The Impact of Trade Liberalization on Iran's Manufacturing TFP: An Application of Olley -Peaks Approach

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Abstract

Productivity is often computed by approximating the weighted sum of the inputs from the estimation of the Cobb-Douglas production function. Such estimates, however, may suffer from simultaneity and selection biases. Olley and Pakes (1996) introduced a semi-parametric method which allows us to estimate the production function parameters consistently and thus obtain reliable productivity measures by controlling for such biases. This study first reviews this method and then introduces a Stata(10) command to implement it for manufacturing industry in Iran. The results show that material, skill labor and capital play important role in production function and this is increasing return to scale (IRS) by estimation of Olley and Pakes approach versus decreasing return to scale (DRS) by fixed effect. After estimation of production and calculated total factor productivity (TFP), we concluded that the effect of export and exit rate on TFP at manufacturing industry (ISIC 4digits) in Iran is not very considerable to compare to import penetration coefficient and year effect.

Keyword: Simultaneity and production functions; Firm Dynamics; Productivity; Iranian manufacturing industry.
1- Introduction

There is plenty of evidence that tariff reduction increases the efficiency of manufacturing firms. Tybout (1992) studied the impact of trade liberalization on the performance of Chilean firms in the 70s. They concluded that industries that experienced higher tariff reductions were the same as those that experienced higher efficiency gains. Similar results were found by Harrison (1994) for the Ivory Coast, by Iscan (1998) for Mexico, and by Hay (2001) for Brazil. More recently, several papers sharing similar methodology, which solves some econometric problems regarding productivity estimation, also tried to answer whether trade liberalization enhances firm productivity gains. Pavcnik (2002) found that the in-plant productivity improvements in Chile can be attributed to trade liberalization. Fernandes (2003) and Muendler (2002), using data from Colombia and Brazil, respectively, found a negative relationship between nominal tariffs and productivity, reinforcing the perception that trade liberalization has a positive impact on productivity. Tybout (2000) surveys several papers on productivity and trade based on firm-level databases.

Recent evidence on firm-level adjustments to trade liberalization have documented that firm jointly make innovation and export market participation decisions (see Aw, Roberts, and Winston (2005), Trefler (2004), Verhoogen (2007)). Another large and established research agenda using micro-level production data has confirmed time and again the strong self-selection of more productive firm into export markets. More recently, another branch of this literature has found some evidence for a "learning-by-exporting" phenomenon, whereby firm improve their productivity subsequent to export market participation (see for instance, De Loecker (2006), Girma, Greenaway, and Kneller (2004), Topalova (2004)).

This paper provides evidence for the trade liberalization hypothesis using a unique firm-level dataset covering virtually the entire manufacturing sector of Iran for the period 1994–2006. We organize the paper as follows. In Section 2 we discuss the estimation procedure for obtaining reliable estimates of productivity. We employ the Olley and Pakes (1996) technique and demonstrate how this allows us to control for the simultaneity bias when we estimate production functions. In Section 3 we discuss the dataset and perform some preliminary analysis and a brief review of Iranian trade liberalization. In Section 4, we show the effect of export and import penetration on total factor productivity of Iran's manufacturing Industry and collects concluding remarks.

2- Productivity

We use the semi-parametric estimator from Olley and Pakes (1996) to estimate total factor productivity (TFP) at the plant level for each group of
plants that operate in the same sector, defined at the four digit level of disaggregation. A key issue in the estimation of production functions is the correlation between unobservable productivity shocks and input levels, which yields inconsistent estimates under OLS. The reason is that the variable input factors and thus their choice can be affected by the current value of the unobservable productivity shock. In other words, the variables of input factors are likely to be correlated positively with the error term. This results in an upward bias of the coefficients on the variable input factors, like labor and material, under OLS. One way to deal with this endogeneity problem is to use instrumental variables as in Arellano and Bond (1991). However, this estimator requires a large number of cross-section observations to obtain reliable estimators. Pooling all sectors together to estimate the production function would be one option, but this has the disadvantage of imposing the same technological coefficients across all sectors. An additional problem is that it is not straightforward to find good instruments. Lagged values of the endogenous input factors are sometimes used; however, the validity of such instruments relies on the absence of serial correlation in production.

As an alternative, Olley and Pakes developed a semi-parametric estimator that uses investment as a proxy for these unobservable productivity shocks. An advantage of this approach is that it also controls for endogenous exit from the sample, which is assumed to occur when productivity falls below a threshold. In particular, plants with more capital, such as importers, are likely to allow for greater reductions in productivity, making the exit threshold a decreasing function of capital. Following Olley and Pakes, we estimate a Cobb-Douglas production function, taking the logs of equation 1, which we denote by small letters,

\[
\begin{align*}
  y_{it} &= \beta_0 + \beta_1 x_{it} + \beta_2 \ln s_{it} + \beta_3 k_{it} + \beta_4 m_{it} + \omega_{it} + \mu_{it} \\
  \omega_{it} &= \omega_{it} + \mu_{it}
\end{align*}
\]

The error term, \( \epsilon_{it} \), has two components, a white noise component, \( \mu_{it} \), and a time varying productivity shock, \( \omega_{it} \), which is known to the firm, but not to the econometrician. It is a state variable that can have an impact on the choices of inputs, which leads to a simultaneity problem. Pakes (1994) shows that the investment function, \( i_{it} = i_{i}(\omega_{it}, k_{it}) \), which is a function of two state variables, capital and productivity, is monotonically increasing in productivity. Inverting the investment function gives an expression for productivity as a function of capital and investment,

\[
i_{it} = i_{i}(\omega_{it}, k_{it})
\]
Substituting equation (3) into (2) allows estimation of the variable input coefficients using nonparametric techniques. In a second step, the survival probability of a plant is predicted from a nonparametric probit regression and, finally, the coefficient on the state variable, capital, are recovered using semiparametric nonlinear least squares.

Substituting the unobserved productivity term out in equation (2) gives a partial linear model:

\[ y_t = \beta_l l_t + \beta_m m_t + \alpha_i (i_t, k_t) + \mu_t \]  

(4)

In the first stage we obtain consistent estimates of \( \beta_l \) and \( \beta_m \). We use a series estimator using a fourth order polynomial in investment and capital. To identify the coefficient on capital we model survival as a function of capital and investment. The estimation algorithm details present in appendix.1

The estimated input coefficients obtained from estimating equation (2) with OLS, and with Olley-Pakes are reported in Table 1. Typically the labor and material coefficients are over-estimated with OLS, which is what can be expected if labor, material usage and productivity shocks are positively correlated.

The productivity measure used here is a productivity index which is constructed by creating a deviation of output \( t \) and input from the group mean in the reference year (1997 in this paper), a method which was used in Pavenik (2002) and Aw et al. (2001)2. The productivity measure can be written as:

\[ \ln \text{TFP} = y_{it} - \bar{y}_{97} - \hat{\beta}_{ls}(l_{it} - \bar{l}_{97}) - \hat{\beta}_{ls}(l_{it} - \bar{l}_{97}) - \hat{\beta}_{ms}(m_{it} - \bar{m}_{97}) - \hat{\beta}_{k}(k_{it} - \bar{k}_{97}) \]  

(5)

Where \( y_{97}, \bar{l}_{97}, \bar{m}_{97}, \bar{k}_{97} \) and \( \bar{k}_{97} \) are the respective group means of the logarithms of real sales, skill labor, unskilled labor, materials and capital and \( \hat{\beta}_{ls}, \hat{\beta}_{ls}, \hat{\beta}_{ms}, \hat{\beta}_{k} \) are the estimates obtained from Olley&Pakes method.

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1- Levinsohn-Petrin (2003) build on the Olley-Pakes approach, but use intermediate inputs instead of investment as a proxy for unobserved productivity shocks. One drawback of their approach is that exit is not explicitly modelled, while in Olley-Pakes it is. We have experimented with this alternative approach and our results remain robust.

2- A detailed discussion of the index number approach can be found in Good et al. (1997).
3-1- Status of Trade liberalization in Iran

Until the end of the 1990s, Iranian trade policy meant extremely high nominal tariffs and a huge amount of nontariff barriers. Nominal tariffs were in general redundant. The price difference between domestic and international prices was much lower than the tariffs suggested. Imports were restricted not because of high nominal tariffs but mainly by huge nontariff restrictions like the lists of prohibited imported goods, difficult access to government import authorization, and the limits on imports for each firm. On the other hand, there were several exception rules that reduced both the tariff and the nontariff barriers for the imports of some specific goods.

In 1990, there was the first attempt to rationalize trade policy. Some of the nontariff barriers were extinguished (elimination of some taxes on imported goods and some of the special regimes faced by several industries), and nominal tariffs had a small reduction. In 1993, the newly elected government announced a new trade policy that would change substantially the old regime. At first, all but a few nontariff barriers were eliminated. Trade policy thereafter would rely mostly on tariffs and on the exchange rate management, although the exchange rate regime was much more flexible than before.

Second, a 5-year schedule of tariff reductions was announced. After these years, the tariff range would be between 0% and 40%. The average tariff would decrease from slightly lower than 50% in 1989 to 14% in 1994. At first there was no discrimination among industries except for a higher protection for the production of goods with high technological requirements, such as computers, some chemical sectors, and biotechnology. The tariff structure was designed according to the comparative advantage, the initial tariff level and tariff on inputs. There were some exceptions, but the result was a much more rational tariff structure.

With a latest Trade (MFN)1 Tariff Restrictiveness Index (TTRI) score of 13.1 percent, tariff protection in Iran has been one of the most restrictive, substantially higher than an average Middle East and North Africa (MENA) and lower-middle-income country. Both the MFN applied and the import-weighted average tariffs (26.2 percent and 19.2 percent respectively) have been above the regional and income group comparator means. MFN duty-free imports accounted for only 8.4 percent of all imports in the early 2000s. A number of nontariff barriers recently have been replaced by their tariff equivalents. Characterized by an active public sector, the country has made limited progress with the market reform plans put forth by preceding administrations since the early 1990s. The government provides large energy

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1- Most Favored Nation.
subsidies to domestic businesses. Efforts are ongoing to diversify the country’s export sector through investments in non-oil sectors, including in free trade zones (Chabahar and the Qeshm and Kish Islands).

3-2- Data and preliminary analysis

The data are taken from the Iranian Central Statistical Office in the manufacturing sector between 1994 and 2006. We have used data of 13038 firms at 1994 year to 15997 firms at 2005 year for 22 various levels of manufacturing (ISIC 4digits). The export status- at every point in time- provides information whether a firm is a domestic producer, an export entrant or a continuing exporter.

Between 1994 and 2005 average growth of total real exports in Iran's manufacturing is about 16%, while the average growth number of firms entering export markets was about 6%.

Table 1: Number of active firms and entry/exit rates in Iranian manufacturing

<table>
<thead>
<tr>
<th>Annual average (1994–2005)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of active firms</td>
<td>13674</td>
</tr>
<tr>
<td>Number of exporters</td>
<td>742</td>
</tr>
<tr>
<td>Number of starters</td>
<td>48</td>
</tr>
<tr>
<td>Entry rate</td>
<td>6.5%</td>
</tr>
<tr>
<td>Exit rate</td>
<td>1.3%</td>
</tr>
<tr>
<td>Growth rate of active firms</td>
<td>1.9%</td>
</tr>
<tr>
<td>Growth rate of exporters</td>
<td>6.2%</td>
</tr>
</tbody>
</table>

Source: Authors

Table 1 shows the average number of firms that we observe and those that are exporting. While in 1994 about 606 firms were exporting, by 2005 about 1062 did so or this represents an increase of 75%. The average number of entire firms over this period is roughly 41 firms resulting in a net increase of the share of exporters in Iran's manufacturing Industry.

In row three we show the number of firms that started exporting. On average 6% of the exporting firms are new entrants in the export market and in total we observe 576 firms that enter the export market at different points in time. The latter is crucial in order to control for time effects when analyzing the impact on the productivity path. It is important to note that only 8% of the export entrants are new firms entering the market. It is this unique setting that allows us to verify the impact of starting to export on productivity by comparing (productivity of) export entrants with similar domestic firms in terms of past productivity shocks and other firm specific observables. The identification of the learning parameter is as such based on
models like Melitz (2003) that indicate that more productive firms become exporters as we control for pre-export productivity shocks of new exporters.

The industry composition of exports has been fairly stable over time where Chemicals (41%), basic metal product (28%), Food and Beverages (9%) and nonmetal mineral products (4%) comprise around 82% of total exports.

The structural change that has kept going on in Iran's manufacturing is also revealed by the patterns of enterprise turnover. In Table 1 we show the market entry and exit patterns in the data. Over the sample period we find an annual average exit rate of 1.3%, which is comparable to exit rates found in other developing regions. For instance, Clerides, Lach and Tybout (1998) report annual average exit rates for Colombia of 1.7%, for Morocco of 3.7% and for Mexico of 1.5%. The entry rate is much higher, on average 6.5% per year. This compares to entry rates of 2.7%, 4.9% and 4.8% reported for Colombia, Morocco and Mexico respectively. The high entry rates in the Iranian economy are not that surprising taking into account that the entry of new firms was an important component of the restructuring and the transition process. Under government policy, entry of new firms has been virtually non existent. With the transition to a market economy also the entry of new enterprises was encouraged and has potentially played an important role in the transition process (e.g. Bilsen and Konings, 1998).

4- Model and Estimation Strategy

To determine the effect of trade liberalization on productivity, we consider a plant with a Cobb-Douglas production function,

$$Y_i = A_i(\tau) L^\beta_s S^\beta_u K^\beta_k M^\beta_m$$  \hspace{1cm} (1)

Where output in firm $i$ at time $t$, $Y_i$, is a function of skilled labor, $L_i$, unskilled labor, $S_i$, capital, $K_i$, and materials, $M_i$. We are interested in assessing whether the productivity of plant $i$ is a function of trade policy, denoted by $\tau$. So the first step is to estimate plant level productivity, and in the second stage we specify how productivity can be affected by trade policy.
4-1- Empirical effect of Trade Liberalization

In the second stage, we specify the possible links between trade liberalization and plant level productivity. Using the plant level measures of TFP from equation (5), we estimate the following equation:

\[ LTFP = 0.06 LTFP_{t-1} + 0.03 LX - 0.1 Year - 0.02 Exit + 0.11 IMPP \]  
\[ t - Statistic = 5.29 \quad 5.42 \quad -49.8 \quad -2.55 \quad 3.04 \]  

Where LX, Year, Exit and IMPP are the respective logarithms of real export, year effect, exit dummy variable and import penetration and estimates obtained from Arrelano and bond dynamic panel data method.

This results show that the effect of import penetration is more pronounced than that of export. This implies a reduction in tariff and non-tariff barriers affect properly TFP, while it is not affected originally by a trade policy.

Table 2: Production function estimates: Fixed Effect and OP estimation results

<table>
<thead>
<tr>
<th>Variables</th>
<th>OP</th>
<th>Fixed Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lk</td>
<td>0.14</td>
<td>0.098</td>
</tr>
<tr>
<td>Lls</td>
<td>0.26</td>
<td>0.32</td>
</tr>
<tr>
<td>Llus</td>
<td>-0.1*</td>
<td>0.09*</td>
</tr>
<tr>
<td>Lmat</td>
<td>0.72</td>
<td>0.52</td>
</tr>
<tr>
<td>Year</td>
<td>-0.13</td>
<td>-.011</td>
</tr>
</tbody>
</table>

* Only these coefficients are not significant
Source: Authors

5- Conclusion

This paper has analyzed the effects of export and import penetration on TFP of Iran's manufacturing industry. In a period of 6 years exports have become more than doubled, the number of firms that started exporting over this period has increased dramatically but this effect on TFP has been very little. One reason refers to performance of trade liberalization which could not affected on TFP accompanied with increasing new export firm.

We start our analysis by showing that exporters have different characteristics than non exporters. We suggest an estimation algorithm to estimate total factor productivity allowing us not only to estimate productivity consistently, but also to take into account potential selection of firms. The traditional technique adopted to estimate the production coefficients and hence compute TFP starting from a (log-linearized) production function in ordinary least squares. However, this technique is affected by several problems, among which the most serious is the so-called simultaneity bias.
Olley and Pakes have found semi-parametric estimation procedures to overcome these problems (Simultaneity bias and selection bias).

This techniques suppose that the productivity term can be decomposed into two terms, $\omega_t + \mu_t$.

Where $\omega_t$ is a productivity shock observed by the firm (but not by the econometrician) that is able to change the input choices while $\mu_t$ is a white noise uncorrelated to inputs. The key point in both the OP and the LP estimators is to "turn unobservable into observables", namely to find an observable proxy for the productivity term $\omega_t$. In particular, the OP methodology uses investment as proxy and supposed to be function of capital and productivity.

The second stage of this paper is about the trade liberalization on TFP. Although the Growth rate of exporter firms more than the Growth rate of active firms, but it is seem those exporter firms can not very good stimulated productivity in Iranian manufacturing industry and TFP can be affected by reduce high nominal tariffs and a huge amount of nontariff barriers.

Appendix A. Data description

The Firm-level data have been taken from the Iranian Central Statistical Office and cover the full annual company accounts of firms operating in the manufacturing sector between 1994 and 2005. The unit of observation is that of an establishment (plant). We have information on 7915 firms and it is a balanced panel including information on market entry and exit and export status.

If we only take into account those (active) firms that report employment, we end up with a sample of 6391 firms or 29,804 total observations over the sample period.

All monetary variables are deflated by the appropriate two digit industry deflators. The industry classification is similar to the ISIC industry classification in the USA and the various industries with corresponding code are: Food and Beverages Products (15), Tobacco Products (16), Textiles (17), Wearing Apparel (18), Leather and Leather Products (19), Wood and Wood Products (20), Pulp, Paper and Paper Products (21), Publishing and Printing (22), Coke and Petroleum Products (23), Chemicals(24), Rubber and Plastic Products (25), Other non-Metallic Mineral Products (26), Basic Metals(27), Fabricated Metal Products (28), Machinery and Equipment n.e.c. (29), Office Machinery and Computers (30), Electrical Machinery (31), RTv and Communication (32), Medical, Precision and Optical Instruments (33), Motor Vehicles (34), Other Transport Equipment (35), Furniture and Manufacturing n.e.c. (36) and Recycling (37).
We observe all variables every year in nominal values, however, investment is not reported accurately so we calculate it from the other information. Value added is obtained using sales and material costs in thousands of Rials, employment is measured by the number of full-time equivalent employees in a given year. Capital is proxy by total fixed assets in book value in thousands of Rials. Investment is calculated from the yearly observed capital stock in the following way

\[ I_{it} = K_{it+1} - (1 - \delta)K_{it} \]

where \( \delta \) is the appropriate depreciation rate (5%–20%) varying across industries j. Furthermore, we deflate value added with Iranian producer price index (PPI). This is not enough to control for the fact that output and factor prices might be different and/or evolve different over time for exporting firms.

We now present the number of active firms by industry over the sample period. It is clear that some sectors have very few observations and do not provide us with enough information to verify the production function parameters.

Table 1: Average number of firms and LTFP 1994–2005 per industry

<table>
<thead>
<tr>
<th>Industry</th>
<th>Average Number</th>
<th>Average LTFP</th>
<th>Industry</th>
<th>Average Number</th>
<th>Average LTFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>2203</td>
<td>0.600</td>
<td>27</td>
<td>408</td>
<td>0.503</td>
</tr>
<tr>
<td>16</td>
<td>2</td>
<td>1.305</td>
<td>28</td>
<td>1041</td>
<td>0.628</td>
</tr>
<tr>
<td>17</td>
<td>1640</td>
<td>0.394</td>
<td>29</td>
<td>1047</td>
<td>0.618</td>
</tr>
<tr>
<td>18</td>
<td>300</td>
<td>0.652</td>
<td>30</td>
<td>35</td>
<td>0.887</td>
</tr>
<tr>
<td>19</td>
<td>306</td>
<td>0.579</td>
<td>31</td>
<td>381</td>
<td>0.666</td>
</tr>
<tr>
<td>20</td>
<td>185</td>
<td>0.654</td>
<td>32</td>
<td>70</td>
<td>0.853</td>
</tr>
<tr>
<td>21</td>
<td>219</td>
<td>0.607</td>
<td>33</td>
<td>133</td>
<td>0.701</td>
</tr>
<tr>
<td>22</td>
<td>275</td>
<td>0.784</td>
<td>34</td>
<td>399</td>
<td>0.812</td>
</tr>
<tr>
<td>23</td>
<td>72</td>
<td>0.807</td>
<td>35</td>
<td>117</td>
<td>0.0738</td>
</tr>
<tr>
<td>24</td>
<td>710</td>
<td>0.743</td>
<td>36</td>
<td>367</td>
<td>0.00643</td>
</tr>
<tr>
<td>25</td>
<td>654</td>
<td>0.606</td>
<td>Total</td>
<td>13674</td>
<td>0.705</td>
</tr>
<tr>
<td>26</td>
<td>3110</td>
<td>0.724</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Authors

Appendix B. Estimating productivity algorithm

We begin the construction of firm-level productivity by estimating the coefficients of the production function. Assuming that a firm’s production can be characterized by Cobb-Douglas technology, we follow Pavcnik (2002) and specify the production function as:

\[ y_{it} = \beta_0 + \beta_1 l_{it} + \beta_2 k_{it} + \beta_3 m_{it} + \omega_{it} + \mu_{it} \]  \hspace{1cm} (1)

Where \( y \) is the logarithm of output, \( l, m \) and \( k \) are the respective logarithms of inputs of labor, materials and capital, \( \omega_{it} \) is the firm
productivity that the producers know but econometricians do not, and $\mu_{it}$ is a productivity shock which is not anticipated by either the firms or econometricians. Since firms may already have knowledge of their productivity levels ($\omega_{it}$) when making their input decisions, there is clear potential for the problem of simultaneity arising, which can then lead to biased coefficient estimates when estimating the production function.

In order to correct for the potential problem of simultaneity in this study, we estimate the production function using the approach developed by Olley and Pakes (1996). In this model, the investment decisions of a firm depend on its productivity and capital stock; therefore, its investment demand function can be specified as:

$$i_{it} = i_t(\omega_{it}, k_{it})$$

(2)

If the investment demand function can be inverted, the unobserved productivity can be written as a function of investment and capital stock:

$$\omega_{it} = i_t^{-1}(i_{it}, k_{it}) = \varphi(i_{it}, k_{it})$$

(3)

Substituting Eq. (1) into (3) we can obtain:

$$y_{it} = \beta_1 l_{it} + \beta_m m_{it} + \alpha_t(i_{it}, k_{it}) + \mu_{it}$$

(4)

Where

$$\alpha_t(i_{it}, k_{it}) = \beta_0 + \beta_k k_{it} + \varphi(i_{it}, k_{it})$$

(5)

After controlling for unobserved productivity, we can then estimate the partially linear Eq(4) and obtain consistent estimates of $\beta_t$ and $\beta_m$.

In order to obtain estimates of the capital coefficient, we first have to consider the conditional expectation on $y_{j,t+1} - \beta_1 l_{j,t+1} - \beta_m m_{j,t+1}$:

$$E(y_{j,t+1} - \beta_1 l_{j,t+1} - \beta_m m_{j,t+1}|k_{j,t+1}) = \beta_0 + \beta_k k_{j,t+1} + E(\omega_{j,t+1}|i_{j,t})$$

(6)

Where $\omega_{j,t+1}$ consists of an expected element and an unexpected element ($\omega_{j,t+1}$) so that $E(\omega_{j,t+1}|i_{j,t}, k_{j,t+1}) = \omega_{j,t+1} - v_{j,t+1}$.
The expectation of $\omega_{i,t+1}$ is associated with the current productivity level ($\omega_{i,t}$)

It therefore can be written as a function of $\omega_{i,t}$ and expressed as $g(\omega_{i,t})$.

We can then substitute Eq. (3) into this function and show $E(\omega_{i,t+1}|\omega_{i,t},k_{i,t+1})$ as:

$$E(\omega_{i,t+1}|\omega_{i,t},k_{i,t+1}) = g(\alpha_t - \beta_k k_i) - \beta_0$$ (7)

We can then substitute (7) into (1) for period $t + 1$ and obtain:

$$y_{i,t+1} - \beta l_{i,t+1} - \beta y_{it+1} = \beta_0 + \beta k_{i,t+1} + E(\alpha_{i,t+1}|\alpha_{i,t},k_{i,t+1}) + y_{i,t+1} + \mu_{i,t+1} = \beta_0 + \beta k_{i,t+1} + g(\alpha_t - \beta k_i) + y_{i,t+1} + \mu_{i,t+1}$$ (8)

In addition to the appropriate correction for simultaneity, Olley and Pakes (1996) also incorporated a correction for potential selection bias induced by the exit of firms; however, our unbalanced panel data is characterized by firm entry, not firm exit; thus, the incorporation of a correction for the potential problem of selection bias is not appropriate for our analysis.

When estimating Eq (4) which is partially linear, $\alpha_i$ is approximated by using a fourth-order polynomial expansion in $k_{it},i_{it}$. By estimating this equation, we obtain estimates of $\beta_1,\beta_m$

which can be denoted $\hat{\beta}_1, \hat{\beta}_m$, as well as predicted values of $\alpha_i$ for each firm and it is denoted as $\hat{\alpha}_i$. Finally, we apply these estimates to Eq. (8) to obtain a consistent estimate of $\beta_k$. Specifically, we use a fourth-order polynomial expansion in $\hat{\alpha}_i = \hat{\alpha}_i - \beta k_i$ to approximate $g(\ )$ After applying $\hat{\beta}_1,\hat{\beta}_m$ and the approximation of $g(\ )$ to (8) and lag it by one period, it can be specified as:

$$y_{i,t+1} - \hat{\beta}_1 l_{i,t+1} - \hat{\beta}_m m_{i,t+1} = c + \beta_k k_i + \sum_{j=0}^{4} \beta_j (\hat{\alpha}_i - \beta_k k_{i,j-1}) + u_i$$ (9)
Where $u_i = v_i + \mu_i$. Since this equation is non-linear in $\beta_k$, we estimate Eq. (9) using the non-linear least squares method and obtain a consistent estimate of $\beta_k (\hat{\beta}_k)$.

In the empirical implementation, output is measured by real total sales, labor input is measured by the number of employees, material input is measured by the value of aggregate material deflated by the wholesale price index for materials, and capital is measured by real net fixed assets.

Overall, to estimate the model, we are able to use the Stata syntax as follow:

```
. opreg ly, exit(exit) state(lk) proxy(lgi) cvars(year) free(lls lmat llus)
  vce(bootstrap, seed(1) reps(50))
```

**The Stat result is report by the following:**

- Olley-Pakes productivity estimator
- Number of obs = 264
- Group variable (i): crossid
- Number of groups = 22
- Obs per group: min = 12
  avg = 12.0
  max = 12

(Replications based on 22 clusters in crossed)

| Coef. | Std. Err. | t | P>|z| | [95% Conf. Interval] |
|-------|-----------|---|------|-------------------|
| ly    | 0.1895366 | .0549317 | 3.45 | 0.001 | .0818723 to .2972008 |
| lls   | 0.2632737 | .1547521 | 1.70 | 0.089 | -.0400349 to .5665824 |
| lmat  | 0.7263652 | .0919991 | 7.90 | 0.000 | .5460503 to .9066801 |
| llus  | -.1093654 | .0706115 | -1.55 | 0.121 | -.2477614 to .0290305 |
| year  | -.1298958 | .0050833 | -25.55 | 0.000 | -.1398588 to -.1199328 |

State: lk
Free: lls lmat llus
Control: year
Proxy: lgi

**Fixed effect estimation result:**

```
xreg ly lk lls lmat llus year, fe
```

- Number of obs = 264
- Group variable: crossid
- Number of groups = 22

| Coef. | Std. Err. | t | P>|t| | [95% Conf. Interval] |
|-------|-----------|---|------|-------------------|
| ly    | .1895366  | .0549317 | 3.45 | 0.001 | .0818723 to .2972008 |
| lls   | 0.2632737 | .1547521 | 1.70 | 0.089 | -.0400349 to .5665824 |
| lmat  | 0.7263652 | .0919991 | 7.90 | 0.000 | .5460503 to .9066801 |
| llus  | -.1093654 | .0706115 | -1.55 | 0.121 | -.2477614 to .0290305 |
| year  | -.1298958 | .0050833 | -25.55 | 0.000 | -.1398588 to -.1199328 |

F(5, 237) = 151.93
Prob > F = 0.0000

corr (u_i, Xb) = 0.1176
The effect of export on total factor productivity by using of Arellano-bond method:

**Dependent Variable:** LTF  
**Method:** Panel Generalized Method of Moments  
**Transformation:** Orthogonal Deviations  
**Date:** 01/30/10  
**Time:** 11:02  
**Sample:** 1 308  
**Cross-sections included:** 22  
**Total panel (unbalanced) observations:** 188  
**White period instrument weighting matrix**  
**White period standard errors & covariance (d.f. corrected)**  
**Instrument list:** @DVNL.TF,-2

<table>
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<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
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</thead>
<tbody>
<tr>
<td>LTF(1)</td>
<td>0.098675</td>
<td>0.011207</td>
<td>8.949256</td>
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<td>LX</td>
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<td>0.005058</td>
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<td>0.7930</td>
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<td>0.002247</td>
<td>-4.945658</td>
<td>0.0000</td>
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<td>0.007242</td>
<td>1.589065</td>
<td>0.1144</td>
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<tr>
<td>EXIT</td>
<td>-0.007775</td>
<td>0.010863</td>
<td>-0.715231</td>
<td>0.4753</td>
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</table>

**Effects Specification**

**Cross-section fixed (orthogonal deviations)**

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<tr>
<td>Adjusted R-squared</td>
<td>0.029006</td>
<td>0.193035</td>
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<tr>
<td>S.E. of regression</td>
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<tr>
<td>J-statistic</td>
<td>18.50363</td>
<td>22.00000</td>
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</table>
References


