Financial constraints and firm productivity in China: do liquidity and export behavior make a difference?

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Abstract

Financial factors have been found highly important in influencing firms' real activities and in promoting aggregate growth. The linkage between finance and firm-level productivity has however been overlooked. We fill this gap in the literature making use of a large panel of Chinese manufacturing firms over the period 2001-2007. We find that, especially for illiquid firms, productivity is strongly constrained by the availability of internal finance. Furthermore, we find higher sensitivities of productivity to cash flow for private exporters, but lower sensitivities for foreign exporters. Our results are robust to estimating a TFP model or a production function augmented with cash flow.

Keywords: productivity, TFP, production function, finance, cash flow, ownership, export

JEL: D24, G32

1. Introduction

"Productivity isn't everything, but in the long run it is almost everything"
-- Nobel Laureate Paul Krugman

A growing literature recognizes that a well developed financial system can influence long-term growth at the country level through its ability to mitigate information and transaction costs, and to impact on saving rates and investment decisions (see Levine, 2005, for a survey). At the firm level, finance has been demonstrated to influence firms' real activities such as investment in fixed capital (Fazzari, Hubbard and Petersen, 1988) and employment (Nickell and Nicolitsas, 1999), which are the main factor inputs for firm production.

The bulk of empirical evidence shows that cross-country differences in the level or growth of gross domestic product (GDP) per capita are not due to factor accumulation, but can be explained by differences in total factor productivity (TFP) (Hall and Jones, 1999; Easterly and Levine, 2001). It is therefore important to explore whether finance fosters growth by directly promoting firm productivity, which is exemplified through technological innovation[1]. This could happen if the financial system is able to supply capital to innovative firms and to direct their operations to be more efficient (Ayyagari et al., 2007). Yet, productivity-enhancing research and development (R&D) activities commonly bear high risks and uncertainty, and require large investments. Furthermore, firms undertaking such innovative activities typically hold relatively large R&D related intangible assets such as patents and knowledge, which cannot be used as collateral. Hence, these firms typically find it hard to obtain loans from banks (Fazzari et al., 2009). One would therefore expect the productivity of these firms to be strongly affected by the availability of internal cash flow.

Although this is obviously an important research question, very few studies in the literature have analyzed links between financial factors and productivity. Among these, Nucci et al. (2005), Gatti and Love (2008), and Moreno-Badia and Slootmaeketrs (2009) found significant effects of financial factors on firms' total factor productivity for Italian, Bulgarian and Estonian firms, respectively. Butler and Cornaggia (2010) focus on US county-level agricultural products and bank deposits data and find that access to external finance can improve productivity in terms of agricultural yields.

[1] Solow's (1957) growth model establishes technological progress and skills as the prime drivers of increases in labor productivity.

Our aim is to fill this gap in the literature, focusing on a large panel of Chinese firms. China is an ideal laboratory to study the relationship between finance and productivity, as despite being characterized by a poorly developed financial system, its firms have exhibited very high growth rates in the last three decades (Allen et al., 2005; Guariglia et al., 2010). Scholars have attributed this phenomenal development to productivity growth, rather than capital or labor accumulation (World Bank, 1997; Brandt et al., 2009; Zheng et al., 2009; Guariglia et al., 2010). Understanding the links between financing constraints and productivity may help to further understand how Chinese firms were able to grow so fast despite severe financing constraints.

Our second contribution is that, for the first time, we analyze the links between firm productivity and financial factors, allowing this relationship to be different for different types of firms. In particular, we focus on whether the relationship differs among privately owned and foreign owned firm. Within these categories, we then look at how it differs among firms characterized by different levels of liquidity on the one hand, and among exporters and non-exporters, on the other.

To test the hypothesis that an increased availability of financial resource can raise firms' productivity, we establish two alternative and complementary models of firm productivity: the first uses total factor productivity as a dependent variable, and the second is based on the estimation of a production function. We find that firms' cash flow positively and significantly affects their productivity, which suggests that firms in China are financially constrained. Differentiating firms on the basis of ownership, we find that both private and foreign firms' productivities are affected by their cash flow. Furthermore, for both private and foreign firms, the link is typically stronger for those firms characterized by negative liquidity, suggesting that firms can use liquidity to smooth fluctuations in internal finance. Finally, private exporters have a higher productivity to cash flow sensitivity than private non-exporters, while foreign non-exporters have a higher sensitivity than foreign exporters. These results suggest that both liquidity and export behavior are important determinants of the link between the availability of internal finance and productivity in the Chinese context.

The remaining part of the paper is organized as follows. Section 2 reviews and discusses the relevant literature. Section 3 introduces our productivity models and estimation methodology. Section 4 describes our data. Section 5 analyzes our results and Section 6 concludes.

2. Economic background

2.1 Aggregate level studies

A number of studies have looked at the links between finance and growth, taking place through improvements in productivity, at the aggregate level. From a theoretical point of view, King and Levine (1993) show that, by improving the probability of successful innovation, financial development has a positive effect on productivity and hence growth. This happens because well developed financial markets can mobilize funds to finance the most efficient investment projects and diversify the risks associated with innovative activities. Another channel is that well developed financial markets can also offer easy and low-cost liquidation to firms undertaking innovation projects, should these firms need funds before the maturity of projects (Bencivenga, Smith and Starr, 1995). Aghion *et al.* (2007) show that perfect financial markets can encourage more long-term productivity-enhancing investments by reducing the liquidity risk connected to the investments.

Levine and Zervos (1998) use data from 47 countries to study the empirical relationship between various measures of stock market development, banking development and measures of long-term economic growth, including productivity (TFP) growth. Stock market liquidity and banking development are both found to be positively and robustly related to the rates of productivity growth. The authors explain this considering that diversified and better financial services can increase the ability to trade an economy's productive technologies and hence facilitate efficient resource allocation. Similarly, in their cross-country study, Beck et al. (2000) find that financial intermediaries in 63 countries exert a large, positive and long-run impact on TFP growth, which feeds through to overall economic growth. Arestis et al. (2003) collect data on a number of measures of financial constraints from 14 countries and find that finance has positive effects on the aggregate capital productivity. Emphasizing the non-linear pattern of the nexus, Huang and Lin (2009) find similar results from a panel of 71 countries. Using a panel of 74 countries, Rioja and Valev (2004) find that finance has a strong positive influence on productivity growth primarily in more developed economies, while in developing economies, finance affects growth primarily though capital accumulation. This finding on developing countries is not consistent with World Bank (1997) and Zheng et al. (2009), according to which productivity improvements rather than factor accumulation is the main contributor to growth in China.

This suggests that China may be different from other developing countries and provides a further motivation for our study.

Butler and Cornaggia (2010) use county-level US corn production data, together with local county bank deposit data over the period 2000-2006, to study the relationship between access to external finance and agricultural productivity. They take advantage of an exogenous shift in the demand for corn, due to a boom in ethanol production, and find that corn yields increased the most in response to the demand shift in those counties with relatively high access to finance. Although their productivity is measured by agricultural yields, they argue that their findings "provide concrete evidence that increased productivity is a key channel through which finance causes economic growth" (p. 34).

2.2 Firm-level studies

A huge literature has shown that financial constraints caused by information asymmetries and agency problems have a significant effect on firms' activities, including fixed capital investment (Fazzari et al., 1988), inventory investment (Carpenter et al., 1994, 1998), and employment (Nickell and Nicolitsas, 1999; Benito and Hernando, 2007). This is due to the fact that firms facing financial constraints have difficulties in raising external finance. Due to the pecking order of financing costs (Myers and Majluf, 1984), these firms have to mainly rely on their own internal finance. Being unable to choose their optimal capital structure, they are unable to make optimal decisions on their real activities. Financially constrained firms may therefore have to forego profitable investment opportunities when they are short of funds. This may distort the efficient allocation of resources and reduce firms' productivity.

Furthermore, if firms wish to improve their productivity by carrying out R&D activities, without a supportive financial system, they will find it extremely difficult to do so. Because of the high risks that are associated with R&D projects and because of their intangible nature, banks are in fact reluctant to finance these projects (Fazzari et al., 2009).

Firm-level research on the links between finance and productivity is limited. Studies in this literature can be divided into two groups. The first uses an indirect methodology to assess the linkages between financial variables and productivity, whereby productivity is used as a dependent variable. Productivity in this literature can be measured in various ways [e.g. labor productivity; TFP measured as a production function residual, using the Olley-Pakes (1996) method or using the Levinsohn and Petrin (2003) method; Malmquist productivity

index]. The second group of studies is based on the estimation of a production function augmented with financial variables.

2.2.1 Studies based on the estimation of a productivity regression

A first group of authors make use of an indirect methodology to assess the linkages between financial variables and firm productivity. These authors typically first generate a measure of firm-level productivity, which they then relate to financial variables. Using data from a cross-section of Bulgarian firms, Gatti and Love (2008) estimate the effects of access to credit, which is proxied by a dummy variable indicating whether firms have credit line or overdraft facilities, on TFP. The explanatory variables that they use as control variables are mainly dummies to indicate firm size, industry type, ownership and other firm characteristics. They find access to credit to be positively and significantly associated with firm TFP.

Moreno-Badia and Slootmaekers (2009) provide evidence on the link between financial constraints and firm-level productivity in Estonia. They find that a large number of firms in their sample, particularly young and highly indebted firms, show some degree of financial constraints. Yet, these constraints do not lower productivity for firms in most sectors, with the exception of R&D. Their results are consistent with the argument that finance may shape firms' innovation activities, which ultimately affects firms' productivity. These effects may then be transmitted to firm-level growth, and subsequently to aggregate growth.

Focusing on Danish firms, Smith *et al*. (2004) analyze the relationship between the source of finance of R&D activities and firm productivity. They find that the productivity of those firms whose R&D activities are financed by public funding is not significantly different from that of the firms whose R&D activities are financed by their own funds. This may suggest that direct government helping hands are not necessary to increase firm productivity, as long as firms' productivity-enhancing activities can be financed elsewhere.

With a similar motivation, Nucci et al. (2005) use data on a panel of Italian firms to study the relationship between firms' capital structure and TFP. They construct a TFP model, where TFP is a function of firms' leverage, the ratio of immaterial to total assets, and other control variables such as firm size. They document a negative relationship between firms' leverage and productivity, which is stronger for firms with a lower share of short-term debt and lower liquidity. They conclude that debt finance does not help productivity.

Nunes et al. (2007) study the relationship between firms' leverage and labor productivity in a panel of Portuguese firms, and find the relationship to be nonlinear. Specifically, they find that leverage tends to negatively affect labor productivity for the majority of the firms with relatively low labor productivity, and positively for firms with high labor productivity.

A positive relationship between leverage and firms productivity may be explained by the bankruptcy argument: a high level of leverage increases the probability of bankruptcy and hence induces managers to try and improve productivity. On the other hand, a negative relationship may arise due to an agency problem. Banks often prefer to issue collateralized loans. Firms' productivity-enhancing R&D activities are negatively related to leverage due to their negative relationship with collateral. Yet, they are positively related to productivity. Consequently, leverage is negatively related to productivity.

Finally, Guan and Lansink (2006) extend the capital structure and firms' productivity studies to agricultural farms. Using the Malmquist productivity growth index to measure Dutch farm performance and a two-step method, they find that long-term debt increases farm productivity growth.

2.2.2 Studies based on the estimation of a production function

A second group of authors examine the links between finance and productivity by including financial variables in a Cobb-Douglas production function. Nickell and Nicolitsas (1999) use UK panel data to examine the impact of increases in financial pressure, which is measured by borrowing ratio, on firm productivity, as well as employment and wage rises. Their model is derived from a production function augmented with financial variables. They find that the borrowing ratio has a positive but small effect on the output to capital ratio. Their findings are consistent with the bankruptcy theory: when financial pressure increases, bankruptcy risks amplify. Firm managers as well as employees have strong incentives to minimize the possibility of bankruptcy. Hence, it is reasonable to expect them to increase their efforts to improve productivity.

Making use of a similar methodology, Harris and Trainor (2005) use plant level panel data on Northern Ireland to study the effects of government capital subsidies on productivity. By comparing firms which received subsidies with those which did not, the authors conclude that capital grants from the government have a significant and positive effect on the level of production in manufacturing.

Ayyagari et al. (2010) suggest that despite the weaknesses of China's formal financial system and the dominance of the use of internal finance by firms, financing from formal financial institutions is associated with faster firm productivity growth, whereas funds raised from alternative channels do not have such positive effects on firms.

Other authors have also identified connections between firms' financing structure and productivity, by estimating production functions augmented with financial variables. Pushner (1995) observes a strong negative relationship between leverage and firm productivity in Japan, which is in line with the findings of Nucci et al. (2005) for Italy. Schiantarelli and Sembenelli (1997) find that both the UK and Italian firms' productivity depends positively on the length of debt maturity, i.e. the use of long-term debt can help to increase productivity.

In summary, all the above papers indicate that there exists an important linkage between the availability of internal and external finance and firms' productivity.

2.3 Shortcomings of previous studies and our contributions

The firm-level studies surveyed above may suffer from methodological problems. First, many of the variables in a productivity equation are likely to be endogenous. Although Nucci et al. (2005) try to identify some exogenous factors affecting firms' capital structure, they use between and within estimators in their estimations, which do not control for endogeneity. Pushner (1995) and Nunes et al. (2007) both apply a quantile regression approach, and their results are still subject to the influence of endogenous determinants of productivity. Therefore, the results obtained by these authors may have to be interpreted with caution.

Second, most of the studies above mainly try to discover a linkage between forms of finance and firm productivity, but few of them take firm heterogeneity into account. Our research will fill this gap in the literature by contributing to explore the role of firm heterogeneity in the finance and firm productivity relationship. In particular, we will assess the extent to which firms owned by different agents and firms characterized by different levels of liquidity and different export behavior exhibit different sensitivities of productivity to internal finance. Furthermore, improving on the existing literature, all our equations will be estimated using a Generalized Method of Moments (GMM) system estimator, which takes into account the endogeneity of all regressors. Finally, for the first time, we will look at the linkages between finance and productivity in the context of the Chinese economy, which in spite of a poorly developed financial system has been characterized by phenomenal productivity and GDP growth in the last three decades.

3. Empirical specifications and estimation methodology

To analyze the relationship between firm-level financial factors and productivity, we follow two alternative estimation procedures. First, we derive a firm-level measure of TFP, which we subsequently regress on financial variables and a number of control variables (indirect approach). Second, as in Nickell and Nicolitsas (1999), we estimate a Cobb-Douglas production function augmented with financial variables (direct approach).

3.1 Indirect approach: estimating a TFP equation

This approach consists of two steps: we first obtain a measure of firm TFP, using the Levinsohn and Petrin (2003) method, which is fully described in Appendix A1. We then establish a model to find the determinants of TFP and uncover whether financial factors exert any effects on it. Specifically, we estimate a model of the following type:

$$tfp_{it} = a_0 + a_1 tfp_{i,t-1} + a_2 X_{it} + a_3 CF_{it} / K_{it} + \nu_i + \nu_j + \nu_t + \nu_{jt} + \varepsilon_{it} \quad (1)$$

Considering that according to Levinsohn and Petrin (2003), firm productivity follows a first-order Markov process, lagged *tfp* must be included to control for serial correlation. X_{it} is a vector of firm *i*'s characteristics, which includes firms' size measured by the logarithm of real total assets, the logarithm of firms' age, export intensity, and a regional dummy. These variables are motivated by and similar to those used in Gatti and Love (2008) and Moreno-Badia and Slootmaeters (2009). Firms' size and age have often been found to be related to firms' productivity (Palangkaraya et al., 2009). Firms' export status is also argued by many researchers to be linked to productivity (Aw et al., 2008). We use firms' export intensity (export to sales ratio) in our models. Given China's economic policies and development mode, regional effects are correlated with many economic environment features, such as tax policy, legal protection, infrastructure, financial market development, and so on, which are ultimately likely to affect firms' performance. These economic environmental features are often more advantageous in the coastal region. We therefore include a coast dummy to

indicate whether firms are located in the coastal provinces.[2] This dummy equals to one if firm *i* is located in one of the coastal provinces, and zero otherwise.

The financial variable CF_{it}/K_{it} is our key explanatory variable. This variable is frequently used in the financial constraints literature as an indicator of firms' internal sources of finance. If firms face difficulties in raising external finance, they have to rely on their own funds, which will limit their ability to carry out investments and force them to forego profitable opportunities. By inspecting this variable, we are looking for whether relying on internal finance retards firm's productivity as well. Typically, productivity-enhancing activities such as R&D or the adoption of new technologies are costly and uncertain, and therefore mainly have to depend on firms' internal funds. When firms have additional cash flow, they may be able to carry out some productivity-enhancing activities and consequently improve their productivity. Cash flow also directly affects firms' real activities, such as capital investment, employment and the accumulation of inventories. Hence, when additional cash flow is available, firms can optimize their real activities, which may further improve their productivity.

The error term in eq. (1) is made up of five components. v_i is a firm-specific effect, which we control for by estimating our equation in first-differences. v_j is an industry-specific effect, which we take into account by including two-digit industry dummies, which control for industry specific characteristics in terms of technology related productivity difference. v_t is a time-specific effect, which we control for by including time dummies capturing business cycle effects in all our specifications. v_{jt} captures industry specific business cycle effects, and is taken into account by including industry and time dummies interacted (Brown et al., 2009; Brown and Petersen, 2009; Guariglia et al., 2010). Finally, ε_{it} is an idiosyncratic error term. This specification will enable us to test whether and how cash flow has an effect on firm TFP[3].

3.2 Direct approach: estimating a production function augmented with cash flow

[2] We define coastal region to include the following 10 provinces and municipalities: Beijing, Fujian, Guangdong, Hebei, Jiangsu, Liaoning, Shandong, Shanghai, Tianjin and Zhejiang. Non-coastal region includes the following 21 provinces and municipalities: Anhui, Hainan, Heilongjiang, Henan, Hubei, Hunan, Jiangxi, Jilin and Shanxi, Chongqing, Gansu, Guangxi, Guizhou, Inner Mongolia, Ningxia, Qinghai, Shaanxi, Sichuan, Tibet, Xinjiang, and Yunnan.

[3] It should be noted that our model may yield inconsistent estimates, since conditional on lagged productivity we implicitly assume that current *tfp* depends on firm-specific determinants and financial determinants, which may be known to firm. Yet, the Markov process assumption in the Levinsohn-Petrin (2003) methodology implies that current firm productivity should be an unpredictable shock, conditional on past productivity (Moreno-Badia and Slootmaeters, 2009). As a consequence, even with an appropriate estimation of the *tfp* measure, the estimated financial effects on productivity may still be biased.

To analyze the extent to which the availability of cash flow affects firms' productivity, we next follow Nickell and Nicolitsas (1999) and incorporate cash flow as well as other firm characteristics variables directly into a production function. To control for heterogeneity due to firm size we normalize the basic production function by capital. We then add controls for firm characteristics as well as our cash flow variable. The normalized production function can therefore be expressed as follows:

$$Y_{it} / K_{it} = b_0 + b_1 Y_{i,t-1} / K_{i,t-1} + b_2 L_{it} / K_{it} + b_3 X_{it} + b_4 CF_{it} / K_{it} + \nu_i + \nu_j + \nu_t + \nu_{jt} + \varepsilon_{it} \quad (2)$$

where Y_{it}, K_{it} and L_{it} denote respectively firm i's output (measured by value added), capital (total fixed tangible assets) and labor (number of employees) at time t. With the exception of firm size, the variables included in X_{it} in eq. (2) are similar to those included in the same vector in eq. (1). X_{it} does not include firm size, since size is controlled for by normalizing the equation by capital. CF_{it}/K_{it} represents cash flow. The five components of the error term are similar to those described with reference to eq. (1).

By estimating the two models described above, we test whether the availability of internal finance plays a role in determining firms' productivity. Our hypothesis is that financial resources can enable firms to improve productivity, since they can make it possible for firms to carry out productivity-enhancing but finance-dependent activities. Therefore, if finance does exert an influence on firm productivity, we would expect positive and significant coefficients on cash flow in both of our models. The combination of the direct estimation of a production and the indirect estimation of TFP can ensure the robustness of our findings.

3.3 Accounting for firm heterogeneity

We account for several dimensions of firm heterogeneity.

3.3.1 Ownership

We first differentiate the effects of cash flow on productivity across groups of firms based on ownership. To this end, we focus on private and foreign owned firms. The former represent

68.1% of our sample, and the latter 16.4%. We chose to focus on these two groups because the former have represented the engine of growth of the Chinese economy in the last three decades despite facing severe financing constraints (Allen et al., 2005; Guariglia et al., 2010), while the latter typically exhibit very high productivity levels. Within these two groups, we then analyze heterogeneity based on liquidity and export behavior.

3.3.2 Liquidity

Liquidity, also known as working capital, is defined as the difference between a firm's current assets and its current liabilities, normalized by total assets. The more liquid a firm's assets, the greater their value can be in short-notice sales. Keeping liquid assets may incur high opportunity costs to firms, but firms with more liquid assets may be viewed as less risky by lenders. Theories suggest that more liquid assets increase firms' ability to raise cash on short notice. However, excessive liquidity may reduce the credibility of the firms to their lenders since, as Myers and Rajan (1998) argue, the liquidity of the assets opens up various trading strategies that may be adverse to the lenders' interests. As a result, excessive liquidity can, in some circumstances, reduce firms' capacity to raise external finance. Nevertheless, firms' liquidity is clearly an aspect that external lenders consider when making lending decisions. Firms with a high share of liquid assets may find it easier to undertake those uncertain productivity enhancing activities than firms with a low or negative share of liquid assets, and rely less on their floating cash flow for such activities. Liquid firms can in fact quickly liquidize some of their assets in case they need extra funds to finance the uncertain productivity enhancing activities. Illiquid firms may not be able to do the same and are hence likely to be more dependent on their existing cash flow for productivity enhancing activities. In addition, firms' net liquid assets are found to smooth fixed capital investment by Fazzari and Petersen (1993) for US firms and by Ding et al. (2010a) for Chinese firms. Net liquid assets are an additional source of finance for firms which have to depend on internal cash flow. Thus, liquid firms' productivity may be less dependent on cash flow than illiquid firms'. Indeed, Nucci et al. (2005) find that low liquidity Italian firms suffer stronger negative effects of leverage on their TFP than their counterparts with high liquidity.

We separate the sample of private firms into those with positive and non-positive liquidity. Negative liquidity should impose extra difficulties for firms to raise external funds since it increases firms' risk of bankruptcy.

3.3.3 Export behavior

In the international economics literature, exporters are often found to be more productive than non-exporters (e.g. Bernard and Jensen, 1999). This finding is often cited as a reason for active export promotion policies in many developing countries. There are two common theoretical explanations for a positive correlation between the export status of a firm and its productivity. One is self-selection: only the most productive firms are able to engage in export activities and compete in international markets (Bernard and Jensen, 1999). The other is the 'leaning-by-doing' hypothesis: entering export markets enables firms to gain new knowledge and expertise, which contribute to improving their productivity (Van Biesebroeck, 2005).

However, firms' exporting behavior could also have an indirect effect on productivity by affecting its sensitivity to cash flow. Specifically, it has been found that exporters are generally financially healthier than non-exporters (Campa and Shaver, 2002; Greenaway et al., 2007; Bellone et al., 2010; Guariglia and Mateut, 2010)[4]. This could be explained considering that exporters have access to both domestic and international financial markets, which allows them to diversify their sources of financing and the associated risks. Furthermore, being also dependent on demand from foreign countries, exporting firms are less tied to the domestic cycle, and less subject to those financial constraints induced by tight monetary policy and recessions at home[5]. They therefore benefit from a more stable cash flow, which relaxes their liquidity constraints (Campa and Shaver, 2002)[6]. Finally, given the presence of sunk costs that need to be met when entering foreign markets for the first time (Roberts and Tybout, 1997), being an exporter also provides a signal that the firm is sufficiently productive to generate enough profits in foreign markets to recover the sunk costs. This increases the likelihood that the firm will be able to service its external debt, and further

[4] Bellone *et al*. (2010) find evidence from a panel of French manufacturing firm data that financial constraints significantly affect firms' export decisions. In particular, better financial health and better access to external finance can make firms more likely to export. Using a panel of UK manufacturing firms, Greenaway et al. (2007) find that continuous exporters exhibit better financial health than non-exporters and participation in export markets improves firms' financial health. Based on a sample of Spanish firms, Campa and Shaver (2002) find that relative to non-exporters, exporters have more stable cash flow and, therefore, capital investment. They conclude that liquidity constraints are less binding for exporters than for non-exporters. Guariglia and Mateut (2010) also find that the inventory investment of UK firms that engage in exports is not constrained by their cash flow.

[5] This argument relies on the assumption that business cycles are not perfectly coordinated across countries.

[6] A more stable cash flow provides in fact greater assurances to lenders that the firm will be able to service its obligations.

relaxes the liquidity constraints that it faces. Hence, one could expect the sensitivity of firms' productivity to cash flow to be weaker for exporters compared to non-exporters.

3.4 Estimation methodology

We first estimate eqs. (1) and (2) separately for private and foreign firms. Within these two categories, we then interact our cash flow variable with dummies indicating whether our observations have negative or positive liquidity on the one hand, and whether they are exporters or non-exporters, on the other. Instead of running separate regressions for each of the subgroups, this methodology allows us to keep the maximum possible sample size and degrees of freedom and to compare the financial effects on firm productivity between different groups of firms.

All of our equations are estimated using the system GMM approach developed by Arellano and Bond (1991) and Blundell and Bond (1998). The possible simultaneity and endogeneity problems in our models can be controlled for with this estimator. We treat all the regressors in our equations (except age) as endogenous, and instrument them using two or more lags of their own. We include year dummies, two-digit industry dummies, and year dummies interacted with industry dummies in all our regressions and instrument sets.

The dynamic model specifications that we estimate can only be appropriate if they are exempt from serial correlation in the first-differenced residuals. In the presence of serial correlation of order 2 in the differenced residuals, the instrument set needs to be restricted to lags 3 and deeper. The latter instruments are valid in the absence of serial correlation of order 3 in the differenced residuals (Brown and Petesen, 2009; Roodman, 2006). We assess the presence of n^{th}-order serial correlation in the differenced residuals using the *m(n)* test, which is asymptotically distributed as a standard normal under the null of no n^{th}-order serial correlation of the differenced residuals[7].

The validity of the instrument sets can also be tested using the Hansen/Sargan statistics (or *J* statistics). However, the Monte Carlo evidence of Blundell, Bond and Windmeijer (2000) shows that when using system GMM on a large panel data to estimate a production

[7] In all our specifications, we found evidence of serial correlation of order 2 in the differenced residuals. We therefore used three lags of our regressors as instruments and only report the *m3* test for third order serial correlation of the differenced residuals in our tables. Deeper lags of the instruments are only included if they improve the specification tests.

function, the Sargan test tends to over-reject the null hypothesis of instrument validity[8]. Given the size of our panel, we are therefore inclined to pay little attention to the *J* test, which we choose not to report.

4. Data and descriptive statistics

4.1 Data

Our data are drawn from the annual accounting reports filed by industrial firms with the National Bureau of Statistics (NBS) over the period 2000-2007. All state-owned enterprises and other types of enterprises with annual sales of five million yuan (about $770,000) or more are covered. These firms operate in the manufacturing and mining sectors and come from 31 provinces or province-equivalent municipal cities.

Observations with negative sales, negative total assets minus total fixed assets, negative total assets minus liquid assets; and negative accumulated depreciation minus current depreciation, were dropped. Since we use firms' export intensity as a control variable, we deleted a small number of firm-years with exports larger than sales. We also dropped firms that did not have complete records on our main regression variables. To control for the potential bias caused by outliers, we removed the one percent tails of the distribution of all variables included in our regressions. We dropped firms with less than three-year consecutive observations, which is a common practice for dynamic models. Our final dataset is an unbalanced panel, containing 125,081 firms, which correspond to 579,795 firm-year observations. Since our models are dynamic and include lagged variables, we can only use the years 2001-2007 in estimation. Observations in each of these years range from the minimum of 37,301 in 2001 to the maximum of 120,603 in 2006[9].

4.2 Descriptive statistics

Table 1 shows descriptive statistics of the variables used in estimation. We present statistics for the full sample, for private, and for foreign firms. Ownership is defined on the basis of the average paid-in-capital over the data period. Specifically, a firm is classified as private

[8] Consistent with this, Nickell and Nicolitsas (1999) report significant Sargan test statistics for all of their reported estimation results on UK firms, and Benito (2005) and Benito and Hernando (2007), for several of theirs.

[9] See Appendix A.2 for more information on the structure of our panel.

(foreign) if at least 50% of its paid-in capital is owned by private (foreign) agents. 68.1% of the firm-years in our sample are privately owned, and 16.4% are foreign-owned. The remaining observations are either state-owned or collectively owned[10]. Chinese private firms have been found in the literature to be the most financially constrained (Héricourt and Poncet, 2008; Poncet et al., 2010; Guariglia et al., 2010). As for foreign firms, the evidence is mixed: while Héricourt and Poncet (2008) and Poncet et al. (2010) find that they are relatively financially healthy, using a much larger data sample, Guariglia et al. (2010) and Ding et al. (2010a) show that their growth and investment are significantly affected by the availability of internal finance.

Table 1 shows that productivity measures such as TFP, the value added to capital ratio, and labor productivity (measured by sales per employee) vary considerably across ownership groups. In particular, foreign firms' TFP and value added over capital are higher than the corresponding values for the whole sample and the private firm sample. On the contrary, labor productivity is the highest for private firms. This suggests that foreign firms are more capital productive, while private firms are more labor productive. The profitability measure of return on sales is very similar across groups, averaging at about 3%. Private firms are much smaller than their foreign counterparts. Labor intensity (measured by the number of employees to real total assets ratio) is lowest for private firms and highest for foreign firms, which possibly suggests that on average foreign capital may be interested in labor intensive industries in China.

Foreign and private firms are both a little more than 8 years old, whereas the average age of all firms is higher (9.8), due to the fact that SOEs are typically much older than other firms.

On average, our sample firms export 16% of their sales. Private firms only export a very small portion (11%) of their total sales. In contrast, foreign firms export more than 45% of their sales. China has been a global manufacturing centre hosting a large number of foreign invested firms. Many of these are established to export, taking advantage of the quality and cost of labor in China. This is confirmed by the high labor intensity shown by these firms.

Both private and foreign firms have higher cash flow to capital ratios (0.4 and 0.5 respectively) than the sample average, which may be a reflection of their better profitability.

[10] Given that SOEs and collective firms only make up small proportions of the sample, and that they are susceptible to soft budget constraints, which may be likely to overshadow any financial effects on their activities, we exclude them from our further analysis.

The *t* tests reported in column 4 show that the differences of all reported variables between private and foreign firm-years are all highly significant at the 1% level.

5. Evaluation of the results

5.1 Indirect approach

We start with the indirect approach. The estimation results of eq. (1) are presented in table 2. Our main model specification for the whole sample is presented in column 1. Columns 2 and 3 report estimates for private and foreign firms respectively, while columns 4 to 6 report some robustness checks. In column 1 all the independent variables are highly significant in explaining firms' TFP. Specifically, size, export intensity, and the coastal location dummy are all positively associated with productivity.

The fact that larger firms are more productive than their smaller counterparts is widely documented in both the theoretical and the empirical literature (Melitz, 2003). Firms' exporting activities are often found to be positively related to their productivity, though the causality is somehow unclear (e.g. Bernard and Jensen, 1999). Productive firms may be able to make their products competitive in the international market, whereas engaging in international competition may push firms to further improve their productivity. Our model confirms the existence of a positive export-productivity association.

China's economic policy has a strong regional dimension. Coastal regions receive obvious preferential policy treatments favoring economic development. It is therefore not surprising to see that firms located in the coastal region exhibit higher TFP levels.

Firms' age is negatively related to TFP, suggesting that older firm-years are typically less productive than their younger counterparts. This can be explained considering that older firms in China are typically SOEs, which are the least efficient (Guariglia et al., 2010).

Finally, our cash flow variable also exhibits a positive and precisely determined coefficient. This indicates that the more cash flow a firm has at hand, the higher its productivity is likely to be. This cash flow effect is also economically significant: every unit increase in the sample firm-years' cash flow to capital ratio leads to a 0.2 percentage increase in the firm's log TFP. The significant and positive coefficient of cash flow is highly sensible in the Chinese case, as credit constraints have been documented to impede firms' investment and growth (Guariglia and Poncet, 2008; Guariglia et al., 2010). The *m3* test indicates that the model specification and instruments are appropriate.

A similar pattern is observed in column 2, which refers to private firms. Private firms in China are subject to market forces, since they do not have government support as SOEs do, or the preferential policy treatment that foreign firms often receive. They were not formally recognised as an integral part of the economy until the early 1990s, which left them with no access to formal financial markets, and their property rights were not well protected until the implementation of the new *Property Law* in 2007. Despite the disadvantages in the market, private manufacturing firms are among the fastest growing economic agents. Their share of total value added in our whole sample increased steadily from 38% in 2000 to 51% in 2007. The regression results in column 2 show that overall private firms' productivity is significantly constrained by their availability of internal cash flow. In line with the literature, this finding confirms that these firms are indeed financially constrained. As for the other regressors, they all have similar coefficients to those reported in column 1.

Column 3 reports estimates for foreign firms. Foreign firms in both industrialized economies and emerging economies are often believed to be highly productive as they are able to operate both at home and in a foreign country (Helpman, Melitz and Yeaple, 2004). In the globalization age, multinational firms are one of the major driving forces of international trade and resource optimization in a global scale. Governments all over the world appear to be keen to attract foreign investment by various policy incentives. While foreign firms share many similar features with domestic private firms, they often enjoy a more favorable environment, such as lower tax rates[11]. Although from the descriptive statistics, the foreign firm-years in our sample seem to be the healthiest and most productive ones overall, the estimation results show a strong and positive cash flow effect on their productivity, suggesting that they suffer from financing constraints. This finding, which is consistent with Guariglia et al. (2010), can be explained considering that local banks may be reluctant to lend to majority owned foreign firms. As documented in World Bank (2006), fully foreign owned firms operating in China have in fact limited access to domestic direct finance.

The coefficients on the other regressors are similar to those reported in column (1) and (2), with the exception of the coefficient associated with the coast dummy, which is insignificant. This can be explained in the light of the fact that 94% of the foreign firm-years in our sample are located in the coastal region.

[11] This was the case in China: before the implementation of the new *Enterprise Income Tax Law* on the 1st January 2008, foreign invested firms could enjoy tax rates of only 15% or 24% compared to a rate of 33% for domestic firms.

Columns 4 to 6 of table 1 present some robustness tests, which all refer to the full sample. We first eliminate the distressed firms, i.e. those characterized by a negative average cash flow over the sample period[12]. This test is aimed at assessing whether it may be those firms which drive the positive cash flow coefficient. Excluding about 40,000 distressed firm-years hardly changes the effects of any of the explanatory variables (column 4). This suggests that the positive cash flow effect in our model is not driven by distressed firms.

In columns 5 and 6, we make use of different measures of firm performance. Specifically, we replace the dependent variable respectively with firms' return on sales (ROS) and labor productivity (LP) to verify whether our cash flow effects hold when other aspects of firm performance are considered. Our results show that the availability of cash flow is positively and significantly associated with both measures of firm performance. This suggests that the availability of internal finance affects other aspects of firm performance in addition to TFP. In none of these specifications does the *m3* test indicate any sign of mis-specification or instrument invalidity.

5.2 Direct approach

We now turn to our direct approach. Table 3 reports estimates of our production function, where firms' output is measured by total real value added. In the specification for the full sample, reported in column 1, the lagged output to capital ratio, the labor to capital ratio, age, and the coast dummy display highly significant and positive coefficients. The main difference between the direct and indirect approach models is the effect of age. In the indirect approach, age is negatively related with TFP, while in the direct approach it has a positive effect on production. The reason for this could be that the TFP model may tend to pick up productivity in terms of technological advantages, whereas the production function model does not. As economic policies in recent years have strongly encouraged high technology intensive domestic and foreign firms in China, it is possible that younger firms in our sample adopt more new technologies and benefit more from such policies than older firms, which may have more experience in production efficiency. China now hosts clusters of foreign invested firms, which bring in advanced technologies and management skills, and are often set up for export. Particularly, most foreign or private firms in our sample are younger than those in the

[12] Note that we do not simply treat firms with negative cash flow in each year as distressed. If a firm has positive cash flow in most of its operational years and experiences negative cash flow due to some sort of shocks in a single year, it is not likely that this firm will behave very differently in that year. However, if a firm on average has negative cash flow, it is possible that the firm is truly distressed.

full sample. Therefore, in the TFP model, our sample firms that are dominated by young foreign and private firms tend to have a lower TFP as they become older. On the contrary, the production function model accounts for the output efficiency from the input of capital, which could be increasing as firms become older and gain production experience.

As in the indirect approach, cash flow exhibits a significant and positive coefficient in our production function: every unit increase in the cash flow to capital ratio is associated with a unit increase in firms' output to capital ratio. The *m3* tests suggest that our production function model specification is properly specified and that our instruments are adequate.

Similar results are observed in column 2, which refers to private firms, and in column 3, which refers to foreign firms. Column 4 assesses the robustness of the results by excluding distressed firms. Once again, the results are unchanged: cash flow remains positively and significantly associated to output.

In summary, both the indirect and direct approaches show that the availability of internal finance is significantly and positively associated with Chinese firms' productivity. This result holds for the entire sample, but also for the sub-samples made up by private and foreign firms. These results are in line with those found for other countries by Nickell and Nicolitsas (1999), Gatti and Love (2008) and Moreno-Badia and Slootmaekers (2009).

5.3 Taking into account other dimensions of firm heterogeneity

We next investigate the effects of firm heterogeneity (other than ownership) on the cash flow-productivity nexus. We initially focus on the sub-sample of private firms, and then on that of foreign firms. We allow for two main dimensions of firm heterogeneity: liquidity and export behavior.

5.3.1 Private firms

As shown in column 2 of tables 2 and 3, these firms' productivity is significantly constrained by the availability of internal finance. We next focus on the effects on the productivity to cash flow sensitivities of two aspects of firm heterogeneity: liquidity and export behavior. We analyze these two dimensions of firm heterogeneity in turn.

Liquidity

Columns 1 and 2 of table 4 present descriptive statistics for private firms characterized by positive and negative liquidity, respectively. We can see that almost 60% of private firm-years have positive liquidity. Firm-years with positive liquidity are much more productive than those with non-positive liquidity by all three measures of productivity. Positive liquidity firms are also more profitable, more labor intensive and possess much more cash flow. Particularly their cash flow ratio is more than two times higher than that of negative liquidity firms. Firms with positive liquidity also have fewer assets and export a smaller proportion of their sales. The *t* tests show that the mean values of these variables are significantly different across the two groups of firm-years. There is no significant age difference between firm-years with positive or non-positive liquidity. It is reasonable to expect stronger cash flow effects on productivity for illiquid firms.

Column 2 of table 5a presents estimates of the TFP model (eq. 1) where the cash flow coefficient is interacted with a dummy indicating positive liquidity on the one hand, and a dummy indicating negative liquidity on the other. We can see that both firms with positive and negative liquidity exhibit positive cash flow sensitivities. Yet the coefficient is higher for the former (0.4) than for the latter (0.2). A χ^2 test suggests that the difference between these two coefficients is statistically significant at the 1% level. Column 2 of table 5b reports estimates of the production function. Once again, the coefficient associated with cash flow is much higher for firms with negative liquidity (2.3) compared to that for more liquid firms (1.4). The difference between these two coefficients is, however, insignificant.

Both our productivity models confirm therefore that cash flow has a stronger positive effect on firms' productivity for illiquid firms than for liquid firms. Having high liquidity can therefore alleviate firms' dependence on internal finance in order to enhance their productivity.

Export behavior

Descriptive statistics reported in columns 4 and 5 of table 4 show that private exporters, which represent 22% of the total, are more productive than non-exporters, as their TFP and value added to capital ratio are higher. However, their labor productivity is much lower, which is possibly related to their high labor intensity. Indeed China's export sector mainly exports labor intensive goods. This is likely to be the result of the country's comparative advantage. Private exporters' return on sales is also lower than that of non-exporters. Private exporters are much larger and older than non-exporters, and on average, they export more

than half of their total sales. They also have a lower cash flow to capital ratio compared to non-exporters. The differences of all variables across exporters and non-exporters are all highly significant. These descriptive statistics suggest that our private exporters are not necessarily less financially constrained than non-exporters. We further investigate this issue by analyzing how the cash flow coefficients in our productivity models differ across exporters and non-exporters.

Column 3 of table 5a reports estimates obtained from the TFP model. Both exporters and non-exporters have significant and positive cash flow coefficients (0.5 and 0.2, respectively), higher for the former. The difference in the cash flow coefficients across exporters and non-exporters is significant at the 1% level. This pattern is supported by the production function model, where the cash flow effect is higher for the private exporters (2.2) compared to non-exporters (1.7; table 5b, column 3). In this case, however, the difference between the two coefficients is not significant at conventional levels. These findings suggest that there is no evidence that the productivity of private exporters in China is affected by the availability of internal finance less strongly than that of non-exporters. Private exporters do not therefore seem to be more financially healthy than non-exporters. This apparently contradictory finding can be explained considering that, as discussed in Manova et al. (2009), private exporters mainly operate in sectors with limited need for outside finance. Hence, the advantages of having a more stable cash flow and of giving a signal of higher financial solidity are less pronounced. The fact that in the TFP model, exporters actually face higher cash flow sensitivities than non-exporters can be explained considering that a large share of China's export is made up of processing export, in which exporting factories mainly import parts and input labor to assemble final products (Lemoine, 2010). These exporters simply follow instructions from their foreign clients to do some simple assembling, hardly undertake product design, and mostly have no R&D activities. Consequently, their productivity may be more dependent on the availability of internal finance. Despite benefiting from favorable policies that encourage exports, Chinese domestic exporters still face huge financial constraints on their productivity improvement. From a policy perspective, channeling more financial resources towards domestic private exporters could substantially raise their productivity.

5.3.2 Foreign Firms

Foreign firms in both industrialized economies and emerging economies are often believed to be highly productive given the fact that they are able to operate both at home and in foreign countries (Helpman, Melitz and Yeaple, 2004). They are also believed to be the most financially healthy as they can access financial markets both at home and abroad (Guariglia and Mateut, 2010). Yet, our findings have shown that, like private firms, the productivity of foreign firms in China is strongly constrained by the availability of internal finance. We next investigate the extent to which the productivity of different types of foreign firms may be affected differently by the availability of cash flow. Like in the case of private firms, we differentiate firms on the basis of their liquidity and their export behavior.

Liquidity

Focusing on liquidity, the descriptive statistics reported in table 6 show that 77% of foreign firm-years have positive liquidity. This percentage is higher than the corresponding percentage for private firm-years (60%). This may indicate that foreign firm-years are financially healthier than their private counterparts. It may be also related to the nature of processing trade that most of the foreign firms in China are involved with. These foreign firms typically hold large stocks of inventories, which are part of their current assets (Ding et al., 2010a). Hence, it is reasonable that many of them appear to have positive liquidity. Columns 1 to 3 of table 6 show that liquid foreign firm-years display much higher productivity and profitability than illiquid observations, even if they are smaller. In particular, their average return on sales is nearly four times as high as that of the other firms. They are also much more labor-intensive, and older. Their export share is higher. Unsurprisingly, their cash flow ratio is more than two times as high as that of the illiquid firms. The differences of all the variables between the two groups are highly significant.

Estimates of our TFP model are reported in column 2 of table 7a. Like for private firms, the cash flow coefficient is much higher for the illiquid firm-years (0.5) than for the liquid firm-years (0.2). The difference between the two coefficients is statistically significant at 5% level. A similar conclusion holds when we estimate the production function (table 7b, column 2). These findings suggest that as for private firms, having positive liquidity reduces foreign firms' TFP dependence on internal finance.

Export behavior

Most of the empirical evidence on the relationship between firms' export status and productivity is based on domestic indigenous firms and multinationals in developed countries. Foreign and domestic exporters are characterized by some fundamental differences in their operation and export activities. Kneller and Pisu (2004) investigate export behavior of foreign firms in the UK and find these firms contribute a disproportionately large share of the UK's total manufacturing exports. These features are shared by the Chinese manufacturing sector. In our full sample, foreign firm-years make up 16.4% of the total observations, but the value of their exports represents 58.7% of the total exports in the sample. The linkage between exports, productivity, and financial constraints may be very different across domestic and foreign exporters.

There has been little research on the productivity of foreign affiliates in developing countries or on the effects of financial constraints on their productivity. Foreign firms producing in developing countries, particularly those which are export-oriented, are likely to be very different from those which produce in industrialized countries. While the latter are mostly driven by market seeking purposes, the former are probably more interested in the low production costs in the developing countries. The globalization process has induced many firms in the industrialized countries to relocate their production lines to developing countries like China, which has low cost skilled labor and provides many preferential policy treatments to foreign investors. A large number of foreign firms establish themselves in China purely for export. In our sample, 13% of the foreign firm-years export 100% of their total sales, 28% export more than 90% of their sales, and 37% export more than three quarters of their sales. On average, foreign exporters in China export 67% of their sales.

As shown in the descriptive statistics reported in columns 4 to 6 of table 6, two thirds of the foreign firm-years in our data set are exporters. Although TFP and the value added to capital ratio are slightly lower for foreign non-exporters compared to foreign exporters, their labor productivity is much higher. Non-exporters are smaller in size and younger, but much more profitable and less labor intensive than exporters. Their cash flow to capital ratio is also higher. The differences in all variables reported in the table between exporters and non-exporters are highly significant for all indicators. We next investigate whether being an exporter affects the nexus between foreign firms' productivity and their cash flow.

The regression results in column 3 of table 7a and 7b indicate that the foreign non-exporters are subject to stronger cash flow effects on productivity than exporters. While non-exporters seem to perform better than exporters according to the descriptive statistics in table 6, their productivity appears to be more constrained by the availability of internal finance.

This result is in line with the literature, which suggests that exporters typically face less binding financial constraints than non-exporters. Considering that foreign exporters typically operate in sectors with high liquidity needs (Manova et al., 2009), this can be explained in the light of the fact that exporting stabilizes firms' cash flow, gives firm access to financial markets abroad, and gives a signal of financial solidity. Compared to non-exporters, Chinese foreign exporters are therefore more likely to be able to secure external finance. Considering their higher sensitivities of productivity to cash flow for foreign non-exporters, these firms should be the target of government policies aimed at productivity and efficiency improvement. As these results are opposite to those for private firm-years, to optimize the outcome of overall productivity improvement, government policies should be carefully designed by treating different firms differently.

6. Conclusions

We have used a sample of 125,081 Chinese manufacturing firms over the period of 2001-2007 to study the impact of the availability of internal finance on firms' productivity. We have estimated a TFP model as well as a production function model augmented with cash flow. We found that Chinese firms' productivity is significantly and positively affected by the availability of internal finance. Our results were robust to the exclusion of distressed firms and to the use of alternative measures of productivity.

We have further explored the finance-productivity nexus focusing on private and foreign owned firms and taking firm heterogeneity into account. We found that the productivity of both private and foreign firms is positively related to the availability of cash flow. This suggests that both types of firms are financially constrained. Furthermore, the association between productivity and cash flow is stronger for illiquid private and foreign owned firm-years than for their more liquid counterparts. This can be explained considering that illiquid firms may be regarded by lenders as risky, and may therefore find it more difficult to obtain external finance. It also suggests that firms can use their liquidity to smooth the negative effects of shocks to internal finance on their activities and, hence, their productivity.

Furthermore, contrary to private firms, foreign non-exporters display higher dependence of productivity on cash flow than exporters. This suggests that being an exporter attenuates the financing constraints faced by foreign firms, but not those of private firms. This contrasting pattern can be explained considering that private exporters typically operate

in sectors characterized by low financial dependence, while the opposite happens for foreign exporters (Manova et al., 2009). The advantages of being an exporter in terms of giving a signal of financial solidity and being able to diversify financing sources are therefore less evident for private firms.

Our study suggests that increasing the accessibility of finance to firms could directly improve productivity at the firm level. Productivity improvement could therefore be the crucial channel through which finance development may affect growth. From a policy perspective, it will therefore be particularly effective to channel finance to those good quality firms whose productivity is highly dependent on the availability of finance. Those firms who would significantly benefit from this additional finance would be firms characterized by low levels of liquidity, private exporters, and foreign non-exporters. Hence, making finance more easily available to these firms could significantly increase firm level productivity, and support long-term economic growth.

Appendix

A.1 Levinsohn and Petrin (2003) method for TFP estimation

The following explanation draws from Levinsohn and Petrin (2003) and Petrin et al. (2004). Let us consider the following production function expressed in logarithmic form, where t indexes time:

$$y_t = \beta_0 + \beta_l l_t + \beta_k k_t + \beta_\tau \tau_t + \omega_t + \eta_t \qquad \text{(A1)}$$

There are three inputs: labor, which is freely variable (l_t); capital, which is a state variable (k_t); and another freely variable intermediate input (τ_t) (e.g. materials or energy). The error term in the production function comprises a state variable transmitted component, ω_t, which impacts on firms' decision rules, and an *i.i.d.* component, η_t, which has no impact on firms' decisions.The demand function for τ_t is given by $\tau_t = \tau_t(\omega_t, k_t)$ and must be monotonic in ω_t for all relevant k_t to qualify as valid determinants of ω_t.

Eq. (A1) suffers from endogeneity and selection problems. A firms' unobserved productivity is in fact likely to be correlated with its input decisions: productive firms tend to

input more capital and labor due to higher current and anticipated future investment opportunities. To control for endogeneity and selection biases, Olley and Pakes (1996) and Levinsohn and Petrin (2003) suggest using investment and intermediate inputs respectively to proxy for productivity. The methodologies proposed by the two studies are in line with each other. Both methods assume a monotonic relationship between the proxy variable and the true productivity shocks, and implicitly require positive investment or intermediate inputs, given that productivity shocks can hardly be negative. Hence, the Olley and Pakes' (1996) method will systematically drop observations with non-positive investment. As a significant number of Chinese firms exhibit this characteristic (Ding et al., 2010b), we choose not to use this method in this paper. On the other hand, most of our firms have positive intermediate input, such as materials and energy consumption. We therefore use the Levinsohn and Petrin (2003) estimator to calculate TFP. We estimate eq. (A1) separately by two-digit industries to allow for technological differences across industries.

Assuming monotonicity, one can invert the input demand function to obtain $\omega_t = \omega_t(\tau_t, k_t)$. The production function can then be rewritten as follows:

$$y_t = \beta_l l_t + \phi_t(\tau_t, k_t) + \eta_t \tag{A2}$$

where $\phi_t(\tau_t, k_t) = \beta_0 + \beta_k k_t + \beta_\tau \tau_t + \omega_t(\tau_t, k_t)$. To obtain consistent non-parametric estimators of the parameters in (A1), one may take the expectation of eq. (A2) conditional on τ_t and k_t. Because η_t is *i.i.d.* and independent of τ_t and k_t, and considering that $E[\phi_t(\tau_t, k_t) \mid \tau_t, k_t] = \phi_t(\tau_t, k_t)$, one gets:

$$E[y_t \mid \tau_t, k_t] = \beta_l E[l_t \mid \tau_t, k_t] + \phi_t(\tau_t, k_t) \tag{A3}$$

Subtracting (A3) from (A2) yields

$$y_t - E[y_t \mid \tau_t, k_t] = \beta_l (l_t - E[l_t \mid \tau_t, k_t]) + \eta_t \tag{A4}$$

Since η_t is *i.i.d.* and independent of l_t, OLS (restricting the intercept to be zero) can give a consistent estimate of β_l. To obtain a consistent estimate of β_k, ω_t is further assumed to follow

a first-order Markov process, and capital is assumed not to immediately respond to the productivity innovation shock ξ_t, which is given by $\xi_t = \omega_t - E[\omega_t \mid \omega_{t-1}]$.

Let us now define y_t^* as output net of labor's contribution, i.e.:

$$y_t^* = y_t - \beta_l l_t = \beta_0 + \beta_k k_t + \beta_\tau \tau_t + E[\omega_t \mid \omega_{t-1}] + \eta_t^* \tag{A5}$$

where $\eta_t^* = \xi_t + \eta_t$. The assumption $E[k_t \eta_t^*] = 0$ holds, because both ξ_t and η_t are uncorrelated with k_t. Assuming $E[\tau_{t-1} \eta_t^*] = 0$, consistent estimates of $E[\omega_t \mid \omega_{t-1}]$ and β_k can be obtained. Finally, a consistent estimate of TFP can also be obtained as the difference between actual output and estimated output.

A.2 Data

Structure of the unbalanced panel

Year	Number of observations	Percent	Cumulative
2001	37,301	6.43	6.43
2002	50,736	8.75	15.18
2003	63,219	10.90	26.09
2004	68,857	11.88	37.96
2005	125,734	21.69	59.65
2006	120,603	20.80	80.45
2007	113,345	19.55	100.00
Total	579,795	100.00	

Number of years per firm	Number of observations	Percent	Cumulative
3	237,080	40.89	40.89
4	86,712	14.96	55.85
5	67,770	11.69	67.53
6	73,632	12.70	80.23
7	114,601	19.77	100.00
Total	579,795	100.00	

Data definitions

Our variables are constructed as follows:

TFP: estimated using the Levinsohn and Petrin (2003) method, applied separately to different industrial groups, with value added as the dependent variable. The *levpet* Stata command was used in estimation,

Value added: profit and loss for the period (net income) + income tax + cost of employees (wages) + depreciation + interest paid

Labor: total number of employees

Capital stock: total tangible fixed assets

Age: current year – firm's year of establishment

Cash flow: net income + annual depreciation.

Return on sales: net income / sales

Labor productivity: real sales / number of employees

Liquidity: (current assets – current liabilities) / total assets

Deflators: taken from the *China Statistical Yearbook* (various issues), which are published by the National Bureau of Statistics of China. We use the provincial capital goods deflator to deflate the capital variable and the provincial gross domestic product (GDP) deflator to deflate other variables.

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Table 1: Descriptive statistics

	All firm-years	Private	Foreign	Diff.
	(1)	(2)	(3)	(4)
TFP	1.058 (0.794)	1.021 (0.763)	1.332 (0.782)	0.000
Y/K	2.496 (3.424)	2.469 (3.329)	2.883 (3.907)	0.000
LP	3.013 (3.194)	3.145 (3.221)	3.062 (3.239)	0.000
ROS	0.030 (0.058)	0.031 (0.051)	0.031 (0.069)	0.002
Real total assets	364.33 (621.09)	309.45 (558.02)	531.06 (729.74)	0.000
L/K	10.993 (17.416)	10.769 (16.753)	11.980 (20.192)	0.000
age	9.819 (8.939)	8.378 (7.618)	8.107 (3.929)	0.000
Exp/sales	0.161 (0.321)	0.111 (0.270)	0.451 (0.421)	0.000
CF/K	0.430 (0.670)	0.436 (0.658)	0.461 (0.727)	0.000
Percentage of observations	100%	68.1%	16.4%	

Notes This table reports the sample means. Standard deviations are presented in parentheses. *TFP* represents total factor productivity; *Y/K*, value added over total fixed tangible assets; *ROS*, return on sales (net income/sales); *LP*, labor productivity (real sales/number of employees); *L/K*, labor intensity (number of employees / real total tangible assets); *Exp/sales*, the ratio of exports over sales; *CF/K*, cash flow over total fixed tangible assets; The currency unit is thousand RMB *yuan* (the exchange rate is approximately of USD : RMB = 1:6.8). See Appendix A2 for precise definitions of all variables. Diff. is the *p*-value of the test statistic for the equality of the means of each variable between private and foreign firm-years.

Table 2: Effects of cash flow on firms' TFP — Indirect estimation

Dependent variable$_{it}$	*tfp*	*tfp*	*tfp*	*tfp*	*ROS*	*LP*
	Total sample	Private firms	Foreign firms	Total sample: Un-distressed firms only (mean(*CF/K*)>0)	Total sample	Total sample
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable$_{i,t-1}$	0.605*** (0.020)	0.607*** (0.026)	0.524*** (0.027)	0.605*** (0.020)	0.620*** (0.022)	0.871*** (0.013)
$size_{it}$	0.102*** (0.011)	0.115*** (0.015)	0.278*** (0.021)	0.102*** (0.011)	-0.003*** (0.001)	-0.019*** (0.007)
age_{it}	-0.126*** (0.009)	-0.120*** (0.014)	-0.177*** (0.021)	-0.108*** (0.009)	-0.018*** (0.001)	-0.084*** (0.007)
$(Exp/sales)_{it}$	0.282*** (0.053)	0.251*** (0.066)	0.115* (0.061)	0.277*** (0.052)	0.012** (0.005)	0.092* (0.052)
$Coast_{it}$	0.753*** (0.081)	0.731*** (0.089)	0.179 (0.175)	0.685*** (0.085)	0.066*** (0.008)	0.052 (0.053)
CF/K_{it}	0.234*** (0.026)	0.242*** (0.035)	0.235*** (0.036)	0.214*** (0.026)	0.013*** (0.002)	0.138*** (0.018)
Number of observations	525145	346549	88776	495631	586025	589183
m3(p-value)	0.885	0.244	0.130	0.668	0.720	0.616

Notes: tfp is the logarithm of *TFP*; *size* is the logarithm of firm's real total assets; *age* is the logarithm of firm's age; *Coast* is a dummy variable equal to 1 if firm *i* is located in one of the 10 coastal provinces at time *t*, and equal to 0 otherwise. *Exp/sales* is the ratio of exports over sales; and *CF/K*, cash flow over total fixed tangible assets. All specifications were estimated using a GMM system specification. The figures reported in parentheses are asymptotic standard errors. Time dummies and time dummies interacted with industry dummies were included in all specifications. Standard errors and test statistics are asymptotically robust to heteroskedasticity. Instruments in all columns include all regressors (except age) lagged three times or more. Time dummies and time dummies interacted with industry dummies were always included in the instrument set. *m3* is a test for third-order serial correlation in the first-differenced residuals, asymptotically distributed as N(0,1) under the null of no serial correlation. * indicates significance at the 10% level. ** indicates significance at the 5% level. *** indicates significance at the 1% level.

Table 3: Effects of cash flow on firms' productivity — Direct estimation

Dependent Variable: Y/K_{it}	Total sample (1)	Private firms (2)	Foreign firms (3)	Total sample: Un-distressed firms only (mean(CF/K)>0) (4)
$Y/K_{i,t-1}$	0.583*** (0.080)	0.430*** (0.076)	0.577*** (0.184)	0.573*** (0.100)
L/K_{it}	0.074*** (0.009)	0.072*** (0.010)	0.106*** (0.034)	0.073*** (0.012)
age_{it}	0.006** (0.002)	0.006 (0.004)	0.041*** (0.008)	0.006** (0.002)
$(Exp/sales)_{it}$	-0.006 (0.262)	-0.494 (0.304)	0.652 (0.545)	0.088 (0.238)
$Coast_{it}$	1.478*** (0.380)	0.775* (0.429)	0.430 (4.264)	1.322*** (0.440)
CF/K_{it}	1.001*** (0.297)	1.717*** (0.295)	1.239*** (0.468)	1.126*** (0.336)
Number of observations	579795	369739	102690	525176
m3(p-value)	0.834	0.368	0.232	0.817

Notes: *Y/K* represents value added over total fixed tangible assets; *L/K* is labor intensity (number of employees / real total tangible assets; *age* is the logarithm of firm's age; *Coast* is a dummy variable equal to 1 if firm *i* is located in one of the 10 coastal provinces at time *t*, and equal to 0 otherwise. *Exp/sales* is the ratio of exports over sales; and *CF/K*, cash flow over total fixed tangible assets. All specifications were estimated using a GMM system specification. The figures reported in parentheses are asymptotic standard errors. Time dummies and time dummies interacted with industry dummies were included in all specifications. Standard errors and test statistics are asymptotically robust to heteroskedasticity. Instruments in all columns include all regressors (except age) lagged three times or more. Time dummies and time dummies interacted with industry dummies were always included in the instrument set. *m3* is a test for third-order serial correlation in the first-differenced residuals, asymptotically distributed as N(0,1) under the null of no serial correlation. * indicates significance at the 10% level. ** indicates significance at the 5% level. *** indicates significance at the 1% level.

Table 4: Descriptive statistics for various categories of private firms

	Liquidity			Exporter		
	>0	<=0	Diff.	yes	no	Diff.
	(1)	(2)	(3)	(4)	(5)	(6)
TFP	1.094 (0.741)	0.910 (0.722)	0.000	1.139 (0.716)	0.985 (0.742)	0.000
Y/K	3.039 (3.789)	1.621 (2.020)	0.000	2.739 (3.403)	2.383 (3.221)	0.000
LP	3.297 (3.245)	2.858 (2.020)	0.000	2.673 (2.656)	3.247 (3.231)	0.000
ROS	0.038 (0.047)	0.022 (0.044)	0.000	0.030 (0.043)	0.032 (0.047)	0.000
Real total assets	277.33 (479.13)	306.11 (483.38)	0.000	393.54 (629.71)	259.05 (424.32)	0.000
L/K	12.679 (18.686)	7.804 (11.528)	0.000	12.958 (18.744)	10.050 (15.523)	0.000
age	8.100 (6.543)	8.089 (7.218)	0.642	8.358 (6.783)	8.020 (6.836)	0.000
Exp/sales	0.107 (0.267)	0.120 (0.278)	0.000	0.504 (0.366)	0.000 (0.000)	0.000
CF/K_{it}	0.550 (0.733)	0.266 (0.422)	0.000	0.415 (0.587)	0.440 (0.655)	0.000
Percentage of observations %	59.5%	40.6%		22.3%	77.7%	

Notes: Liquidity is defined as the ratio: (current assets – current liabilities) / total assets. Diff. is the *p*-value of the test statistic for the equality of means. Also see *Notes* to table 1.

Table 5a: Differential effects of cash flow on various categories of private firms' TFP — Indirect estimation

Dependent Variable: tfp_{it}	All private firm-years (1)	<=/>0 liquidity (2)	exporters/ non-exporters (3)
$tfp_{i,t-1}$	0.607*** (0.026)	0.613*** (0.022)	0.621*** (0.025)
$size_{it}$	0.115*** (0.015)	0.110*** (0.012)	0.105*** (0.014)
age_{it}	-0.120*** (0.014)	-0.125*** (0.014)	-0.102*** (0.013)
$(Exp/sales)_{it}$	0.251*** (0.066)	0.239*** (0.057)	0.205*** (0.072)
$Coast_{it}$	0.731*** (0.089)	0.719*** (0.086)	0.476*** (0.072)
CF/K_{it}	0.242*** (0.035)		
$CF/K_{it} \times Type1$		0.372*** (0.060)	0.464*** (0.067)
$CF/K_{it} \times (1-Type1)$		0.213*** (0.030)	0.222*** (0.035)
Number of observations	346549	346549	346549
χ^2 *(p-value)*		0.008	0.000
m3 (p-value)	0.244	0.261	0.294

Notes: *Type1* indicates firm-years with non-positive liquidity in column 2, and exporters in column 3. χ^2 tests the null hypothesis H_0: $CF/K_{it} \times Type1 = CF/K_{it} \times (1-Type1)$.* indicates significance at the 10% level. ** indicates significance at the 5% level. *** indicates significance at the 1% level. Also see Notes to table 2.

Table 5b: Differential effects of cash flow on various categories of private firms' productivity—Direct estimation

Dependent Variable: Y/K_{it}	All private firm-years	<=/>0 liquidity	exporters/ non-exporters
	(1)	(2)	(3)
$Y/K_{i,t-1}$	0.430*** (0.076)	0.509*** (0.107)	0.418*** (0.071)
L/K_{it}	0.072*** (0.010)	0.074*** (0.014)	0.073*** (0.009)
age_{it}	0.006 (0.004)	0.010** (0.005)	0.005 (0.004)
$(Exp/sales)_{it}$	-0.494 (0.304)	-0.916** (0.427)	-0.530 (0.330)
$Coast_{it}$	0.775* (0.429)	0.632 (0.607)	0.563 (0.448)
CF/K_{it}	1.717*** (0.295)		
$CF/K_{it} \times Type1$		2.274*** (0.541)	2.206*** (0.399)
$CF/K_{it} \times (1-Type1)$		1.432*** (0.402)	1.738*** (0.275)
Number of observations	369739	369739	369739
χ^2 *(p-value)*		0.178	0.156
m3 (p-value)	0.368	0.489	0.355

Notes: *Type1* indicates firm-years which are non-exporters in column 2, and exporters in column 3. χ^2 tests the null hypothesis H_0: $CF/K_{it} \times Type1 = CF/K_{it} \times (1-Type1)$.* indicates significance at the 10% level. ** indicates significance at the 5% level. *** indicates significance at the 1% level. Also see Notes to table 3.

Table 6: Descriptive statistics for various categories of foreign firms

	Liquidity			Exporters		
	>0	<=0	Diff.	yes	no	Diff.
	(1)	(2)	(3)	(4)	(5)	(6)
TFP	1.481 (0.819)	1.214 (0.807)	0.000	1.430 (0.805)	1.396 (0.860)	0.000
Y/K	3.273 (4.234)	1.712 (2.573)	0.000	2.995 (3.918)	2.740 (4.061)	0.000
LP	3.641 (4.208)	3.063 (3.677)	0.000	3.146 (3.776)	4.238 (4.596)	0.000
ROS	0.043 (0.070)	0.012 (0.074)	0.000	0.033 (0.071)	0.041 (0.075)	0.000
Real total assets	578.22 (806.76)	668.49 (920.12)	0.000	628.62 (862.95)	539.62 (773.02)	0.000
L/K	11.976 (19.394)	7.978 (14.363)	0.000	12.292 (19.694)	8.531 (15.243)	0.000
age	8.133 (3.698)	7.338 (3.564)	0.000	8.193 (3.704)	7.453 (3.589)	0.000
Exp/sales	0.440 (0.419)	0.427 (0.418)	0.000	0.653 (0.348)	0.000 (0.000)	0.000
CF/K	0.585 (0.902)	0.226 (0.475)	0.000	0.478 (0.798)	0.550 (0.908)	0.000
Percentage of observations	76.8%	23.2%		66.9%	33.1%	

Notes: Liquidity is defined as the ratio: (current assets – current liabilities) / total assets. Diff. is the *p*-value of the test statistic for the equality of means. Also see *Notes* to table 1.

Table 7a: Differential effects of cash flow on various categories of foreign firms' TFP — Indirect estimation

Dependent Variable: tfp_{it}	All foreign firm-years	<=/>0 liquidity	exporters/ non-exporters
	(1)	(2)	(3)
$tfp_{i,t-1}$	0.524*** (0.027)	0.513*** (0.028)	0.530*** (0.027)
$size_{it}$	0.278*** (0.021)	0.281*** (0.022)	0.282*** (0.022)
age_{it}	-0.177*** (0.021)	-0.167*** (0.021)	-0.182*** (0.020)
$(Exp/sales)_{it}$	0.115* (0.061)	0.132** (0.062)	0.160** (0.065)
$Coast_{it}$	0.179 (0.175)	0.187 (0.176)	0.149 (0.178)
CF/K_{it}	0.235*** (0.036)		
$CF/K_{it} \times Type1$		0.466*** (0.115)	0.171*** (0.034)
$CF/K_{it} \times (1-Type1)$		0.211*** (0.034)	0.272*** (0.044)
Number of observations	88776	88776	88776
χ^2 *(p-value)*		0.025	0.030
m3 (p-value)	0.130	0.144	0.151

Notes: *Type1* indicates firm-years with negative liquidity in column 2, and exporters in column 3. χ^2 tests the null hypothesis H_0: $CF/K_{it} \times Type1 = CF/K_{it} \times (1-Type1)$.* indicates significance at the 10% level. ** indicates significance at the 5% level. *** indicates significance at the 1% level. Also see Notes to table 2.

Table 7b: Differential Effect of cash flow on various categories of foreign firms' productivity—Direct estimation

Dependent Variable: Y/K_{it}	All foreign firm-years	<=/>0 liquidity	exporters/ non-exporters
	(1)	(2)	(3)
$Y/K_{i,t-1}$	0.577*** (0.184)	0.482*** (0.143)	0.481*** (0.147)
L/K_{it}	0.106*** (0.034)	0.112*** (0.026)	0.111*** (0.028)
age_{it}	0.041*** (0.008)	0.041*** (0.007)	0.041*** (0.007)
$(Exp/sales)_{it}$	0.652 (0.545)	0.421 (0.417)	0.694 (0.516)
$Coast_{it}$	0.430 (4.264)	1.338 (3.670)	-0.321 (3.411)
CF/K_{it}	1.239*** (0.468)		
$CF/K_{it} \times Type1$		2.829*** (1.051)	1.232*** (0.462)
$CF/K_{it} \times (1-Type1)$		1.539*** (0.408)	2.043*** (0.362)
Number of observations	102690	102690	102690
χ^2 *(p-value)*		0.319	0.018
m3 (p-value)	0.232	0.250	0.591

Notes: *Type1* indicates firm-years which are non-exporters in column 2, and exporters in column 3. χ^2 tests the null hypothesis H_0: $CF/K_{it} \times Type1 = CF/K_{it} \times (1-Type1)$.* indicates significance at the 10% level. ** indicates significance at the 5% level. *** indicates significance at the 1% level. Also see Notes to table 3.