand and production function when output and inputs are heterogeneous. We have three unobservables with very specific meanings. Gross productivity \( \omega_{it} \) is productivity without subtracting the part that is being to be evaporated in producing higher quality. Until now, most of the work on productivity has been devoted to measure \( \omega_{it} - \alpha(\delta_{Qt}) \) or net productivity, that is a relevant measure but doesn’t inform about the potential of productivity of the firm (it is non strictly comparable across firms with products that differ in quality). At the same time, we have two types of firm heterogeneity. The heterogeneity that comes from the production of outputs of different quality, \( \delta_{Qt} \), and the differences in demand that come from horizontal attributes of the products, \( \delta_{Hit} \). Importantly, we expect \( \delta_{Qt} \) to enter in the determination of net productivity in (2) but we can safely assume that this not the case for \( \delta_{Hit} \).

Without observing output prices, in practice a frequent situation, we cannot try to estimate independently equation (2) and we have to combine both equations substituting (2) for \( y_{jt} \) in the demand function:

\[ r_{it} = \frac{\alpha_0}{\eta_{it}} + (1 - \frac{1}{\eta_{it}})\beta_0 + (1 - \frac{1}{\eta_{it}})(\beta_K k^* + \beta_L l^* + \beta_M m^*) + z_{it} \frac{\alpha}{\eta_{it}} + (1 - \frac{1}{\eta_{it}})\omega_{it} - (1 - \frac{1}{\eta_{it}})\alpha(\delta_{Qt}) + \delta_{Qt} + \frac{\delta_{Hit}}{\eta_{it}} + v_{it}, \]
where $v_{it} = (1 - \frac{1}{\eta_{it}})e_{it}$.  

This equation makes clear several problems of the standard estimates of productivity carried out with a revenue dependent variable, taking as productivity the composite $(1 - \frac{1}{\eta_{it}})\omega_{it} - (1 - \frac{1}{\eta_{it}})\alpha(\delta_{Qit}) + \delta_{Qit} + \delta_{Hit}/\eta_{it}$. First, without including the effect of the observable demand shifters $z_{it}\alpha/\eta_{it}$ all this demand heterogeneity is confusingly included in productivity. Second, if the inputs are not measured in standarized quantities their quality is also incorporated to the residual. Third, the measure obtained is, in the best of the cases, a mix of productivity, quality effects and horizontal heterogeneity of sales.

Stressing that $\omega_{it}$ is a main variable of interest, let us re-write the combined equation in the following way

$$r_{it} = \frac{\alpha_0}{\eta_{it}} + (1 - \frac{1}{\eta_{it}})\beta_0 + (1 - \frac{1}{\eta_{it}})(\beta_Kk^* + \beta_Ll^* + \beta_Mm^*) + z_{it}\frac{\alpha}{\eta_{it}} + (1 - \frac{1}{\eta_{it}})\omega_{it} + \Delta_{it} + v_{it},$$  

(3)

where $\Delta_{it} = -(1 - \frac{1}{\eta_{it}})\alpha(\delta_{Qit}) + \delta_{Qit} + \delta_{Hit}/\eta_{it}$.  

Equation (3) looks like a standard revenue equation with the addition of unobservable $\Delta_{it}$. Below we discuss in detail the estimation of this equation with an OP/LP procedure and the complications introduced by the new unobservable.

**Elasticity of demand**

To estimate equation (3) we need to estimate the elasticity of demand. A robust estimate

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6 Let’s split marginal cost in logs as $mc_{it} = \overline{mc}_{it} - \omega_{it}$, where $\overline{mc}_{it}$ is the part of marginal cost that can be written in terms of observables. Considering optimal pricing $p_{it} = \ln \frac{\eta_{it}}{\eta_{it}-1} + \overline{mc}_{it} - \omega_{it} + \alpha(\delta_{Qit})$, following the alternative route we have

$$r_{it} = \alpha_0 - (\eta_{it} - 1)\ln \frac{\eta_{it}}{\eta_{it}-1} - (\eta_{it} - 1)\overline{mc}_{it} + z_{it}\alpha$$

$$+(\eta_{it} - 1)\omega_{it} - (\eta_{it} - 1)\alpha(\delta_{Qit}) + \eta_{it}\delta_{Qit} + \delta_{Hit}.$$  

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7 Our alternative equation can be written as

$$r_{it} = \alpha_0 - (\eta_{it} - 1)\ln \frac{\eta_{it}}{\eta_{it}-1} - (\eta_{it} - 1)\overline{mc}_{it}$$

$$+z_{it}\alpha + (\eta_{it} - 1)\omega_{it} + \Delta_{it},'$$

where $\Delta_{it}' = \eta_{it}\Delta_{it}$.  

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of the elasticity of demand, but not separable from the short run elasticity of scale of the firm, can be obtained in the following way. Assume that there are two relevant markets for the firm (domestic and exports), but the method can be generalized to any other number of markets or be used without any information of markets. Jaumandreu and Yin (2016) show that

\[ \eta_{it} \cdot \eta_{it}^{-1} \exp(u_{it}) = \frac{1}{\nu} \eta^D - 1 + \left( \frac{\eta^D}{\eta_{it}^{-1}} - 1 \right) \exp(u_{it}) = a(S^X_{it}) \exp(u_{it}), \]

where \( \eta_{it} \) represents the average elasticity of the firm and \( \eta^D \) and \( \eta^X \) the domestic and exports demand elasticities. \( S^X_{it} \) is the export intensity of the firm and the second equality is simply a compact form of writing the nonlinear expression in \( S^X_{it} \). Calling \( \nu = \beta_L + \beta_M \) to the short run elasticity of scale of the firm, we can estimate the following system of two equations:

\[
\begin{align*}
\frac{R_{it}}{VC_{it}} & = \frac{1}{\nu} \frac{\eta_{it}}{\eta_{it} - 1} \exp(u_{it}) = \frac{1}{\nu} \eta^D - 1 + \left( \frac{\eta^D}{\eta_{it}^{-1}} - 1 \right) S^X_{it} \exp(u_{it}) = a(S^X_{it}) \exp(u_{it}), \\
\end{align*}
\]

\[
\begin{align*}
\text{Estimating productivity} \\
\text{Let’s assume that } \omega_{it} \text{ follows an in-homogeneous exogenous AR Markov process, } \omega_{it} = \beta_t + \rho \omega_{it-1} + \xi_{it}. \text{ Assume firms maximize profits. The inverse of the first order condition for materials provides a way to write } \omega_{it-1} \text{ in terms of observable variables and } \Delta_{it-1}.
\end{align*}
\]

\[
\begin{align*}
\omega_{it-1} & = -\frac{\eta_{it-1}}{\eta_{it-1} - 1} \ln \beta_M - \frac{\alpha_0}{\eta_{it-1} - 1} + \frac{\beta_0}{\eta_{it-1} - 1} + (p_{M_{it-1}} + m_{it-1}^*) - (\beta_K k_{it-1}^* + \beta_L l^*_{it-1} + \beta_M m_{it-1}^*) \\
& - \frac{\alpha}{\eta_{it-1} - 1} \Delta_{it-1} \\
& = h_{it-1} - \frac{\eta_{it-1}}{\eta_{it-1} - 1} \Delta_{it-1}.
\end{align*}
\]
Using the Markov process and this expression, equation (3) can be written as
\[
\rho \phi = (1 - \frac{1}{\eta_{it}}) \beta_0 + (1 - \frac{1}{\eta_{it}}) \beta_t + (1 - \frac{1}{\eta_{it}}) (\beta_K k^* + \beta_L l^* + \beta_M m^*) + z_{it} \frac{\alpha}{\eta_{it}} \\
+ (1 - \frac{1}{\eta_{it}}) \rho \phi_{it-1} + (\Delta_{it} - \rho \frac{\eta_{it-1}}{\eta_{it-1} - 1} \Delta_{it-1}) + \xi_{it} + \upsilon_{it}.
\]
(4)

What is new in equation (4), with respect to a standard setting, is the term \((\Delta_{it} - \rho \frac{\eta_{it-1}}{\eta_{it-1} - 1} \Delta_{it-1})\), where recall that \(\Delta_{it} = -(1 - \frac{1}{\eta_{it}}) \alpha(\delta_{Qit}) + \delta_{Qit} + \delta_{Hjt}/\eta_{it}\).

What can we expect with respect to this extra term? First, it is convenient to note that if the firm chooses freely the level of quality, the first order condition from equating the effect on revenue to the effect on cost gives
\[
\frac{\partial \alpha(\delta_{Qit})}{\partial \delta_{Qit}} = \frac{\eta_{it}}{\eta_{it} - 1}.
\]

Consider the linear approximation \(\alpha(0) \simeq \alpha(\delta_{Qit}) - \frac{\partial \alpha(\delta_{Qit})}{\partial \delta_{Qit}} \delta_{Qit}\). It implies that \(\alpha(\delta_{Qit}) \simeq \alpha(0) + \frac{\eta_{it}}{\eta_{it} - 1} \delta_{Qit}\), so \(-(1 - \frac{1}{\eta_{it}}) \alpha(\delta_{Qit}) + \delta_{Qit} \simeq -(1 - \frac{1}{\eta_{it}}) \alpha(0) - \delta_{Qit} + \delta_{Qit} = -(1 - \frac{1}{\eta_{it}}) \alpha(0)\), and the term collapses with similar terms that only depend on the elasticity of demand.

This suggests that this part of \(\Delta_{it}\) can be relatively unharmful in the estimation of the equation. Alternatively, the first order condition suggests that \(\delta_{Qit}\) is an unknown function of the markup and that the procedure of estimation may try to control for \(\delta_{Qit}\) in this way.

Second, we have the problem of the horizontal differentiation heterogeneity represented by \(\delta_{Hjt}\) in \(\Delta_{it}\) and \(\delta_{Hjt-1}\) in \(\Delta_{it-1}\). One possible solution is to treat this heterogeneity as very persistent and decompose it in a fixed effect and an uncorrelated disturbance. Another is to select the sample to firms in which we can assume there is no horizontal differentiation or it is simply random.

In what follows we present some exploratory estimates estimates of equation (4). These estimates assume that the term \((\Delta_{it} - \rho \frac{\eta_{it-1}}{\eta_{it-1} - 1} \Delta_{it-1})\) doesn’t create any problem (can be absorbed in other parts of the equation). To estimate the elasticity they impose a restriction on \(\ln(\frac{1}{\nu} \frac{\eta_{it}}{\eta_{it-1}})\) (the elasticity is allowed to vary only in the cross-section) according to the mean value for each firm of \(\tau_{it} - \nu c_{it}\).

\(^8\)In addition, of course, to the specification in terms of standardized quantities.
3. AN EXPLORATORY MODEL

Equations

Let us assume: 1) We can forget about \((\Delta_{it} - \rho \frac{\eta_{it-1}}{\eta_{it-1} - 1} \Delta_{it-1})\) because vertical differentiation effects tend to cancel and horizontal effects are unimportant (we assume that what remains can be absorbed into other terms of the equation); 2) The elasticity of demand only changes across firms, remaining constant over time (see below how we treat the elasticity of demand); 3) We can specify the Markov process as a general in-homogeneous process \(\omega_{it} = \beta_t + g(\omega_{it-1}) + \xi_{it}, \omega_{it} = \beta_t + \rho \omega_{it-1} + \xi_{it}\); 4) The effect of \(\alpha_{it}, \) defined below, is a nonlinear effect modelled by function \(h(a_{it})\). Under these assumptions, equation (4) becomes

\[
\begin{align*}
\omega_{it-1} &= \frac{-\eta_i}{\eta_i - 1} \ln \beta_M - \frac{\alpha_0}{\eta_i} + \frac{\beta_0}{\eta_i - 1} + (p_{it-1} + \tau_{it-1}) - (\beta_K k^*_it + \beta_L l^*_it + \beta_M m^*_it) - (1 - \frac{1}{\eta_i}) g(\omega_{it-1}) + \xi_{it}, \\
&= \frac{h(a_{it-1})}{\eta_i} + z_{it-1} \frac{\alpha}{\eta_i} - \frac{1}{\eta_i} \ln(1 - \tau_{it-1}),
\end{align*}
\]

where \(\tau_{it-1}\) stands for sales-related taxes. We estimate equation (5) with \(\omega_{it-1}\) replaced by expression (6).

*Sales effort* is defined as the ratio of sales expenditure over total production cost. In the vector \(z_{it}\) we include the rest of the shifters: One set are the location dummies, including \(east_{it}, middle_{it}\) and \(core_{it}\), i.e. eastern area, middle area and firm belonging to the economic center (see Appendix A). Other set includes \(soe_{it}\), export dummy \(export_{it}\), subsidy dummy \(subsidy_{it}\), entry dummy \(entry_{it}\), exit dummy \(exit_{it}\) and firm’s age \(age_{it}\) (see Appendix A and Table 6). We have performed extensive sensitivity analysis to decide which shifters should enter the equation.
In practice we ignore the price of a standard unit of capital and materials, so we include the expenditures \( (p_{Kt} + k_{it}^*) \) and \( (p_{Mt} + m_{it}^*) \) while we assume that the term \( (1 - \frac{1}{\eta_i}) (\beta_{K} \cdot p_{Kt} + \beta_{M} \cdot p_{Mt}) \) is absorbed in other terms of the equation.

### Elasticity

According to the first order condition of short-run cost minimization of \( L_{it} \) and \( M_{it} \)

\[
\frac{P_{Mt}M_{it}^* + w_i L_{it}^*}{R_{it}} = \frac{MC_{it}}{P_{it}^D} (\beta_{L} + \beta_{M}) \exp(u_{it}),
\]

where \( u_{it} \) is a composite error that we are going to assume that averages zero over time for each firm. Noticing that \( \frac{P_{it}^D}{MC_{it}} = \frac{1}{1 - \tau_{it} \cdot \eta_i} \), taking logs and averaging over time we can arrive at

\[
\ln\left(\frac{\eta_i}{\eta_i - 1}\right) = \frac{1}{N_i} \sum_t \ln \left( \frac{(1 - \tau_{it}) R_{it}}{P_{Mt}M_{it}^* + w_i L_{it}^*} \right) + \ln (\beta_{L} + \beta_{M}),
\]

where \( \frac{1}{N_i} \sum_t \ln \left( \frac{(1 - \tau_{it}) R_{it}}{P_{Mt}M_{it}^* + w_i L_{it}^*} \right) \) is firm \( i \)'s average log share of net revenue over variable cost. Therefore we can express demand elasticity \( \eta_i \) as a function of the short-run output elasticity of variable inputs, i.e.

\[
\eta_i = \frac{\exp\left[\frac{1}{N_i} \sum_t \ln \left( \frac{(1 - \tau_{it}) R_{it}}{P_{Mt}M_{it}^* + w_i L_{it}^*} \right) + \ln (\beta_{L} + \beta_{M})\right]}{\exp\left[\frac{1}{N_i} \sum_t \ln \left( \frac{(1 - \tau_{it}) R_{it}}{P_{Mt}M_{it}^* + w_i L_{it}^*} \right) + \ln (\beta_{L} + \beta_{M})\right] - 1}.
\]

We can use this expression together with equations (5) and (6) and search for the parameters to be estimated simultaneously.\(^9\)

### Moments

The residual of equation (5) is a function of the parameters \( \theta \) to be estimated. We base our estimation on the moment restrictions

\[
E [A(z_i) \cdot \zeta_i(\theta)] = 0,
\]

\(^9\)Output prices should bigger than marginal cost, i.e. \( \ln\left(\frac{\eta_i}{\eta_i - 1}\right) \) should be set as \( \max\left\{ 0, \frac{1}{N_i} \sum_t \ln \left( \frac{(1 - \tau_{it}) R_{it}}{P_{Mt}M_{it}^* + w_i L_{it}^*} \right) + \ln (\beta_{L} + \beta_{M})\right\} \). But this function is non smooth and renders very difficult the search for the parameters. Therefore we use following continuous approximation while searching for the parameters

\[
\ln\left(\frac{\eta_i}{\eta_i - 1}\right) = \left[\frac{1}{N_i} \sum_t \ln \left( \frac{(1 - \tau_{it}) R_{it}}{P_{Mt}M_{it}^* + w_i L_{it}^*} \right)\right] \cdot \frac{\exp(\beta_{L} + \beta_{M}) - 1}{e - 1}.
\]
where $A(z_i)$ is a matrix $L \times T_i$ of functions of the exogenous variables $z_i$ (notice that we write them in vector form), $\zeta_i(\theta)$ is a vector $T_i \times 1$ and $L$ is the number of moments. The GMM problem is

$$
\min_{\theta} \left[ \frac{1}{N} \sum_i A(z_i) \zeta_i(\theta) \right]' W_N \left[ \frac{1}{N} \sum_i A(z_i) \zeta_i(\theta) \right],
$$

where $N$ is the number of firms. We use the two-step GMM estimator of Hansen (1982). We first obtain a consistent estimate $\hat{\theta}$ of $\theta$ with a weighting matrix $W_N = \left( \frac{1}{N} \sum_i A(z_i)A(z_i)' \right)^{-1}$. In the second step we then compute the optimal estimate with weighting matrix $W_N = \left( \frac{1}{N} \sum_i A(z_i) \zeta_i(\theta) \zeta_i(\theta)' A(z_i)' \right)^{-1}$.

Our baseline specification has 21 parameters: constant, 9 coefficients of time dummies, 2 of location dummies, 3 production function coefficients, 3 coefficients in the series approximation of the unknown function $h(\cdot)$ and 3 coefficients more in the series approximation of the unknown function $g(\cdot)$. We do not need to include all the 23 parameters in $\theta$, what would the search bundersome. Only the 3 production function coefficients and 6 parameters related to demand shifters (3 coefficients in the series approximation of $h(\cdot)$, $a_0$, $\beta_{east}$, and $\beta_{core}$) are nonlinear. Therefore, only these 9 parameters need be inclued in $\theta$. The rest 12 parameters can be "concentrate out."

In our empirical application we use polynomials in the exogenous variables as instruments. This strategy is widely employed in the literature, e.g., in Doraszelski & Jaumandreu (2013); Wooldridge (2009)’s GMM version of the two-stage procedures of OP, LP, and ACF and in the sieve estimation procedure of Ai & Chen (2003, 2007). The exogenous variables we rely on are constant, time dummies, $k_{it-1}, l_{it-1}, m_{it-1}$ and $a_{it-1}$. We use a basic set of 32 instruments: the constant, time dummies (9 instruments); univariate polynomial of degree three in $a_{it-1}$ (3 instruments); a complete set of polynomials in $k_{it-1}, l_{it-1}$ and $m_{it-1}$ (19 instruments). Once the model is estimated, we can recover $\omega_{it}$ according to (6).

\footnote{In practice we will prefer not to treat $k_{it}$ as exogenous because of presumably errors in its measurement.}
4. DATA

The source of our data is the Annual Census of Industrial Production, a firm-level survey conducted by the National Bureau of Statistics (NBS) of China. This annual census includes all industrial non-state firms with more than 5 million RMB (about $600,000) in annual sales plus all industrial state-owned firms (SOEs). Our source is then the same used in Brandt, Van Biesebroeck, and Zhang (2012).\footnote{The same data source has been used, for example, in Hsieh and Klenow (2009) and Lu (2013).} In the current estimation we use data for the period 1998-2008, but we are working with the data 1998-2013.

Our sample hence consists basically of large firms and some smaller SOEs. The available information includes firm demographics such as location, industry code, the date of birth and some detail on ownership. We obtain from the data the revenue of the firm, physical capital, wage bill, cost of materials, the number of workers and the amount spent in sales promotion.

We want to use the data as a panel of firms, that is, we want to exploit all the observations repeated over time which are available for the same individual. One reason is that our modeling implies productivity evolving over time, whose estimation depends on the sequence of observations of the firm. Another is that we are interested in detecting the new born firms and the firms that eventually shut down. In order to make all this possible we have had to address two important and related questions: the problem of discontinuity of information and the detection of the “economic” entry and exit of firms in the middle of all the additions to and drops from the sample.

Discontinuity of information for an existing firm can happen in the raw data base for two reasons. First, if a firm is non-state owned and falls below the sales threshold of RMB 5 million. If the firm re-enters the sample keeping its ID, we only get some missing observations in the time sequence of the firm. But, when the firm doesn’t re-enter sample, we unfortunately have strictly no way to distinguish its disappearance from economic shutdown. Second, and more importantly, a firm can have been allocated a different ID (9 digit-code) during the period. Firms occasionally receive a new ID if they are subject to some
restructuring (change of name, ownership...), merger or acquisition. This creates a lot of broken sequences and spurious entry and exit.

We have done an intensive work (in the style of Brandt, Van Biesebroeck, and Zhang, 2012) to link over time the data of the firms that presumably had the ID changed. This process has used extensively information such the firm’s name, corporate representative, 6-digit district code, post code, address, telephone number, industry code, year of birth, and has been implemented in several steps: first checking on neighbor years two by two, then longer panel sequences with the following/previous years.

The results of treating the sample in this way seem very satisfactory. Focusing on manufacturing, and considering firm time sequences with a minimum of two years, we have a total of 445,397 firms and 2,253,383 firm-year data points with information. So, after our linking, firms stay in the sample by an average of 5 years. We have time sequences of 5 or more years for more than half of the firms and more than 80% of these sequences have no interleaved missings. The degree of response of the sample firms, considered year to year, tends to be higher than 95%.

The linked data details are summarized in Table 1. Column (1) shows that the single observations discarded after the process are a small percentage, except for the starting and final years, at which the process of linking is more difficult. Columns (2) and (3) document the growth of the sample over time, particularly important in the Census year of 2004. Entry and exit, reported in columns (4) and (5), show very sensible values and explain part of this increase. Entry is defined as the set of firms newly included in the sample and born the same year or any of the two previous years. Its average rate is about 8%. The increase in newly born firms in the Census years of 2004 and 2008 is particularly high, reflecting probably the effort of administrative authorities in being exhaustive. Exit is defined as the set of firms last seen in the sample the previous year. It is hence something indirectly induced by our linking and that can include failures in the linking process as well as mixing some firms in a process of drastic downsizing. But its rate is very sensible, close to the rate of entry, somewhat decreasing over time. This seems a particular good outcome which validates the process. The resulting net entry rate (entry minus exit), reported in column
reversed the sign from negative to positive in 2003. Column (7) documents the increases in the sample which are not related to entry and exit. The data seem to denote a quite continuous statistical improvement of the Annual Census too, tending to include more and more firms. Part of this improvement can be related to the increase of the number of firms with a size above the threshold.

We clean the linked data according to the conditions reflected in Table 2. We set to missing value the observation of a year if there are some particularly small values in labor (less than 8 workers); some abnormal values in other variables (details in the table); or some consistency problems (details in the table); or outliers (0.5% from top and bottom of Sales effort/Cost of principal business, Variable cost/Revenue). This enlarges the number of data points without information. We then use for each firm the time subsequence (adjacent years) of maximum length provided that is greater than one year. The cleaned sample retains 80.6% of the firms and 70.5% of observations.

Table 3 provides basic statistical information on the cleaned data. Columns (2) to (4) report unweighted averages of the firm’s levels of revenue, capital and employment, and columns (5) to (7) unweighted averages of their rates of growth. Columns (2) to (4) show that revenue per firm triplicates over the period, while real capital stays at the same level and there is a significant fall in the average number of workers (more than 25%). Columns (5) to (7) show a intense average growth of output, closely followed by capital, and a positive growth for employment after 2002. In column (8) we compute a standard measure of TFP, the growth of deflated revenue minus the weighted growth of capital, labor and materials. We use as weights the average of the cost shares in moment $t$ and $t - 1$, after computing total cost as the sum of the wage bill, the cost of materials and a cost of capital calculated using a common user cost. TFP growth is strong, especially after 2001, and averages 2.7%. This estimate is compatible with Brandt, Van Biesebroeck, and Zhang (2012) estimates.

It is worthy to dedicate some space to comment on what this data shows about the evolution of the Chinese manufacturing during the 2000s. There is implicit in this data an spectacular growth of the industrial output accompanied by a huge growth and reallocation of productive resources. The number of firms is roughly multiplied by a factor of three. This
means that, to obtain the growth of the industrial aggregates corresponding to revenue, capital and employment from the reported firm-level, we should multiply one plus the rate of growth of the corresponding mean level by three. This gives the following rough picture: nominal revenue was multiplied during the period by nine, capital by three and employment by two. The increase in output is hence based in an intense increase of productivity of the firms, on the one hand, as the calculation of TFP already made clear. Capital and labor hugely increased as well, but with an important displacement of the leading economic role to firms of smaller size. This is the reason why, despite the increase of the aggregates, capital per firm stays stable and employment per firm diminishes more than one quarter.

We splits manufacturing in ten sectors which group two-digit industries (see Table 4 for the correspondence). Table 5 provides descriptive statistics of the sample on which we are going to base our estimations. It starts by reporting the number of firms and observations after cleaning in each sectors. Columns (4) to (7) report unweighted averages of revenue, capital, quality-adjusted workers and materials. We can see on average electronics, metals and transport equipment have larger scale and timber, non-metal and food are among the smallest. It clearly show that metals, chemical and paper are capital-intensified and testile, timber and machinery lie in the opposite end. Columns (8) and (9) report the degree of sales effort and variable cost share. Sectors do not differ too much in average sales effort and variable cost, ranging from 3.4% to 6.8% for the former and 82.5% to 88.1% for the later. Columns (10) and (12) report the proportion of observatios that are state owned (SOE), export and doing R&D. We define a firm SOE if it’s state-control or collective-control, exporter if export amount over 5 million Yuan and doing R&D if R&D expenditure over 100 thousand Yuan in that year. The average SOE proportion is only between 5.3% (textile) and 18.6% (food) but financial capital of the state firms shows a state share above 60%. There are remarkable defference in the proportion of export and doing R&D, ranging from 8.2% (paper) to 42.9% (textile) for the former and 2.6% (timber) to 17.5% (electronics) for the later. Table 5 also reporting TFP growth in these industris to show that the main charateristics commented for the whole industry are generalized across sectors.
5. RESULTS

In this section we report our preliminary results. First, we report the results of the estimation of the parameters and we characterize the distribution of $\omega$. Second, we decompose productivity growth by means of the OP dynamic decomposition proposed by Melitz and Polanec (2012). Third, we pay specific attention to the relationship between firm age and productivity. The fourth subsection makes a global assessment.

5.1. Parameter estimates and facts of productivity growth

Table 6 presents the estimation of the parameters of the production function and Markov process and Table 7 of the demand shifters. Estimation is carried out by nonlinear GMM. The reported coefficients and standard errors are second stage estimates.

Columns (2) to (4) of Table 6 show the point estimates of the parameters of the production function. The results look globally sensible, with plausible values and low standard errors. In all 10 industries, the short-run returns to scale as given by $\nu = \beta_L + \beta_M$, and the overall returns to scale as given by $\beta_K + \beta_L + \beta_M$, are resonable. Columns (5)–(7) report the coefficients of Markov process, modeled by means of a polynomial of order three.

Sales effort is defined as the ratio of sales expenditure over total production cost. The effect of Sales effort is also modeled by means of a polynomial of order three. Columns (2)–(4) of Table 7 report the coefficients. The results look again sensible, with plausible values and standard errors. Table 7 reports also the effects of other shifters.

Table 8 reports some characteristics of the distribution of $\omega$ and markups. We also report labor productivity. As can be seen in columns (2)-(3), $\omega$ and labor productivity grow very fast for all industries during 1999-2008, with the grow of the later being systematically higher (recall that the labor input changes little on average). Our estimation shows that total factor productivity grows very fast. Figure 1 depicts the densities of the levels of $\omega$ and their changes over time. The distributions turn out to be sensible and very informative, with a trend to that moves them to the right consistently during 1999-2008 and by subperiods. Columns (4)–(7) of Table 8, along with figure 1, show the dispersion of the distribution of
Our model estimates firm-specific markups. Columns (8)–(11) of Table 8 report the distribution of the estimated markups. They are reasonable and consistent with other estimates. Columns (12)–(13) show that markups are positively correlated with $\omega$ and labor productivity in all industries.

5.2. Productivity growth decomposition

We compute aggregate productivity weighting by revenue. There are three possible channels through which the growth of aggregate productivity can take place: industrial dynamics, the improvement of allocation efficiency, and the average individual growth of productivity of the existing firms. According to the first channel, aggregate productivity grows if more efficient firms enter and lower productivity firms exit. According to the second channel, aggregate productivity grows if market shares of the high productivity firms expand and market shares of low productivity firms shrink. According to the third channel, overall productivity grows as the result of average productivity growth of the incumbents.

To identify the relevance of each channel we perform a Melitz and Polanec (2012) type of decomposition. In this decomposition, entrants’ contributions to overall productivity growth are positive if they have higher productivity than incumbents. And exitors’ contributions to aggregate productivity growth are positive if their productivity is lower than incumbents. We first decompose the revenue-weighted productivity growth of 9 two-year periods respectively into the contributions of three groups: incumbents, entrants and exitors. Then we take unweighted averages of the growth rates. Table 9 clearly shows that the spectacular productivity growth in all the 10 industries during this period is based on very similar rates of productivity growth, with very little contribution of industry dynamics (entry and exit) and reallocation.

We break entrants further into two groups of entrants: recent and older. The latter consist of entrants that are at least 3 years old when first appear in the sample. From columns (8) and (10) we can see that the contributions of both groups are negative in all
industries, which means both kinds of entry tend to be by firms with lower productivity. Column (12) shows that exit has a somewhat positive contribution (except industry 8). The net effect of industry dynamics is negative in all 10 industries. Table 10 further documents these facts. We can see that in all 10 industries all kind of entrants are less efficient than incumbents.

Allocation efficiency improvement and industrial dynamics’ contribution may be sensitive to the employed time horizon. When we decompose the revenue-weighted productivity growth along different time horizons the picture remains the same.

5.3. The source of growth: a young-firm-populated economy

Most of the firms in the industry are rather young. Table 11 shows the median of distribution of ages for several years. Firms become younger and younger in all 10 industries. After 2002 the age of about half of the firms is less than 8 years in all industries.

We further document the productivity growth of firms during its life-cycle. Figure 2 shows nonparametric regressions of the growth rate of $\omega$ on firms age. In all 10 industries, productivity grows very fast after entry and then tends to converge to the industry average. Firms’ productivity growth is faster within the first 7 first years years in their life-cycle. This is one of the main reasons by which average productivity grows so fast: most firms are very young and young firms’ productivity tends to grow very fast. Notice that, according to our results in 5.2, this rapid growth is associated to an entry with lower levels of productivity than the incumbents.

We decomposes survivor’s productivity growth between two groups: young firms and old firms. According to the findings of Table 11, we define young firms as those that are 8 year old or less. Young firms indeed contribute a huge amount to total productivity growth in every industry, and the young firm’s contribution to growth becomes even more important in the late years of the period.
5.4. An interpretation

Why are there so many entrants during the period? What is stimulating potential entrants to enter? Why is productivity growth of the young firms so fast?

It is a period in which the number of SOEs shrunk rapidly and exports expanded greatly after China’s entry into WTO in 2001. Numerous business opportunities were created owing to demand expansion domestically and overseas. A great number of private firms promptly grasped these business opportunities. Entrepreneurs knew that sales were there almost for sure and they needed not worry too much about them. These new competitors were market-oriented and reacted to market opportunities more flexibly than incumbents. They swiftly created new firms and started to produce. At the beginning their cost may have been higher but they were confident that this was going to change as their experience accumulated and sales grew. It is not strange that a great number of firms entered, most with demand advantages and some cost disadvantages (on this see also Jaumandreu and Yin, 2016, that finds that most demand advantages are contributed by the entrants).

According to literature, entrants can be more efficient than incumbents because of newer technology. But, on the other hand, start-up costs and/or learning-by-doing may prevent entrants from reaching immediately their production frontier. Many papers find that, in fact, entrants have somewhat lower productivity than incumbents as we do. Learning-by-doing (and may be imitation) seems in any case to make firms mature quite quickly in China during this period, so that they reach the highest efficient level rapidly.

All these clues together give the following picture: owing to unprecedented demand during the period numerous new firms enter and deeply renew the productive manufacturing system. Learning-by-doing (and may be imitation) make firms’ productivity to grow very fast, particularly the first years. It is in this sense that we attribute to demand the productivity growth of this period, it is like a "demand dividend."
6. CONCLUDING REMARKS

The ultimate goal of this paper is to measure and compare firm-level productivities robust to quality, as well as the evolution of quality, in China manufacturing 1998-2013. During this period, China manufacturing experienced a huge growth. Firms’ sales increased at a high pace both domestically and in the market for exports. This growth was also based on an intense product turnover.

Our preliminary estimates show that main engines of growth were the new firms, growing very fast after entry during a presumably stage of learning-by-doing, converging later to the average productivity growth. Our preliminary estimates are already robust to input quality but still not necessarily to product differentiation. Next steps of this research will involve more explicit controls and check of the role of vertical and horizontal differentiation.
Appendix A: Variables

Capital stock

Firms report the value of their capital stock at original purchase prices and their capital stock at original purchase prices less accumulated depreciation. To convert these nominal values in an estimate of the real capital stock we need two things: the sequence of real investments and an estimate of the real capital stock at the starting year. Capital is then constructed by applying the perpetual inventory method assuming a yearly depreciation of 9%.

For firms founded after 1997, it is straightforward to get the starting nominal capital stock and the sequence of nominal investments by difference between the gross capital book values of two years. For those founded before 1998, we apply a method similar to Brandt, Van Biesebroeck, and Zhang (2012). We first estimate a yearly nominal rate of investment in fixed assets at 2-digit industry level using 1998-2003 firms’ data. We assume that the nominal gross capital observed for the firm comes from the growth at this rate of the capital with which the firm was born. We then estimate the capital stock at birth, deflate it, and compute the real stock in the first year of observation by applying the perpetual inventory method with the series of real investments implied by our calculation.

The investment deflator before 2006 is taken from Brandt, Rawski and Sutton (2008). We we have updated it using the Fixed Asset Investment price index from China Statistical Yearbook.

Core

Dummy for economic center. Defined as the capital city of province or their surburbs. For industry 2, 6 and 7, defined as prefecture-level (or above) city or their surburbs.

Cost of materials

The NBS definition of intermediate inputs includes direct materials, intermediate inputs used in production, intermediate input in management, intermediate input in business operation (sales cost) and financial expenses. As we want to use a measure of variable cost, the inclusion of general management expenses, sales cost and financial costs is problematic.
To estimate intermediate consumption we have alternatively started by the manufacturing costs, which include materials, labor cost and depreciation of capital during the process of production. From these manufacturing costs we have then deduced the inputed wage bill and inputed depreciation of capital. From 2004 to 2007, we can do this using the detailed information on the structure of intermediate inputs. For the rest of years we assume the same proportions.

Entrant firm
For first time in the sample and born the same year or one of the two previous years.

Ownership (State)
The share of state in financial capital, computed as the sum of the amounts reported as state and collective capital over total financial capital.

Price of materials
We closely follow Brandt, Van Biesebroeck and Zhang (2012), computing the price of materials for each industry as a weighted average of the output prices of the industries to which the concerned industry purchases its inputs. For the weights we use the Input-Output table corresponding to 2002, which includes 42 sectors. The 2-digit manufacture price indices are from China Statistical Yearbook. The prices of agriculture, construction, transportation, retail and wholesale and some service sectors are calculated by comparing GDP at current prices and constant prices, which are included in the Collection of Statistical Material from 1949 to 2009.

Price of output
Output price index at 2-digits from China Statistical Yearbook.

Revenue and export revenue
Firms report the value of their revenue and the value of industrial export sales at current prices.

R&D
Firms report the value of R&D expenditure in 2001 and each year of the period 2005-2007.

Sales effort
All expenditures related to sales (e.g promotion and advertising) as reported by the firm.
Financial capital

Firms report the structure of their financial capital each year, includes the value of financial capital from state, collective, private, HMT (Hongkong, Macao and Taiwan) and foreign investors.

Wage bill, employment, wage.

Firms report several components of total yearly employees compensation that we add up as wage bill. These components are wages, unemployment insurance premium, pension and medical insurance premium, housing mutual fund and total welfare fees. It should be taken into account that firms only began to report retirement and health insurance in 2003, and housing benefits in 2004.

Employment is the total number of employees, which includes all the full-time production and nonproduction workers, reported by the firm. It excludes part-time and casual workers.

Average wage is obtained by dividing the wage bill by employment.

Appendix B: Firm’s dynamic quality decision

Assume \( \delta' = g(\delta, x) + \epsilon \). Here we neglect \( i \) and \( t \). The prime is used to represent next period, and \( x \) is firm’s effort to adjust next-period product quality. The function \( g(\delta, x) \) gives the quality that can be forecasted for next period as a function of current quality and effort \( x \) while \( \epsilon \) reflects an unforecastable shock.

It is equivalent to think of the problem as either choosing optimal \( x \) or optimal \( g(\delta, x) \), so we will develop it in the latest terms denoting \( g(\delta, x) \) by \( \overrightarrow{\delta} \) and calling it expected quality for next period. Realized quality will depart from this choice according to the shock \( \epsilon \).

Let \( p_x \) represents the per unit cost of effort to adjust quality. Then adjustment cost \( C_\delta(x) \) in (10) is

\[
C_\delta(x) = p_x x = p_x r(\overrightarrow{\delta}, \delta)
\]

where \( r(\cdot) \) is the result of inverting \( g(\cdot) \) for \( x \).

According to (10), we have the following Bellman equation
\[ V(s, p_x) = \operatorname{Max}_\delta \left\{ \Pi(s_{it}) - C_K(K, I) - p_x r \left( \overline{\delta}', \delta \right) + \rho \int V(s', p'_x) dF(s', p'_x | s, \overline{\delta}', p_x) \right\} \]

where given the definition of \( \delta' \) is easy to see that

\[ \int V(s', p'_x) dF(s', p'_x | s, \overline{\delta}', p_x) = \int V(s', \overline{\delta}' + \epsilon, p'_x) dF(s', \epsilon, p'_x | s, p_x) \]

(apply a change of variable and the density of a transformation).

Optimal choice will be characterized by

\[ -p_x r_1 + \int \frac{\partial V(s', \overline{\delta}' + \epsilon, p'_x)}{\partial \overline{\delta}} dF(s', \epsilon, p'_x | s, p_x) = 0 \]

Using that

\[ V(s', \overline{\delta}' + \epsilon, p'_x) = \operatorname{Max}_{\overline{\delta}''} \left\{ \Pi(s', \overline{\delta}' + \epsilon) - C_K(K', I') - p'_x r \left( \overline{\delta}'', \overline{\delta}' + \epsilon \right) + \rho \int V(s'', \overline{\delta}'' + \epsilon, p''_x) dF(s'', \epsilon, p''_x | s', p'_x) \right\} \]

we can specify the derivative. Using the subindice \( \delta \) for the derivative of profits, the prime to indicate time and the notation \( E(\cdot) \) for the integral of the derivatives, we have

\[ \rho [E(\Pi'_{\delta}) - E(p'_x r_2)] = p_x r_1 \]
References


Jaumandreu, J. (2016), "Endogenous input quality variation as a help to estimate the production function, not a nuisance," mimeo, Boston University.


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<td>0.033</td>
<td>0.061</td>
<td>0.953</td>
</tr>
<tr>
<td>2007</td>
<td>0.019</td>
<td>315,769</td>
<td>0.095</td>
<td>0.086</td>
<td>0.057</td>
<td>0.029</td>
<td>0.066</td>
<td>0.966</td>
</tr>
<tr>
<td>2008$^i$</td>
<td>0.195</td>
<td>333,330</td>
<td>0.056</td>
<td>0.170</td>
<td>0.108</td>
<td>-</td>
<td>-</td>
<td>1.000</td>
</tr>
<tr>
<td>1998-2008</td>
<td></td>
<td>445,397</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.963</td>
</tr>
</tbody>
</table>

$^a$ All sectors in manufacturing. Firms which stay a minimum of two years.

$^b$ As proportion of the remaining number of firms.

$^c$ Gives a total 2,253,383 firms-year observations with information.

$^d$ Newly included firms born in $t$, $t - 1$ or $t - 2$, as proportion of number of firms at $t$.

$^e$ Firms last seen at $t - 1$ as proportion of number of firms at $t$. Not defined for 1998 and 1999.

$^f$ Entry rate - exit rate.

$^g$ Sample growth - net entry.

$^h$ Proportion of firms in sample at year $t$ which report information.

$^i$ Entrants of year 2008, 48,396, treated in this line as if they were to stay.
Table 2: Filters used to clean the sample

Values of variables are set to missing value in the following cases

Abnormal values:
- Zero or less in Export, Sales effort, State Capital, Collective Capital, Foreign Capital, Payable Taxes.

Values of variables and key variable (Revenue) are set to missing in the following cases

Small values:
- Less than 8 workers.
- Revenue, Capital, Wage bill, and Cost of materials less than 30 thousand yuan.

Abnormal values:
- Zero or less in Revenue, Capital, Labor, Wage bill, Cost of materials, Financial Capital.
- Born before 1949 or after 2008.

Inconsistency:
- Revenue less than Sales effort, Wage bill, Cost of materials or Variable cost (Wage bill + Cost of materials).
- Revenue less than Total Payable Taxes.
- Total Financial Capital less than State Capital + Collective Capital + Foreign Capital.

A missing value determines the interruption of the firm time sequence. We only use the time subsequence of maximum length provided that is longer than one year.
Table 3: Basic descriptive statistics by year

<table>
<thead>
<tr>
<th>Years</th>
<th>Number of firms$^a$</th>
<th>Average levels</th>
<th>Average growth rates</th>
<th>TFP$^e$ growth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(1) Revenue$^b$</td>
<td>Capital$^c$</td>
<td>Labor$^d$</td>
</tr>
<tr>
<td>1998</td>
<td>67,573</td>
<td>47.473</td>
<td>31.830</td>
<td>376</td>
</tr>
<tr>
<td>1999</td>
<td>80,717</td>
<td>48.466</td>
<td>30.322</td>
<td>343</td>
</tr>
<tr>
<td>2000</td>
<td>83,851</td>
<td>56.556</td>
<td>29.978</td>
<td>334</td>
</tr>
<tr>
<td>2001</td>
<td>91,034</td>
<td>59.558</td>
<td>28.933</td>
<td>307</td>
</tr>
<tr>
<td>2002</td>
<td>99,381</td>
<td>65.417</td>
<td>27.931</td>
<td>294</td>
</tr>
<tr>
<td>2003</td>
<td>109,117</td>
<td>78.777</td>
<td>27.584</td>
<td>285</td>
</tr>
<tr>
<td>2004</td>
<td>144,603</td>
<td>78.004</td>
<td>22.808</td>
<td>239</td>
</tr>
<tr>
<td>2005</td>
<td>162,187</td>
<td>89.208</td>
<td>24.095</td>
<td>238</td>
</tr>
<tr>
<td>2006</td>
<td>183,753</td>
<td>100.404</td>
<td>24.831</td>
<td>229</td>
</tr>
<tr>
<td>2007</td>
<td>206,001</td>
<td>114.989</td>
<td>25.725</td>
<td>220</td>
</tr>
<tr>
<td>2008</td>
<td>179,179</td>
<td>139.032</td>
<td>30.283</td>
<td>230</td>
</tr>
<tr>
<td>1998-2008</td>
<td>318,543</td>
<td>88.943</td>
<td>27.019</td>
<td>264</td>
</tr>
</tbody>
</table>

$^a$ The cleaned sample retains 71.5% of the firms and 62.5% of observations.

$^b$ Nominal. Millions of RMBs.

$^c$ Deflated by an investment price index. Millions of RMBs.

$^d$ Number of workers.

$^e$ Growth of deflated revenue minus the growth of capital, labor and deflated materials weighted by the average cost shares between $t$ and $t-1$ computed using a common cost of capital.
<table>
<thead>
<tr>
<th>Industry</th>
<th>Two-digit industries (code)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Food, drink and tobacco</td>
<td>Agricultural and By-Product Processing (13); Food Manufacturing (14); Beverage Manufacturing (15); Tobacco Products (16).</td>
</tr>
<tr>
<td>2. Textile, leather and shoes</td>
<td>Textile (17); Apparel, Shoes, and Hat Manufacturing (18); Leather, Fur, and Coat Products Manufacturing (19).</td>
</tr>
<tr>
<td>3. Timber and furniture</td>
<td>Wood Processing, and Other Wood Products (20); Furniture Manufacturing (21).</td>
</tr>
<tr>
<td>5. Chemical products</td>
<td>Chemical Materials &amp; Products (26); Pharmaceutical (27); Chemical Fiber (28); Rubber Products (29); Plastic Products (30).</td>
</tr>
<tr>
<td>7. Metals and metal products</td>
<td>Ferrous Metal Smelting and Rolling Processing (32); Non-Ferrous Metal Rolling Processing (33); Metal Products (34).</td>
</tr>
<tr>
<td>8. Machinery</td>
<td>General Machinery Manufacturing (35); Special Machinery Manufacturing (36).</td>
</tr>
<tr>
<td>10. Electronics</td>
<td>Electronic Machinery and Equipment (39); Electronic Communication Equipment and Computer (40); Instrument, Meter, Stationery and Office Machine (41).</td>
</tr>
</tbody>
</table>
Table 5: Descriptive statistics by industry

<table>
<thead>
<tr>
<th>Industry</th>
<th>Num. of firms</th>
<th>Num. of obs.</th>
<th>TFP growth&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Revenue&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Capital&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Equipment&lt;sup&gt;d&lt;/sup&gt;</th>
<th>Materials&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Sales effort&lt;sup&gt;e&lt;/sup&gt;</th>
<th>Variable cost&lt;sup&gt;f&lt;/sup&gt;</th>
<th>Prop. SOEs</th>
<th>Prop. Export</th>
<th>Prop. R&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Food</td>
<td>36631</td>
<td>157958</td>
<td>0.005</td>
<td>79.113</td>
<td>20.976</td>
<td>203</td>
<td>61.505</td>
<td>0.068</td>
<td>0.841</td>
<td>0.186</td>
<td>0.134</td>
<td>0.051</td>
</tr>
<tr>
<td>2. Textile</td>
<td>50518</td>
<td>217752</td>
<td>0.029</td>
<td>58.400</td>
<td>15.468</td>
<td>327</td>
<td>46.418</td>
<td>0.034</td>
<td>0.881</td>
<td>0.053</td>
<td>0.429</td>
<td>0.034</td>
</tr>
<tr>
<td>3. Furniture</td>
<td>13448</td>
<td>53571</td>
<td>0.031</td>
<td>41.903</td>
<td>10.072</td>
<td>180</td>
<td>33.047</td>
<td>0.051</td>
<td>0.857</td>
<td>0.062</td>
<td>0.245</td>
<td>0.026</td>
</tr>
<tr>
<td>4. Paper</td>
<td>15452</td>
<td>70305</td>
<td>0.027</td>
<td>52.366</td>
<td>25.538</td>
<td>197</td>
<td>39.973</td>
<td>0.043</td>
<td>0.849</td>
<td>0.160</td>
<td>0.0822</td>
<td>0.031</td>
</tr>
<tr>
<td>5. Chemical</td>
<td>53252</td>
<td>242213</td>
<td>0.030</td>
<td>78.809</td>
<td>30.728</td>
<td>222</td>
<td>61.659</td>
<td>0.059</td>
<td>0.840</td>
<td>0.134</td>
<td>0.185</td>
<td>0.095</td>
</tr>
<tr>
<td>6. Non-metal</td>
<td>27857</td>
<td>126065</td>
<td>0.039</td>
<td>48.957</td>
<td>23.770</td>
<td>249</td>
<td>36.529</td>
<td>0.062</td>
<td>0.825</td>
<td>0.152</td>
<td>0.113</td>
<td>0.044</td>
</tr>
<tr>
<td>7. Metals</td>
<td>31514</td>
<td>133910</td>
<td>0.023</td>
<td>157.140</td>
<td>57.822</td>
<td>326</td>
<td>128.912</td>
<td>0.037</td>
<td>0.874</td>
<td>0.092</td>
<td>0.208</td>
<td>0.048</td>
</tr>
<tr>
<td>8. Machinery</td>
<td>39540</td>
<td>176136</td>
<td>0.035</td>
<td>64.073</td>
<td>17.420</td>
<td>241</td>
<td>48.957</td>
<td>0.054</td>
<td>0.840</td>
<td>0.135</td>
<td>0.170</td>
<td>0.109</td>
</tr>
<tr>
<td>9. Transport</td>
<td>14980</td>
<td>67719</td>
<td>0.042</td>
<td>151.369</td>
<td>42.188</td>
<td>371</td>
<td>117.701</td>
<td>0.046</td>
<td>0.848</td>
<td>0.167</td>
<td>0.180</td>
<td>0.140</td>
</tr>
<tr>
<td>10. Electronics</td>
<td>35351</td>
<td>161767</td>
<td>0.037</td>
<td>161.957</td>
<td>30.302</td>
<td>342</td>
<td>133.005</td>
<td>0.056</td>
<td>0.847</td>
<td>0.113</td>
<td>0.318</td>
<td>0.175</td>
</tr>
</tbody>
</table>

<sup>a</sup> Growth of deflated revenue minus the growth of capital, labor and deflated materials weighted by the average cost shares between t and t – 1 computed using a common cost of capital. During 1999-2008.

<sup>b</sup> Nominal. Millions of RMBs.

<sup>c</sup> Deflated by an investment price index. Millions of RMBs.

<sup>d</sup> Total wage bill / average wage at two digital sector level.

<sup>e</sup> Marketing cost / Cost of principal business.

<sup>f</sup> (Materials + Total wage bill) / Revenue.
Table 6: Estimation of parameters (Nonlinear GMM)\(^a\)

<table>
<thead>
<tr>
<th>Industry</th>
<th>Inputs</th>
<th>lag (\omega)</th>
<th>Overidentif.</th>
<th>(\chi^2)(df)</th>
<th>p val.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(k)</td>
<td>(l)</td>
<td>(m)</td>
<td>(1^b)</td>
<td>(2^c)</td>
</tr>
<tr>
<td>1. Food</td>
<td>0.111</td>
<td>0.213</td>
<td>0.767</td>
<td>0.773</td>
<td>0.164</td>
</tr>
<tr>
<td></td>
<td>(0.011)</td>
<td>(0.020)</td>
<td>(0.014)</td>
<td>(0.157)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>2. Textile</td>
<td>0.028</td>
<td>0.315</td>
<td>0.747</td>
<td>1.048</td>
<td>-0.179</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.024)</td>
<td>(0.016)</td>
<td>(0.295)</td>
<td>(0.075)</td>
</tr>
<tr>
<td>3. Furniture</td>
<td>0.134</td>
<td>0.137</td>
<td>0.804</td>
<td>-0.286</td>
<td>0.137</td>
</tr>
<tr>
<td></td>
<td>(0.031)</td>
<td>(0.048)</td>
<td>(0.052)</td>
<td>(0.612)</td>
<td>(0.084)</td>
</tr>
<tr>
<td>4. Paper</td>
<td>0.163</td>
<td>0.188</td>
<td>0.704</td>
<td>-0.259</td>
<td>0.431</td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
<td>(0.028)</td>
<td>(0.039)</td>
<td>(1.742)</td>
<td>(0.150)</td>
</tr>
<tr>
<td>5. Chemical</td>
<td>0.155</td>
<td>0.242</td>
<td>0.671</td>
<td>0.107</td>
<td>0.145</td>
</tr>
<tr>
<td></td>
<td>(0.012)</td>
<td>(0.020)</td>
<td>(0.018)</td>
<td>(0.231)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>6. Non-metal</td>
<td>0.062</td>
<td>0.228</td>
<td>0.830</td>
<td>0.375</td>
<td>-0.308</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.013)</td>
<td>(0.011)</td>
<td>(0.188)</td>
<td>(0.048)</td>
</tr>
<tr>
<td>7. Metals</td>
<td>0.021</td>
<td>0.184</td>
<td>0.885</td>
<td>1.045</td>
<td>0.257</td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td>(0.014)</td>
<td>(0.009)</td>
<td>(0.368)</td>
<td>(0.041)</td>
</tr>
<tr>
<td>8. Machinery</td>
<td>0.103</td>
<td>0.261</td>
<td>0.751</td>
<td>1.423</td>
<td>0.168</td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.019)</td>
<td>(0.013)</td>
<td>(0.154)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>9. Transport</td>
<td>0.180</td>
<td>0.260</td>
<td>0.631</td>
<td>0.849</td>
<td>0.212</td>
</tr>
<tr>
<td></td>
<td>(0.018)</td>
<td>(0.022)</td>
<td>(0.028)</td>
<td>(0.448)</td>
<td>(0.049)</td>
</tr>
<tr>
<td>10. Electronics</td>
<td>0.072</td>
<td>0.356</td>
<td>0.688</td>
<td>1.538</td>
<td>0.205</td>
</tr>
<tr>
<td></td>
<td>(0.011)</td>
<td>(0.031)</td>
<td>(0.018)</td>
<td>(0.258)</td>
<td>(0.025)</td>
</tr>
</tbody>
</table>

\(^a\) Standard errors are in parentheses.

\(^b\) Polynomial of order one.

\(^c\) Polynomial of order two.

\(^d\) Polynomial of order three.
Table 7 Estimation of parameters for demand shifters (Nonlinear GMM)

<table>
<thead>
<tr>
<th>Industry</th>
<th>S_eff1&lt;sup&gt;a&lt;/sup&gt;</th>
<th>S_eff2&lt;sup&gt;a&lt;/sup&gt;</th>
<th>S_eff3&lt;sup&gt;a&lt;/sup&gt;</th>
<th>East&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Middle&lt;sup&gt;c&lt;/sup&gt;</th>
<th>C_city&lt;sup&gt;d&lt;/sup&gt;</th>
<th>Core&lt;sup&gt;e&lt;/sup&gt;</th>
<th>Export&lt;sup&gt;f&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.Food</td>
<td>5.003</td>
<td>-0.623</td>
<td>-2.000</td>
<td>0.079</td>
<td>0.097</td>
<td>-0.080</td>
<td>-0.018</td>
<td>-0.055</td>
</tr>
<tr>
<td></td>
<td>(1.075)</td>
<td>(4.649)</td>
<td>(4.729)</td>
<td>(0.010)</td>
<td>(0.010)</td>
<td>(0.011)</td>
<td>(0.007)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>2.Textile</td>
<td>-0.500</td>
<td>1.464</td>
<td>0.930</td>
<td>0.063</td>
<td>0.058</td>
<td>-0.002</td>
<td>-0.010</td>
<td>-0.075</td>
</tr>
<tr>
<td></td>
<td>(0.905)</td>
<td>(10.394)</td>
<td>(14.051)</td>
<td>(0.012)</td>
<td>(0.013)</td>
<td>(0.008)</td>
<td>(0.004)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>3.Furniture</td>
<td>7.680</td>
<td>-4.910</td>
<td>0.261</td>
<td>0.067</td>
<td>0.074</td>
<td>-0.070</td>
<td>-0.005</td>
<td>-0.103</td>
</tr>
<tr>
<td></td>
<td>(2.268)</td>
<td>(14.664)</td>
<td>(15.829)</td>
<td>(0.033)</td>
<td>(0.036)</td>
<td>(0.023)</td>
<td>(0.013)</td>
<td>(0.035)</td>
</tr>
<tr>
<td>4.Paper</td>
<td>7.001</td>
<td>6.177</td>
<td>-39.081</td>
<td>0.065</td>
<td>0.117</td>
<td>0.008</td>
<td>-0.030</td>
<td>-0.056</td>
</tr>
<tr>
<td></td>
<td>(1.651)</td>
<td>(14.087)</td>
<td>(16.419)</td>
<td>(0.029)</td>
<td>(0.035)</td>
<td>(0.018)</td>
<td>(0.021)</td>
<td>(0.046)</td>
</tr>
<tr>
<td>5.Chemical</td>
<td>4.626</td>
<td>1.720</td>
<td>-3.257</td>
<td>0.083</td>
<td>0.079</td>
<td>-0.006</td>
<td>-0.048</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
<td>(0.744)</td>
<td>(4.562)</td>
<td>(6.006)</td>
<td>(0.016)</td>
<td>(0.018)</td>
<td>(0.009)</td>
<td>(0.008)</td>
<td>(0.018)</td>
</tr>
<tr>
<td>6.Non-metal</td>
<td>5.465</td>
<td>-33.814</td>
<td>34.280</td>
<td>0.038</td>
<td>0.039</td>
<td>0.014</td>
<td>-0.015</td>
<td>-0.031</td>
</tr>
<tr>
<td></td>
<td>(0.829)</td>
<td>(8.278)</td>
<td>(9.085)</td>
<td>(0.005)</td>
<td>(0.006)</td>
<td>(0.006)</td>
<td>(0.004)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>7.Metals</td>
<td>2.647</td>
<td>-6.403</td>
<td>5.376</td>
<td>0.111</td>
<td>0.070</td>
<td>0.017</td>
<td>-0.006</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>(1.395)</td>
<td>(11.351)</td>
<td>(9.883)</td>
<td>(0.011)</td>
<td>(0.013)</td>
<td>(0.006)</td>
<td>(0.006)</td>
<td>(0.013)</td>
</tr>
<tr>
<td>8.Machinery</td>
<td>4.287</td>
<td>0.420</td>
<td>-5.125</td>
<td>0.046</td>
<td>0.048</td>
<td>-0.011</td>
<td>-0.031</td>
<td>-0.020</td>
</tr>
<tr>
<td></td>
<td>(0.965)</td>
<td>(7.620)</td>
<td>(12.774)</td>
<td>(0.010)</td>
<td>(0.011)</td>
<td>(0.006)</td>
<td>(0.005)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>9.Transport</td>
<td>5.060</td>
<td>-11.535</td>
<td>5.446</td>
<td>0.072</td>
<td>0.073</td>
<td>0.011</td>
<td>-0.045</td>
<td>-0.016</td>
</tr>
<tr>
<td></td>
<td>(0.844)</td>
<td>(7.058)</td>
<td>(12.736)</td>
<td>(0.014)</td>
<td>(0.020)</td>
<td>(0.011)</td>
<td>(0.010)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>10.Electronics</td>
<td>-1.167</td>
<td>10.722</td>
<td>-10.588</td>
<td>0.028</td>
<td>-0.025</td>
<td>0.022</td>
<td>-0.013</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>(0.867)</td>
<td>(6.538)</td>
<td>(5.644)</td>
<td>(0.016)</td>
<td>(0.018)</td>
<td>(0.008)</td>
<td>(0.007)</td>
<td>(0.019)</td>
</tr>
</tbody>
</table>

<sup>a</sup> S_eff1, 2, 3 stand for polynomial of order 1, 2, 3 of sales effort, respectively.

<sup>b</sup> If a firm locates in eastern part (coastal area), this variable is 1; or else 0.

<sup>c</sup> If a firm locates in middle part, this variable is 1; or else 0.

<sup>d</sup> 1 for capital city of provence (include all it’s countryside); the other 0.

<sup>e</sup> 1 for urban or suburb of prefecture-level (or above) city; the other 0.

<sup>f</sup> If a firm’ export amount is positive, this variable is 1; or else 0.
Table 8: Description of estimated productivity and markup

<table>
<thead>
<tr>
<th>Industry</th>
<th>Growth(^a) (%)</th>
<th>St. dev.(^b)</th>
<th>90/10(^c)</th>
<th>Markup</th>
<th>Corr. Markup</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\omega)</td>
<td>Labor(^d)</td>
<td>(\omega)</td>
<td>Labor</td>
<td>(\omega)</td>
</tr>
<tr>
<td>1. Food</td>
<td>4.725</td>
<td>8.565</td>
<td>1.150</td>
<td>1.113</td>
<td>7.130</td>
</tr>
<tr>
<td>2. Textile</td>
<td>3.677</td>
<td>8.045</td>
<td>0.590</td>
<td>0.803</td>
<td>3.165</td>
</tr>
<tr>
<td>3. Timber</td>
<td>3.965</td>
<td>8.176</td>
<td>1.077</td>
<td>0.877</td>
<td>7.745</td>
</tr>
<tr>
<td>4. Paper</td>
<td>5.177</td>
<td>8.705</td>
<td>1.056</td>
<td>0.920</td>
<td>6.707</td>
</tr>
<tr>
<td>5. Chemical</td>
<td>5.830</td>
<td>8.142</td>
<td>0.922</td>
<td>0.994</td>
<td>4.620</td>
</tr>
<tr>
<td>6. Non-metal</td>
<td>6.068</td>
<td>9.785</td>
<td>0.814</td>
<td>1.001</td>
<td>4.870</td>
</tr>
<tr>
<td>7. Metals</td>
<td>3.683</td>
<td>7.557</td>
<td>0.709</td>
<td>0.912</td>
<td>3.300</td>
</tr>
<tr>
<td>8. Machinery</td>
<td>6.136</td>
<td>8.827</td>
<td>0.888</td>
<td>0.905</td>
<td>4.794</td>
</tr>
<tr>
<td>9. Transport</td>
<td>5.848</td>
<td>8.935</td>
<td>0.896</td>
<td>0.950</td>
<td>6.417</td>
</tr>
<tr>
<td>10. Electronics</td>
<td>6.047</td>
<td>8.065</td>
<td>0.843</td>
<td>0.959</td>
<td>5.010</td>
</tr>
</tbody>
</table>

\(^a\) First take difference of unweighted average of log productivity at 1999 and 2008, then geo-average over 1999 and 2008.

\(^b\) Standard deviation of log productivity.

\(^c\) 90 percentile / 10 percentile of the level of productivity.

\(^d\) Labor productivity, defines as (deflated value-added) / (average number of labor).

\(^e\) q25, q50 and q75 are 25, 50, 75 percentile of markup, respectively.

\(^f\) Average each firm’s productivity over time.
Table 9: Decomposition of productivity growth (%)

<table>
<thead>
<tr>
<th>Industry</th>
<th>Growth Rate&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Survivor&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Allocation&lt;sup&gt;c&lt;/sup&gt;</th>
<th>E_Entry&lt;sup&gt;d&lt;/sup&gt;</th>
<th>NE_Entry&lt;sup&gt;e&lt;/sup&gt;</th>
<th>Exit&lt;sup&gt;f&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ω Labor</td>
<td>ω Labor</td>
<td>ω Labor</td>
<td>ω Labor</td>
<td>ω Labor</td>
<td>ω Labor</td>
</tr>
<tr>
<td>1. Food</td>
<td>7.780 19.745</td>
<td>9.493 24.148</td>
<td>0.190 0.056</td>
<td>-0.592 -2.233</td>
<td>-1.760 -2.900</td>
<td>0.449 0.674</td>
</tr>
<tr>
<td>2. Textile</td>
<td>7.762 19.344</td>
<td>9.122 21.648</td>
<td>1.437 2.754</td>
<td>-0.667 -1.479</td>
<td>-2.149 -3.973</td>
<td>0.019 0.395</td>
</tr>
<tr>
<td>3. Timber</td>
<td>6.584 21.094</td>
<td>9.740 25.654</td>
<td>1.295 -0.704</td>
<td>-1.613 -1.047</td>
<td>-3.236 -3.237</td>
<td>0.397 0.428</td>
</tr>
<tr>
<td>5. Chemical</td>
<td>14.517 22.407</td>
<td>13.830 22.044</td>
<td>2.420 3.920</td>
<td>-0.489 -1.431</td>
<td>-1.379 -2.882</td>
<td>0.134 0.756</td>
</tr>
<tr>
<td>6. Nonmetal</td>
<td>16.383 30.579</td>
<td>15.536 28.450</td>
<td>2.607 4.202</td>
<td>-0.438 -0.717</td>
<td>-1.624 -2.115</td>
<td>0.301 0.759</td>
</tr>
<tr>
<td>7. Metals</td>
<td>6.985 22.038</td>
<td>8.503 21.154</td>
<td>0.409 6.145</td>
<td>-0.544 -1.974</td>
<td>-1.394 -4.020</td>
<td>0.009 0.733</td>
</tr>
<tr>
<td>8. Machinery</td>
<td>16.859 27.230</td>
<td>15.621 25.427</td>
<td>2.886 4.485</td>
<td>-0.009 -0.659</td>
<td>-1.608 -2.400</td>
<td>-0.031 0.377</td>
</tr>
<tr>
<td>9. Transport</td>
<td>15.758 27.056</td>
<td>15.936 26.699</td>
<td>1.159 3.340</td>
<td>0.131 -0.966</td>
<td>-1.692 -2.449</td>
<td>0.224 0.433</td>
</tr>
<tr>
<td>10. Electronics</td>
<td>12.036 19.193</td>
<td>15.706 23.421</td>
<td>0.826 -0.172</td>
<td>-0.924 -1.723</td>
<td>-3.605 -2.958</td>
<td>0.033 0.625</td>
</tr>
</tbody>
</table>

<sup>a</sup> First weighted (by revenue) average productivity (log) of begining and end year respectively for each two-year period, take difference,then average over 2000-2008.

<sup>b</sup> Operating in both the begining year and the end year.

<sup>c</sup> Growth rate owing to the change of OP covarance among survivors.

<sup>d</sup> Economic entry, i.e. firms that first appears in the sample and is younger than 2(indclude) years old.

<sup>e</sup> Non-economic entry, i.e. firms that first appears in the sample and is old than 2 years old.

<sup>f</sup> Firms that last appears in the sample.
Table 10: Average productivity of Incumbent, economic, noneconomic entrant and exiter

<table>
<thead>
<tr>
<th>Industry</th>
<th>omiga</th>
<th>Labor productivity$^b$</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Incumbent</td>
<td>E_Entry$^c$</td>
<td>NE_Entry$^d$</td>
<td>Exit</td>
</tr>
<tr>
<td>All industry</td>
<td>43.490</td>
<td>37.881</td>
<td>33.947</td>
<td>32.194</td>
</tr>
<tr>
<td>1. Food</td>
<td>-0.079</td>
<td>-0.160</td>
<td>-0.205</td>
<td>-0.190</td>
</tr>
<tr>
<td>2. Textile</td>
<td>-0.025</td>
<td>-0.082</td>
<td>-0.120</td>
<td>-0.056</td>
</tr>
<tr>
<td>3. Timber</td>
<td>-0.074</td>
<td>-0.160</td>
<td>-0.174</td>
<td>-0.153</td>
</tr>
<tr>
<td>4. Paper</td>
<td>-0.078</td>
<td>-0.154</td>
<td>-0.214</td>
<td>-0.137</td>
</tr>
<tr>
<td>5. Chemical</td>
<td>-0.032</td>
<td>-0.117</td>
<td>-0.201</td>
<td>-0.111</td>
</tr>
<tr>
<td>6. Nonmetal</td>
<td>-0.044</td>
<td>-0.092</td>
<td>-0.235</td>
<td>-0.120</td>
</tr>
<tr>
<td>7. Metals</td>
<td>-0.058</td>
<td>-0.087</td>
<td>-0.154</td>
<td>-0.079</td>
</tr>
<tr>
<td>8. Machinery</td>
<td>-0.045</td>
<td>-0.073</td>
<td>-0.175</td>
<td>-0.095</td>
</tr>
<tr>
<td>9. Transport</td>
<td>-0.050</td>
<td>-0.087</td>
<td>-0.193</td>
<td>-0.069</td>
</tr>
<tr>
<td>10. Electronics</td>
<td>-0.043</td>
<td>-0.095</td>
<td>-0.191</td>
<td>-0.088</td>
</tr>
</tbody>
</table>

$^a$ Delete 5% outliers from top and bottom.

$^b$ Level, thousand yuan.

$^c$ Economic entry, i.e. firms that first appears in the sample and is younger than 2(indclude) years old.

$^d$ Non-economic entry, i.e. firms that first appears in the sample and is old than 2 years old.
<table>
<thead>
<tr>
<th>Industry</th>
<th>Whole sample</th>
<th>Entry&lt;sup&gt;a&lt;/sup&gt;</th>
<th>exit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>98 00 02 04 06 08</td>
<td>00 02 04 06 08</td>
<td>98 00 02 04 06 08</td>
</tr>
<tr>
<td>All industry</td>
<td>7 8 8 6 6 6</td>
<td>3 3 3 2 2</td>
<td>6 8 8 5 6</td>
</tr>
<tr>
<td>1. Food</td>
<td>8 8 7 5 5 5</td>
<td>2 2 2 1 2</td>
<td>6 8 7 5 6</td>
</tr>
<tr>
<td>2. Textile</td>
<td>6 7 7 4 5 6</td>
<td>3 2 2 2 3</td>
<td>5 7 7 4 5</td>
</tr>
<tr>
<td>3. Timber</td>
<td>5 6 6 4 4 4</td>
<td>3 2 2 1 2</td>
<td>5 6 7 4 5</td>
</tr>
<tr>
<td>4. Paper</td>
<td>9 9 8 7 7 7</td>
<td>3 3 3 2 3</td>
<td>8 9 9 7 10</td>
</tr>
<tr>
<td>5. Chemical</td>
<td>7 8 8 6 6 6</td>
<td>3 3 3 2 3</td>
<td>6 8 7 6 6</td>
</tr>
<tr>
<td>6. Nonmetal</td>
<td>10 9 8 6 6 5</td>
<td>4 3 2 1 2</td>
<td>6 8 9 6 7</td>
</tr>
<tr>
<td>7. Metals</td>
<td>6 7 7 5 5 6</td>
<td>3 3 2 2 3</td>
<td>5 7 7 4 5</td>
</tr>
<tr>
<td>8. Machinery</td>
<td>13 12 9 6 6 6</td>
<td>5 3 3 2 3</td>
<td>9 10 10 5 7</td>
</tr>
<tr>
<td>9. Transport</td>
<td>9 8 8 6 7 6</td>
<td>3 4 3 2 3</td>
<td>6 8 8 6 7</td>
</tr>
<tr>
<td>10. Electronics</td>
<td>6 7 7 6 6 6</td>
<td>3 3 3 2 3</td>
<td>6 8 7 5 6</td>
</tr>
</tbody>
</table>

<sup>a</sup> Includes economic and non-economic entry.
Figure 1: Distribution of estimated productivity
Figure 2: Nonparametric regression of productivity growth and firm age