Examining the liquidity and productivity relationship: Evidence from post-reform China

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Abstract

A loose financial policy through the provision of loans and fiscal subsidies to state-owned enterprises and households has long been practiced in China, though financial liberalization since the 1980s has revitalized banks and other institutions. By using provincial data, this paper attempts to show the relationship between liquidity and productivity in post-reform China. China's total factor productivity growth is estimated by the Malmquist index. A total of four regression models have been employed and the findings support the inverse relationship between liquidity and productivity, especially since 2008. China's loose financial policy that promoted "cash-richness" must be reexamined as excessive liquidity coexisted with decline in total factor productivity. An increase of 1% in liquidity would result in about 0.6% loss in total factor productivity due to market distortion.

Keywords: Total factor productivity, excess liquidity, subsidies, China

JEL classification: E65, G28, N25, O47, O54, P34.

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I Introduction

Despite the "Nixon-Kissinger Initiative" in 1972 that lured China to the side of the USA in the Cold War had opened a new chapter in China's economic development, China's market reform in 1978 has resulted in four decades of rapid economic growth. The large influx of foreign direct investment had enabled China to achieve the world's largest international reserve and largest global trade surplus. However, given its difference in political ideology, China's economic growth and expansion would come with its ideological influence. Through its "cheque book diplomacy", China has engaged in an expansionary policy in the international arena. Since 2014-2015, for example, the "one belt, one road" project aimed to initiate infrastructure development westward to the Euro-Asia region and other developing countries have ended up with many huge "debt traps" experienced by the recipient countries (Li, 2017a; Roland, 2017). However, China's decades of rapid growth have also exposed to numerous domestic inadequacies and problems. One problem relates to the deployment of the financial resources through provision of bank loans to state-owned enterprises (SOEs) and government subsidies to enterprises and households. The question is whether large provision of financial liquidity could promote the real economy.

There are several existing theoretical frameworks that studied the economic performance of financial resources. In the theory of the firm, the principal-agency theory studied the intrinsic interest between the shareholders and management of the corporation (Ross, 1973; Jensen and Meckling, 1976; Jensen, 1994). In financial markets, raising capital through private channels would allow firms to accumulate capital for expansion (Tobin, 1965, 1980). In developing countries, the study on shallow finance or financial repression pioneered by McKinnon (1973) and Shaw (1973) argued that the productivity of financial capital is crucial in growth and development, and it is only through a process of financial deepening that could direct financial capital to productive ends. Studies by Li and Leung (1994) and Li (1997) have considered the monetization process and financial liberalization in China's reform. Another line of theoretical development deals with the argument in "soft budget constraint" in socialist countries where provision of state subsidies to enterprises and households have resulted in massive fiscal deficits (Kornai, 1982).

The theoretical discussion in this paper relates to two strands of literature. The first concerns the possibility of excess liquidity leading to resource misallocation, while the second concentrates on the impact of resource misallocation and the possible loss in total factor productivity (TFP). The literature on excess liquidity and credit misallocation covered discussions related to banks, financial market, and business cycle. For example, Shleifer and Vishny (2010) argued that additional capital liquidity would not lead to increase in bank lending and investment. Bleck and Liu (2014) showed a crowding-out effect in a situation of excess liquidity, as credit resource would be misallocated when central bank injected excessive liquidity into the economy. While Benmelech and Bergman (2012) discussed a credit trap equilibrium which argued for the ineffectiveness of an expansionary monetary policy in stimulating investment, Li (2013, 2014, 2017b) and Li and Hazari (2015) pointed further to the theoretical potentiality of the "low interest rate trap" that led to speculation rather than investment. In the discussion on business cycles, while Eisfeld and Rampini (2005) showed the benefits of resource allocation in business cycles, Hoffmann and Schnabl (2011) argued that credit expansion in a situation of distorted capital price might cause a slump, and subsequent oscillations in the financial sector would lead to rise in risky projects. Pan *et al*. (2016) used both provincial and firm data to show that China's excess liquidity could be as high as 50%, and although it came without severe inflation, excess liquidity had resulted in credit misallocation and inefficiency between the state sector and private sector.

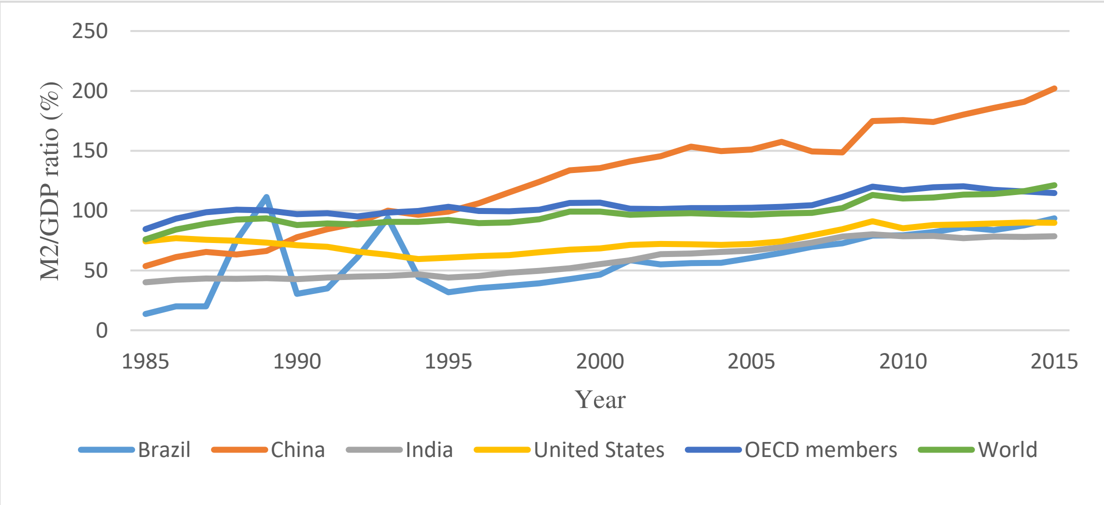
Studies on the relationship between resource misallocation and TFP included discussions on technology-skill mismatch, inefficient operation of technology and trade barrier (Acemoglu and Zilibotti, 2001; Parente and Prescott, 1999, 2000; Alcala and Ciccone, 2004). Restuccia and Regerson (2008) discussed the distortion in the cost of capital caused by imposition of tax on high productivity plants and provision of subsidies for low productivity plants. On economy-wide studies, Hsieh and Klenow (2009) benchmarked US firms to show that productivity loss in China and India amounted to 50% and 60%, respectively. Similarly, Gopinath *et al*. (2015) showed that a decrease in interest rate would lead to misallocation in capital resources. By distinguishing between domestic credit frictions and capital inflows, Reis (2013) showed that unproductive firms increased at the expense of productive firms in the non-tradable sector. Based on Asia's 1997-1998 financial turmoil, Virgiliu and Xu (2014) used producer-level data from South Korea to show that capital misallocation led to a fall of 8% in TFP.

China's loose financial policy has remained unchanged for decades and despite the enlarging market economy and financial liberalization in the 1980s and the 1995 banking reform that had opened new financial channels and institutions, state financial intervention remained crucial (Li and Liu, 2004; Li, 1999, 2009). Discussion using the excess liquidity framework could provide an additional and useful tool to analyze China's loose financial performance. By employing the concept of abundance in liquidity and shallow finance (Polleit and Gerdesmeier, 2005; Ferrero *et al*., 2010; Brana *et al*., 2012), this paper argues that despite China's rapid growth in the last few decades, China's "cash-richness" had merely led to expansion in its money supply but not in its effectiveness. This empirical study shows that China's credit misallocation hindered its total TFP growth, leading eventually to its decline. Economic centralization has meant that the state involved in all production activities. Typically, there are two sources of financial intervention. State banks and finance institutions would provide loans at ultra-low interest rate to state-owned enterprises (SOEs) to maintain production and employment, while fiscal subsidies were provided to both enterprises to maintain a low price and households to subsidize their living expenses. Despite economic reform in 1978, the adoption of a market economy and reform of banks in the 1990s, bank loans and subsidies still served as important sources of funds to state enterprises and households, especially in such economic difficult time as in 2009 when the state deployed a four trillion-yuan stimulus package after the global financial meltdown of 2008 to rescue the economy, resulting in the high M2 growth rate reaching 28% in 2009 (Li, 1994, 2017a).

Given China's decades-long practice of a loose financial policy through provision of loans and fiscal subsidies, it would be necessary to examine if such practices are producing positive economic results as the China economy is becoming more marketized, especially in the period after the 2008 world financial turmoil. China's data on outstanding loans and state subsidies can be used to examine the possibility of excess liquidity and its impact on TFP. For simplicity, excess liquidity is empirically considered when the increase in liquidity resulted in an inverse relationship with TFP growth. Section II provides the discussion on China's economic and financial data and the construction of variables for empirical analysis. Section III presents the methodology, while section IV elaborates on the empirical findings. The last section concludes the paper.

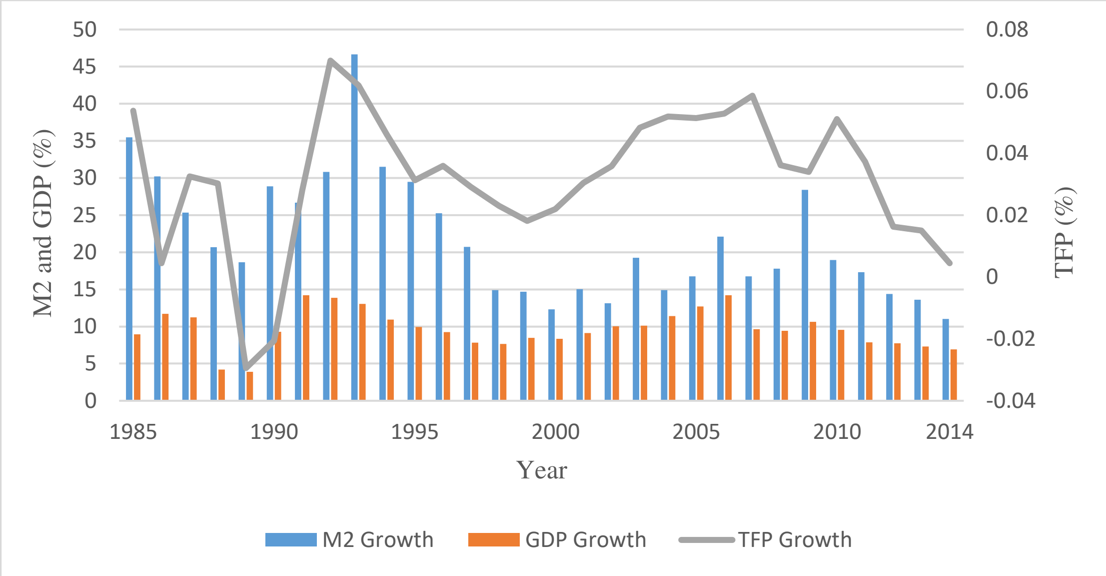
II The China Data

Data from the World Bank shown in Figure 1 for the period 1985-2015 concludes that China's M2/GDP ratio has experienced drastic increases from 50% to over 200% between 1985 and 2015. China's has a much higher M2/GDP ratio when compared to such developing countries as Brazil and India and such developed countries as the USA and other OECD countries. Indeed, China's M2/GDP ratio is nearly twice as large as that of the world average.



Source: World Bank Databank.

Fig. 1 M2/GDP ratio in selected countries: 1985 – 2015



Sources: World Bank Databank, estimates by the authors.

Fig. 2 China's annual growth rates of M2, GDP and TFP: 1985 - 2014

Similarly, China's M2 growth rate has been higher than the growth rates of GDP and total factor productivity (TFP), as shown in Figure 2. Since 2009, the average M2 growth rate has been higher than 17%. Both GDP and TFP growth rates shown in Figure 2 had declined since 2009. Such a decline has already been observed in several studies. For example, Bai *et al*. (2016) demonstrated that liquidity injection has been used in the infrastructure sector though bank loan provisions. Brandt *et al*. (2013) showed that China's loss in TFP was due to resource misallocation between state and non-state sectors, while Li (2018) showed that China's manufacturing TFP declined since 2008. Other studies on China's banking performance have shown similar conclusions (Li, 2009; Chen *et al*., 2011; Chong *et al*., 2013).

In addition to the construction of such conventional variables as physical capital, human capital and labor, additional data on subsidies, outstanding loans and several control variables are collected. The various macro-data for the 29 provinces in China that covered the period from 1984 to 2015 are obtained from the various issues of the *Statistical Yearbook of China*, the *Finance Yearbook of China*, the WIND database, the *China Compendium of Statistics* and the *Population Censuses* of 1990, 2000 and 2010. Due to insufficient data, the province of Tibet has been dropped from the sample, while the data of Chongqing was incorporated into Sichuan province after 1997.

By using the perpetual inventory approach in constructing the provincial capital stock, we followed the steps in Chow and Li (2002), Li (2003, 2009) and Liu ad Li (2012) to construct, derive and update the provincial physical capital stock to 2015. To avoid double counting on both side of the equation, we separated the loan sector from the capital stock. The capital stock so constructed thus excluded bank loans. Similarly, in constructing the human capital stock, we followed the method and steps in Li (2009) and Li and Liu (2011) that depended on the six schooling levels in China (primary, junior secondary, senior secondary, specialized secondary, vocational secondary and higher education). With the new classification of education introduced since 2004, the six schooling levels were combined into four schooling levels (primary, junior secondary, senior secondary and higher education) to calculate the human capital stock using the average schooling year per capita. The construction of human capital is based on the number of graduate students aged 15-64 in each schooling levels in 1990 as a benchmark and adjusted by provincial migration and death rate. The human capital stock is derived by the total sum of schooling year for each province. Primary and Junior Secondary require 5 and 8 years of schooling, respectively. Senior Secondary includes Specialized Secondary and Vocational Secondary in the old classification with 11 years, while Higher education with 14.5 years. The data on the number of workers is used as the labor proxy.

China's provincial data on the final account of budgetary revenue and expenditure show the provision of government subsidy expenditures to loss-making SOEs and price-subsidies to households. Subsidies to loss-making SOEs refer mainly to the financial subsidies allocated to the SOEs for them to stay in production in accordance with the state plan, but losses were incurred because the low planned price was unable to offset the cost of production including the backward technology and equipment and poor marketing strategy. For example, to maintain price stability, planned price tended to stay low and SOEs could not compete with non-state enterprises. Bank loans are effectively subsidies given to maintain production in SOEs to avoid closure and rise in unemployment, especially in sensitive industries and regions. While subsidies are sources of economic distortion, other argued that subsidies aided China's export growth (Eckaus, 2006; Grima *et al*., 2009)

The data on price subsidy to households formed the largest proportion of fiscal subsidies, especially subsidies given to agricultural produce. Price subsidies are part of the financial policy used to adjust the market price on daily necessities and agricultural produce. The price subsidy was intended to stabilize prices, regulate supply and demand, and balance the interests of producers and consumers. The sum of the Subsidies to Loss-making Enterprises and Expenditure for Price Subsidies in the 29 provinces are used as the proxy for the subsidy variable. However, due to the adjustment on the budget and final accounts of local governments in 2007, the subsidies data could only be available for the period of 1991-2006. The subsidies variable is measured by the sum of subsidies to the enterprises and household adjusted by the GDP deflator to derive the real values. We use subsidies as another input and incorporated it with capital stock, human capital and labor unit to measure the TFP growth rate by using the Malmquist index in the empirical research.

For the financial variable and since the provincial M2 data would not be available, the data on the outstanding loan to GDP would be used as a proxy to measure the liquidity (see, for example, Levine and Zervos, 1993; Caldern and Liu, 2003; Giuliano and Marta, 2009; Pan *et al*., 2016). We let the growth rate of outstanding loan over the growth rate of GDP as a measure of the liquidity ratio. In addition, we used several control variables that could affect or reflect China's TFP growth. Firstly, data on provincial patents should give an indication on the relationship between innovation and TFP growth, as studies have shown that patent played a significant role in TFP growth (Schmooker, 1963; Griliches, 1990; Dosi *et al*., 1990; Porter and Stern, 2000). The patents data are obtained from the various years of the *Patent Statistics Annual Report* published by the State Intellectual Property Office. The provincial data on the hospital bed per capita and the student-teacher ratio are used as additional control variables to measure the extent of infrastructure development (Fernald, 1999; Duggal *et al.,* 1999; Haughwout, 2003; Mitra *et al*., 2012). Finally, data on the birth rate shall show the relationship between population growth and TFP (Jones, 1995; Hall and Jones, 1999;

Afonso *et al*, 2013; Gollin and Richard, 2014). The statistical summary of variables is shown in Appendix Table 1.

III Methodology

We begin by estimating China's TFP growth rate using real GDP in each province as the output, while inputs include the constructed capital stock, human capital and labor units. The subsidy variable is then inserted as another input variable to show if subsidies affected TFP. In addition to the traditional Solow residual method in estimating the TFP (Solow, 1956), we employ the Malmquist index method to estimate China's TFP. The Malmquist index is originally used to construct the consumption quantity index before it is applied to productivity and efficiency analysis (Sten, 1953; Caves *et al.*, 1982; Charnes *et al.*, 1978, 1994). The advantage of the Malmquist index is that it does not require a priori assumption on the structure of the production function and can decompose productivity changes to allow for the existence of inefficient behavior. Furthermore, the use of the first difference method in deriving China's TFP growth using the Malmquist index would avoid possible data anomalies.

The construction of the Malmquist productivity index is based on the definition of distance function and the linear programming method is used to estimate the boundary production function of the decision-making unit (DMU). The estimated Malmquist productivity index shows effectively the TFP growth rates. In addition, the change in efficiency and technology progress is also measured during the process. Consider there are k units of DMUs, and each DMU uses n kinds of inputs x in t period, and get m kinds of outputs Y. In time t, the possible production set that satisfies certain technical constraints is represented by S:

(1) $$S^t = (\mathrm{x}, \mathrm{y}).$$

According to the definition of the distance function in Shephard (1970), the output distance function of the production possibility set S in time t relative to time $t+1$ is:

(2) $$D_O^t(x^t, y^t) = \inf\left\{\theta \middle| \left(x^t, \frac{y^t}{\theta}\right) \in S^{t+1}\right\} = (\sup\{\mathrm{z}|(x^t, zy^t) \in s^{t+1}\})^{-1},$$

where D is the distance function, the subscript "O" indicates that the distance function is based on the definition of the output, while x^t and y^t indicate the input and output at period t, respectively. Accordingly, the distance function D_O^t stands for the value of the distance function of DMU at period t in the production frontier at period t+1. At the same time, the distance function $D_O^{t+1}(x^t, y^t)$ stands for the value of the distance function of DMU at period t+1 in the production frontier at period t. The distance function $D_O^{t+1}(x^{t+1}, y^{t+1})$ stands for the value of the distance function of DMU at period t+1 in the production frontier at period t+1. The Malmquist productivity index can be expressed as:

(3) $$M_O^t = \frac{D_O^t(x^{t+1}, y^{t+1})}{D_O^t(x^t, y^t)} \ .$$

The Malmquist index measures the changes of TFP from period t to t+1 under the technical conditions in period t. Similarly, under the technical conditions of period t+1, the change of TFP from period t to t+1 can be expressed as:

(4) $$M_O^{t+1} = \frac{D_O^t(x^{t+1}, y^{t+1})}{D_O^{t+1}(x^t, y^t)}.$$

The construction of the Malmquist productivity index based on period t and t+1 is symmetrical in economic meaning. To avoid the difference caused by arbitrariness in choosing period and according to Fisher's (1922) idea of ideal index, we can define the geometric mean for the comprehensive productivity index. Next, we use two geometric means from the Malmquist productivity index to measure the change of productivity from period t to t+1, we thus have

(5) $$M_0(x^{t+1}, y^{t+1}; x^t, y^t) = (M_O^t * M_O^{t+1})^{\frac{1}{2}} = [\frac{D_O^t(x^{t+1}, y^{t+1})}{D_O^t(x^t, y^t)} * \frac{D_O^{t+1}(x^{t+1}, y^{t+1})}{D_O^{t+1}(x^t, y^t)}]^{1/2}.$$

If the index is greater than 1, it would indicate that the TFP has increased from period t to t+1 and we could thus calculate the TFP growth rate.

According to Fare (1992) and Ray and Desli (1997), the technical efficiency change in TFP can be decomposed into pure technical efficiency change and scale efficiency change, shown as:

(6) $$M_0(x^{t+1}, y^{t+1}; x^t, y^t) = TFPCH = \frac{D_O^{t+1}(x^{t+1}, y^{t+1})}{D_O^t(x^t, y^t)} * \left[\frac{D_O^t(x^{t+1}, y^{t+1})}{D_O^{t+1}(x^{t+1}, y^{t+1})} *\right.$$

$$\left[\frac{D_O^t(x^t,y^t)}{D_O^{t+1}(x^t,y^t)}\right]^{\frac{1}{2}} = \frac{D_O^{t+1}(x^{t+1},y^{t+1})_v}{D_O^t(x^t,y^t)_v} * \left[\frac{\frac{D_O^t(x^{t+1},y^{t+1})_c}{D_O^t(x^{t+1},y^{t+1})_v}}{\frac{D_O^t(x^t,y^t)_c}{D_O^t(x^t,y^t)_v}} * \frac{\frac{D_O^{t+1}(x^{t+1},y^{t+1})_c}{D_O^{t+1}(x^{t+1},y^{t+1})_v}}{\frac{D_O^{t+1}(x^t,y^t)_c}{D_O^{t+1}(x^t,y^t)_v}}\right]^{\frac{1}{2}} * \left[\frac{D_O^t(x^{t+1},y^{t+1})_v}{D_O^{t+1}(x^{t+1},y^{t+1})_v} * \frac{D_O^t(x^t,y^t)_v}{D_O^{t+1}(x^t,y^t)_v}\right]^{\frac{1}{2}}.$$

The efficiency change measures the relative technical efficiency movement under the conditions of constant return of scale from period t to t+1, capturing whether the production is catching up or getting farther away from the production possibility frontier. The value of this indicator could be greater than 1, less than 1 or equal to 1, respectively, indicating that technical efficiency has improved, reduced or remained unchanged. Technical change could be used to capture the possible movement of the production frontier while the production is assumed to be on the frontier. If the index is greater than 1, it should indicate that the technical set moved forward, while equal to 1 indicates that technology does not change, and less than 1 indicates that the technical set moved backward.[1]

In the empirical framework, we began with the pooled OLS and fixed effect regression models to test the relationship between the TFP growth rate and liquidity. By using the additional control variables, we estimate the equation as follows:

(7) $$TFP_{i,t} = \alpha_0 + \beta_1 TFP_{i,t-1} + \beta_2 LOANgdp_{i,t} + \beta_3 X_{i,t} + \mu_t + \eta_i + \varepsilon_{i,t},$$

where $TFP_{i,t-1}$ denotes the lagged value of the TFP growth rate in province *i*, $LOANgdp_{i,t}$ represents the liquidity variable, which is indicated by the growth rate of the loan over the growth rate of the GDP at time *t* in province *i*. $X_{i,t}$ (benchmark) is the control variable, which includes the number of patent, hospital bed per capita, student-teacher ratio, and the birth rate. μ_t and η_i are the province-specific fixed effect and time-fixed effect, respectively. $\varepsilon_{i,t}$ is the error term.

The regression of pooled OLS and fixed effect might not address the possible endogeneity issue. Firstly, it is plausible that the productivity growth rate would have

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[1] In the Malmquist index, the TFP change can be decomposed into technology change (TECHCH) and efficiency change (EFFCH), which could in turn be divided into pure efficiency change (PEFFCH) and scale change (SCH). We do not discuss the PEFFCH and SCH in the subsequent tables.

an impact on the growth rate of loans. For example, for some higher TFP province in China, such as Jiangsu and Shanghai, they would have more loan resources made available to stimulate economic or productivity growth, which in turn could likely affect the amount of the outstanding loan. Secondly, there may be some omitted variables in the regression model, such as the availability of province-specific resource, market segmentation and institutional factors, though province-specific fixed effect model could solve this problem. However, if the omitted variable is related to the independent variables, it would also lead to the endogeneity issue and the estimated coefficients would be biased.

To solve the problems arising from endogeneity, we improve the regression exercise by using the system-Generalized Method of Moments (GMM) as discussed in Arellano and Bond (1991). The GMM regression includes the first-differenced GMM estimation and system GMM estimation. Taking the first difference of model shown in Equation (7), we have first-differenced GMM model indicated by Equation (8),

(8) $$\Delta TFP_{i,t} = \beta_1 \Delta TFP_{i,t-1} + \beta_2 \Delta LOANgdp_{i,t} + \beta_3 \Delta X_{i,t} + \Delta \varepsilon_{i,t}$$

By differentiating the model and setting the instruments as the lagged of the variables, the first-differenced GMM estimation eliminate the unobserved cross-section individual effect and overcome the potential endogeneity problem caused by heteroscedasticity. However, Blundell and Bond (2000) argue that the estimator from the first-differenced GMM estimator could still be bias and imprecise when the instruments are weakly correlated with subsequent first differences. To solve the weak instruments problem, we used the system GMM estimation model shown in Equation (9), which applied the lagged first-difference of the series as instrument variables for the equations in levels (Arellano and Bover, 1995), shown as:

(9) $$\begin{cases} TFP_{i,t} = \beta_1 TFP_{i,t-1} + \beta_2 LOANgdp_{i,t} + \beta_3 X_{i,t} + \varepsilon_{i,t} \\ \Delta TFP_{i,t} = \beta_1 \Delta TFP_{i,t-1} + \beta_2 \Delta LOANgdp_{i,t} + \beta_3 \Delta X_{i,t} + \Delta v_{i,t}, \end{cases}$$

Blundell and Bond (1998, 2000) found that the system GMM estimation could overcome the small sample bias problem in the first-differenced GMM estimation caused by the weak instruments. The system GMM estimation used the instrument variable which is constructed appropriately by the lagged first-differences to generate the additional moment conditions, which are combined with the standard moment conditions from the first-differenced GMM estimation. This method also releases the restrictions on the distribution of the random error term and allows the random error term to have heteroscedasticity and sequence correlation. Therefore, the estimator would be unbiased and more efficient than other estimators and we applied the system GMM estimator in the empirical findings.

Other research studies argued that it is not possible to determine the functional relationship between the TFP growth rate and liquidity with specific parameter constraints (Cooper and Ross, 1998; Cao *et al.*, 2008, Bleck and Liu, 2014). Thus, the linear parametric model may run the risk of invalid parameter estimation. To ensure consistent estimates, we extend the empirical exercise by using the nonparametric regression model to study the relationship between the TFP growth rate and liquidity. The nonparametric method relaxes the restrictions on the assumptions of the distribution and the functional form. In addition, it allows the data to determine the adaptability and flexibility of the functional form (Henderson *et al.*, 2008; Li *et al.*, 2016). Hence, we have:

(10) $$TFP_{i,t} = \alpha_0 + f\ (LOANgdp_{i,t}, X_{i,t}) + \varepsilon_{i,t},$$

where $f\ (\cdot, \cdot)$ is an unknown function.

Next, we estimate model (9) by using the nonparametric local polynomial linear estimation, as in Fan and Gilbels (1992) and Ullah and Roy (1998). Suppose $y_{i,t}$ represents $TFP_{i,t}$ and $x_{i,t}$ represents $(LOANgdp_{i,t}, X_{i,t})$, then we approximate the unknown regression function $f(.,\ .)$ locally by a polynomial. For given x, we have the first-order Taylor expansion:

(11) $$y_{i,t} = \alpha_0 + f(x) + \delta(x)\left(x_{i,t} - x\right) + \varepsilon_{i,t},$$

where $\delta(x) = (\beta_1(x), \beta_2(x))$, $\beta_1(x) = \dfrac{\partial f(x)}{\partial x_1}$, $\beta_2(x) = \dfrac{\partial f(x)}{\partial x_2}$, x_1 and x_2 represent possible excess liquidity $LOANgdp_{i,t}$ and other control variables $X_{i,t}$, respectively. Then this polynomial is fitted locally by a weighted least squares regression problem:

(12) Minimize $\sum_{i=1}^{n}\sum_{t=1}^{T}\left((y_{i,t}-y_i)-\beta_0(x_{i,t}-x_i)\right)^2 k(\frac{x_{i,t}-x}{h})$.

We solve this function and calculate the nonparametric local polynomial linear estimator, shown as:

(13) $\tilde{\delta}(x)=[\sum_{i=1}^{n}\sum_{t=1}^{T}(x_{i,t}-x_i)'(x_{i,t}-x_i)k(\frac{x_{i,t}-x}{h})]^{-1}\sum_{i=1}^{n}\sum_{t=1}^{T}(x_{i,t}-x_i)'(y_{i,t}-y_i)k(\frac{x_{i,t}-x}{h})$,

where *h* is the bandwidth and *k* is the kernel function. According to model (9), we could have the estimator of the nonparametric regression,

(14) $\beta_1(x)=(1,0)'\tilde{\delta}(x),\ \beta_2(x)=(0,1)'\tilde{\delta}(x)$,

where β_1 and β_2 represent the two partial derivatives of function, $f\ (\cdot,\ \cdot)$ at $x=(x_1,x_2)$. When compared to the traditional parametric regression, the advantage of the nonparametric local polynomial linear estimation is more efficient because it avoids the bias estimation caused by the misspecification error of the model.

Lastly and as a control study, we reconstructed the work in Brandt *et al*. (2013) on the influence of excess liquidity on TFP loss. We followed the steps in Brandt *et al*. (2013) to measure the TFP loss according to resource misallocation between the state sector and non-state sector in each province：

(15) $TFP_i=[Y_{i,s}^{1-\phi}+Y_{i,n}^{1-\phi}]^{\frac{1}{1-\phi}}/(L_i^{\alpha}K_i^{1-\alpha})=[(TFP_{i,s}L_{s|i}^{\alpha}K_{s|i}^{1-\alpha})^{1-\phi}+(TFP_{i,n}L_{n|i}^{\alpha}K_{n|i}^{1-\alpha})^{1-\phi}]^{\frac{1}{1-\phi}}$,

(16) $TFP_i^*=[TFP_{i,s}^{\frac{1-\phi}{\phi}}+TFP_{i,n}^{\frac{1-\phi}{\phi}}]^{\frac{\phi}{1-\phi}}$

(17) $TFPloss_i=\ln(TFP_i^*/TFP_i)$,

where TFP_i and TFP_i^* represent respectively the actual TFP and the efficient TFP in province *i*. $Y_{i,s}$ and $Y_{i,n}$ are, respectively, the real GDP of state sector and non-state sector in province *i*. L_i and K_i represent respectively the employment and capital stock in each province *i*. $L_{s|i}$, $L_{n|i}$, $K_{s|i}$ and $K_{n|i}$ are, respectively, the share of employment and capital stock at state sector and non-state sector in province *i*. $TFP_{i,s}$ and $TFP_{i,n}$ represent, respectively, the TFP at state sector and non-state sector. ϕ^{-1} is the elasticity of the substitution, and α is the output elasticity of labor. The efficient

TFP is then the aggregate TFP after reallocating the resource to each sector and province, and the TFP share equals to the share of employment and capital stock in each sector and province. We use the province level date to construct the capital stock in each sector and province and combine with the employment and real GDP to measure the TFP loss from 1991 to 2014. As in Hsieh and Klenow (2009) and Brandt *et al*. (2013), we set the output elasticity of labor α equals to 0.67 and the elasticity of the substitution ϕ^{-1} to 1.5.

IV Empirical Results

We examine the relationship between TFP and liquidity as represented by the growth rate of loan to the growth rate of GDP ratio. The Malmquist index is used to calculate China's TFP for the period 1984-2014 using the estimated physical capital stock, human capital stock and labor. Then, we use different time periods to test the relationship between the TFP growth rate and liquidity. Next, the performance of China's provincial TFP is adjusted by using the subsidy figures for the period 1991-2006. Thus, provincial TFP growth rates with and without subsidy are presented. Lastly, by following Brandt *et al*. (2013), we measure the TFP loss with resource misallocation for the period 1991-2014 and reexamine the relationship between TFP loss and excess liquidity. In alignment with the practice in China's National Bureau of Statistics, the 29 provinces are grouped into four regions: Central (Anhui, Henan, Hubei, Hunan, Jiangxi and Shanxi), East (Beijing, Fujian, Guangdong, Hainan, Hebei, Jiangsu, Shandong, Shanghai, Tianjin and Zhejiang), Northeast (Heilongjiang, Jilin and Liaoning) and West (Gansu, Guangxi, Guizhou, Inner Mongolia, Ningxia, Qinghai, Shaanxi, Sichuan, Xinjiang and Yunnan).

Appendix Table 2 reports the four sets of findings on TFP change, efficiency change, technical change and TFP growth for the 29 provinces and the four regions in different time periods. For the period 1984-1991, China has shown a TFP growth rate of 1.41%. China's TFP growth experienced a rapid increase in the two periods of 1991-1999 and 1999-2007, especially in the Eastern region, and in such provinces as Guangdong, Jiangsu and Shandong, the TFP growth rates amounted to 9%. However, both the TFP change and TFP growth rates depended more on technical change instead of efficiency change. The situation changed after the 2008 global financial meltdown as the TFP growth rate was much lower in the period 2007-2014. Even in the Eastern region, the average TFP growth rate fell by nearly 4%, while the TFP growth rates in the other two regions fell by 1% to 2%, except for the central region. Appendix Table 3 shows the national performance for the period 1985-2014. We find that the average national TFP growth rate was around 3.58%, which gives a similar finding when compared to other studies (e.g. Chow and Li, 2002; Wu, 2011; Li, 2003, 2016). Nevertheless, the TFP growth rate declined dramatically in 2009 and in the period of 2011-2014. The decline was due not only to efficiency change, but due also to technical change.

In Appendix Table 4, we took into consideration subsidies to measure the provincial TFP change, efficiency change, technical change and TFP growth rate in the period 1991-2006 and the estimates are compared with those TFP growth rates without subsidies. The use of subsidy has always been debated as a source of economic distortion. In Communist China, subsidy provisions have been used since 1949 and SOEs and households have taken such provision for granted. Even though the findings show that the average TFP growth rate have improved in most provinces, it is interesting to note that such richer and more market-oriented coastal provinces as Guangdong, Shanghai and Jiangsu performed better with subsidies. Similarly, there are a total of 5 provinces (Heilongjiang, Henan, Hubei, Jiangxi, and Jilin) whose TFP growth rate declined with subsidies. Most of these provinces are non-coastal provinces that were less attractive to foreign investment. Among the four regions, it is only the central region which has performed slightly better in TFP growth without subsidies, while the TFP growth in all the three other regions performed weaker without subsidies. Since economic reform, it has been the remote provinces in central and western regions which have been the focus of subsidy provisions as they, unlike the coastal provinces, were unattractive to foreign investment.

The estimates of the benchmark model in Table 1 show the relationship between control variables and TFP growth rates using pooled regression, fixed effect and system-GMM methods. We find that the control variables show different degrees of significance with the TFP growth rate. The birth rate has a negative significant impact on TFP growth in all three regressions. Patent gives a negative relationship but is significant only in regression (2). The student-teacher ratio shows a positive significant impact on TFP growth in regression (1). The impact of hospital bed on TFP growth is negative but are significant in regressions (1) and (3).

Table 1 The benchmark model

	(1)	(2)	(3)
	OLS(pooled)	Fixed-Effect	SYS-GMM
VARIABLES	tfpch	tfpch	tfpch
Ltfpch	0.6103***	0.4714***	0.6055***
	(0.0259)	(0.0369)	(0.0933)
birthrate	-0.0016***	-0.0016***	-0.0014***
	(0.0002)	(0.0003)	(0.0005)
patent	-0.0000	-0.0000***	-0.0000
	(0.0000)	(0.0000)	(0.0000)
ST-ratio	0.0005**	-0.0001	0.0004
	(0.0003)	(0.0003)	(0.0006)
hospital bed	-0.0003***	-0.0001	-0.0003**
	(0.0001)	(0.0001)	(0.0001)
Constant	0.0289***	0.0330***	0.0291***
	(0.0077)	(0.0108)	(0.0104)
AR (1)			-3.64***
AR (2)			-3.46***
Sargan test			546.59***
Hansen test			27.14
Observations	841	841	841
R-squared	0.508	0.555	
Number of province	29	29	29

Notes: *** p<0.01, ** p<0.05, * p<0.1. tfpch is the TFP growth rate, Ltfpch is the lag change in the TFP growth rate, birthrate represents the birth rate, patent represents the number of patent in each province, ST-ratio and hospital bed are the student-teacher ratio and hospital bed per capita, respectively.

Table 2 reports the regression estimates on the relationship between excess liquidity and TFP growth rate. The TFP estimation based on the Malmquist method is compared to the Solow method using OLS estimation. The TFP growth rates from regression (1) to (3) are constructed by the Malmquist productivity index. Regressions (1) and (2) report the OLS estimate by using the pooled and fixed effect methods, respectively. The empirical results show a negative significant impact of excess liquidity using the loan to GDP ratio on the TFP growth rate. To deal with the endogenous problem, we use system GMM to test whether the excess liquidity would hinder real economic growth. Regression (3) shows that a 1% increase in excess liquidity leads to a decrease of 0.48% in TFP growth rate.

Table 2 Liquidity and TFP growth rates

VARIABLES	TFP growth rate (Malmquist productivity index)			TFP growth rate (Solow residual method)		
	OLS (pooled)	Fixed-Effect	SYS-GMM	OLS (pooled)	Fixed -Effect	SYS-GMM
	(1)	(2)	(3)	(4)	(5)	(6)
Ltfpch	0.6005***	0.4447***	0.5691***	0.9675***	0.9210***	0.9546***
	(0.0255)	(0.0359)	(0.0897)	(0.0077)	(0.0184)	(0.0290)
loangdp	-0.0049***	-0.0061***	-0.0048***	-0.0005***	-0.0004***	-0.0005***
	(0.0009)	(0.0009)	(0.0011)	(0.0001)	(0.0001)	(0.0001)
birthrate	-0.0015***	-0.0014***	-0.0015**	-0.0002***	-0.0002***	-0.0002***
	(0.0002)	(0.0003)	(0.0006)	(0.0000)	(0.0000)	(0.0000)
patent	-0.0000	-0.0000***	-0.0000	-0.0000	-0.0000	-0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ST-ratio	0.0006**	-0.0001	0.0005	0.0000	0.0000	0.0000
	(0.0003)	(0.0003)	(0.0011)	(0.0000)	(0.0000)	(0.0001)
hospital bed	-0.0002**	0.0001	-0.0002	-0.0000**	-0.0000**	-0.0000
	(0.0001)	(0.0001)	(0.0004)	(0.0000)	(0.0000)	(0.0000)
Constant	0.0317***	0.0290***	0.0341	0.0048***	0.0106***	0.0064**
	(0.0076)	(0.0107)	(0.0402)	(0.0008)	(0.0022)	(0.0030)
AR (1)			-3.63***			-1.78*
AR (2)			-3.16***			-2.37**
Sargan test			734.69**			828.64***
Hansen test			28.16			27.62
Observations	841	841	841	841	841	841
R-squared	0.525	0.581		0.954	0.957	
Number of province	29	29	29	29	29	29

Notes: Same as Table 1.

The results in Table 2 confirmed our hypothesis about the inverse relationship between liquidity and TFP growth rate. The injection of excessive liquidity into the economy did hurt TFP growth instead of stimulating economic growth. The result shows not only that the excess liquidity has significant negative effect on TFP growth rate in regression (1) and (2), but also that the coefficient is significant negative in the system-GMM method. However, all the control variables in the GMM estimation do not show any significant impact. The TFP growth rate from regression (4) to (6) are constructed by the Solow method. We find that the results are consistent with those using the Malmquist productivity index.

We further investigate the influence of liquidity on TFP growth rate in different time periods. Table 3 shows that the significant negative relationship between liquidity and TFP growth rate in the two periods from 1985 to 1998 and from 2010 to 2014 in regressions (1) and regression (3), respectively, while regression (2) presents the positive significant for the period from 2000 to 2008. From the data shown in Figure 2, the M2 growth rate was much lower in this period. However, after the 2008 world financial turmoil and the subsequent injection of the four-trillion rescue package in 2009, the relationship between TFP growth and liquidity showed a reverse trend. The TFP growth rate from regression (4) to (6) are constructed by the Solow residual method. The evidence clearly shows the negative and significant relationship between liquidity and TFP growth rate in regression (4) and (6). The results are also in line with our previous arguments that excess liquidity would hinder real economic growth. We do not find the obvious relationship between liquidity and TFP growth rate in the period from 2000 to 2008. Nonetheless, the result does not support the view that real economic growth could be promoted by using greater supply of liquidity.

When subsidies are incorporated in the measure of TFP growth rate, Table 4 shows a more severe negative relationship between liquidity and TFP growth. Although the result in regression (1) is not significant, the results in regressions (2) and regression (3) once again confirmed the inverse relationship between liquidity and TFP growth rate. It is worth to note that the coefficient estimates of *loangdp* in regression (3) in Table 4 is -0.0098, which shows a larger negative than the coefficient estimates in Table 2 (-

0.0048) when subsidies were not included in the TFP. In magnitude terms, Table 4 shows that an 1% increase in liquidity would lead to a further decline of TFP growth by 0.98%. One can conclude that excess liquidity has a greater negative impact on TFP growth when subsidies were incorporated.

Table 3 Liquidity and TFP growth rates: Different sample periods

VARIABLES	TFP growth rate (Malmquist productivity index)			TFP growth rate (Solow residual method)		
	1985-1998 (SYS-GMM)	2000-2008 (SYS-GMM)	2010-2014 (SYS-GMM)	1985-1999 (SYS-GMM)	2000-2008 (SYS-GMM)	2010-2014 (SYS-GMM)
	(1)	(2)	(3)	(4)	(5)	(6)
Ltfpch	0.4262***	0.7892***	0.4116***	0.9009***	0.9375***	0.9381***
	(0.0663)	(0.1178)	(0.1094)	(0.0412)	(0.0488)	(0.0650)
loangdp	-0.0120***	0.0017*	-0.0068*	-0.0010***	-0.0000	-0.0006**
	(0.0019)	(0.0010)	(0.0034)	(0.0002)	(0.0001)	(0.0002)
birthrate	-0.0014*	-0.0013**	0.0005	-0.0001	-0.0002**	0.0002
	(0.0008)	(0.0005)	(0.0011)	(0.0001)	(0.0001)	(0.0002)
patent	0.0000	-0.0000	-0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ST-ratio	0.0002	0.0005	0.0022*	0.0002	-0.0001*	0.0001
	(0.0011)	(0.0007)	(0.0012)	(0.0002)	(0.0000)	(0.0001)
hospital bed	-0.0002	-0.0002	-0.0004	0.0001	-0.0000	-0.0001*
	(0.0004)	(0.0003)	(0.0003)	(0.0001)	(0.0000)	(0.0000)
Constant	0.0488	0.0169	-0.0038	0.0022	0.0083***	0.0026
	(0.0425)	(0.0226)	(0.0218)	(0.0074)	(0.0030)	(0.0036)
AR (1)	-3.28***	-3.51***	-2.01**	-1.41	-2.55**	-1.06
AR (2)	-2.98***	1.10	-0.60	-0.97	-0.39	-1.56
Sargan test	307.27***	137.35***	42.32**	216.59*	308.83***	18.65
Hansen test	28.42	27.05	26.98	26.52	27.63	28.28
Observations	377	261	145	377	261	145
Number of province	29	29	29	29	29	29

Notes: Same as Table 1.

Table 4 Liquidity and TFP with subsidies

VARIABLES	(1) OLS(pooled) tfpch_s	(2) Fixed-Effect tfpch_s	(3) SYS-GMM tfpch_s
Ltfpch_s	0.0310	-0.1602**	0.0391
	(0.0455)	(0.0790)	(0.0402)
loangdp	-0.0123	-0.0192**	-0.0098***
	(0.0083)	(0.0076)	(0.0015)
birthrate	-0.0007	0.0112***	-0.0011
	(0.0018)	(0.0032)	(0.0010)
patent	0.0000	0.0000	0.0000***
	(0.0000)	(0.0000)	(0.0000)
ST-ratio	0.0024	-0.0002	0.0026***
	(0.0017)	(0.0022)	(0.0005)
hospital bed	0.0011	-0.0043	0.0005
	(0.0008)	(0.0046)	(0.0006)
Constant	-0.0021	0.2114	0.0029
	(0.0542)	(0.2500)	(0.0260)
AR (1)			-2.29**
AR (2)			0.42
Sargan test			248.76*
Hansen test			22.24
Observations	400	400	400
R-squared	0.020	0.211	
Number of province	29	29	29

Notes: Same as Table 1.

Table 5 Nonparametric Regression: Liquidity and TFP growth rates

VARIABLES	(1) Npregress Tfpch	(2) Npregress_FE Tfpch	(3) Npregress Tfpch_s	(4) Npregress_FE Tfpch_s
loangdp	-0.0065***	-0.0078***	-0.0481***	-0.0270***
	(0.0013)	(0.0014)	(0.0177)	(0.0086)
hospital bed	-0.0002**	-0.0003*	0.0009	-0.0002
	(0.0001)	(0.0001)	(0.0016)	(0.0008)
birthrate	-0.0035***	-0.0041***	0.0028	-0.0007
	(0.0003)	(0.0003)	(0.0037)	(0.0025)
ST-ratio	0.0020***	0.0017***	0.0000	0.0000***
	(0.0003)	(0.0003)	(0.0000)	(0.0000)
patent	0.0000	0.0000***	0.0031	0.0010
	(0.0000)	(0.0000)	(0.0027)	(0.0020)
Observations	866	866	426	426
R-squared	0.618	0.720	0.506	0.763

Notes: Same as Table 1.

Table 5 presents the results of nonparametric regression model based on model (8). The first two columns show the relationship between the TFP growth rate and liquidity. The only difference between regression (1) and regression (2) is that we incorporated fixed effect in regression (2). We could find that the coefficient estimated of liquidity is consistent with our previous parametric models with fixed effects and system GMM. A situation of excess liquidity hindered real economic growth since the coefficient of *loangdp* is negative and significant. Regression (3) and regression (4) show the relationship between liquidity and TFP growth rate with subsidies. Again, the difference between regression (3) and regression (4) is that we incorporated the fixed effect in regression (4). The results in Table 5 are consistent with those in the parametric model. In addition, the non-parametric with-subsidy regression results in Table 5 (-4.81%) shows a larger negative than the non-parametric results without subsidies (-0.65%). This evidence clearly shows that excess liquidity has a larger negative impact on TFP growth rate when subsidies were incorporated in the measure of TFP growth.

Lastly, as a control study, the regression results on the influence of excess liquidity on TFP loss as discussed in Brandt *et al*. (2013) are shown in Table 6. Among the three regression models, the GMM regression results are significant and the positive estimate confirmed that excess liquidity has a positive and significant impact on TFP loss, and an increase of 1% in excess liquidity would result in 0.6% loss in TFP due to market distortion. The estimates in Table 6 further confirmed the discussion on the inverse relationship between excessive injection of liquidity and the TFP growth rate.

Table 6 Liquidity and TFP loss

	(1)	(2)	(3)
	OLS(pooled)	Fixed-Effect	SYS-GMM
VARIABLES	tfploss	tfploss	tfploss
loangdp	0.0723	0.0147*	0.0060***
	(0.0500)	(0.0077)	(0.0009)
hospital bed	-0.0281***	-0.0044***	-0.0030*
	(0.0057)	(0.0012)	(0.0017)
birthrate	-0.0558***	-0.0621***	-0.0031
	(0.0137)	(0.0033)	(0.0022)
patent	0.0000***	-0.0000	-0.0000
	(0.0000)	(0.0000)	(0.0000)
ST-ratio	0.0640***	-0.0198***	0.0005
	(0.0146)	(0.0024)	(0.0012)
Ltfploss			0.9758***
			(0.0348)
Constant	1.3614***	1.5889***	0.1754
	(0.4205)	(0.0737)	(0.1178)
AR (1)			-1.20
AR (2)			1.20
Sargan test			458.58
Hansen test			27.36
Observations	696	696	667
R-squared	0.179	0.982	
Number of province	29	29	29

Notes: Same as Table 1. tfploss is the TFP loss between the state sector and non-state sector due to resource misallocation.

V Conclusion

In this paper, we investigated the growth rate of TFP in China from 1984 to 2014 by using province level data and the relationship between liquidity and TFP. First, we find that China's TFP growth rate experienced dramatic decrease after 2008 and when subsidies are taken into consideration in studying TFP growth rate in different provinces, the empirical results are mixed but tended to suggest that the provision of subsidies in several provinces, including those rich coastal provinces, has significant positive effect on the TFP growth rate. Several explanations could come forward. One could be that provision of subsidies has already been regarded as a norm across provinces. It could be likely that subsidy provisions supplemented household income bringing them up to the actual market situation. Similarly, subsidy to enterprises aided their low cost of production. In other words, wage and cost of production in China was low because government subsidies compromised the rest of households' wage and enterprises' cost of production. Fiscal subsidies could have distorted the market, leading foreign investors to think that cost of production in China was low.

The empirical results confirmed a situation of excess liquidity as the estimates showed a negative effect of liquidity on TFP growth rate in both the full sample and sub-samples. We also applied the provincial level data from 1991 to 2014 to measure the aggregate effect of excess liquidity and estimate its influence on TFP loss. We conclude that the increase of liquidity would lead to the TFP losses because of the resource misallocation between the state sector and non-state sector. In summary, our paper provides an empirical study showing the effect of excess liquidity on credit misallocation and decline of the TFP in China. We believe that the excess liquidity would lead to resource misallocation, which would in turn hinder TFP growth in China.

The empirical study in this paper may shed some light on the result of China's prolonged loose financial policy. Despite its decades of rapid economic growth, studies have confirmed that TFP growth has been due more to technical change probably from inward investment than to indigenous efficiency change (Li, 2009; Li and Liu, 2011; Li *et al.*, 2011). Despite its political intention in the control of the economy, this paper has shown that China's established financial policy of low cost loan provision and fiscal subsidies to enterprises and households would have backfired economically, as the excessive supply of financial fund simply led to increase in "cash-richness" rather than promoting productivity. This shall serve as a wakeup call in making an assessment to China's financial policy.

Appendix Table 1 Statistical Summary

Variable	Obs	Mean	Std. Dev.	Min	Max
real GDP	899	1588.105	2263.74	21.749	16421.6
human capital	896	5.72758	1.866406	2.19644	14.037
capital stock	899	7820.751	11735.59	109.06	88999.9
labor	899	2271.653	1619.521	169.8	6606.5
TFPgrowth	870	0.022805	0.036641	-0.03875	0.10479
loangdp	870	1.343972	0.97758	-2.79829	9.79428
hospital bed	870	32.16405	10.67947	15.8147	62.1962
birthrate	870	14.34199	4.825314	4.85	27.08
ST-ratio	870	20.20766	4.427019	9.8	32.8535
patent	870	15498.85	44103.66	0	504500

Appendix Table 2

TFP Change, Efficiency Change, Technical Change and TFP Growth for selected years by province

Province	TFP change				Efficiency Change				Technical Change				TFP Growth			
	1984-1991	1991-1999	1999-2007	2007-2014	1984-1991	1991-1999	1999-2007	2007-2014	1984-1991	1991-1999	1999-2007	2007-2014	1984-1991	1991-1999	1999-2007	2007-2014
Anhui	0.99	1.05	1.04	1.06	0.97	1.02	0.99	1.00	1.02	1.03	1.05	1.05	-1.17%	5.08%	3.60%	5.56%
Beijing	1.02	1.06	1.05	1.00	1.02	1.00	1.00	1.00	1.00	1.06	1.05	1.00	1.93%	5.93%	4.94%	-0.24%
Fujian	1.01	1.04	1.02	1.03	1.00	1.02	0.98	1.01	1.01	1.02	1.04	1.02	1.05%	4.36%	1.65%	2.80%
Gansu	1.02	1.01	1.03	1.01	1.00	0.97	0.98	1.01	1.02	1.04	1.05	1.01	1.75%	1.07%	2.75%	1.42%
Guangdong	1.06	1.07	1.07	1.01	1.00	1.00	1.00	0.99	1.05	1.07	1.07	1.02	5.71%	6.92%	7.30%	0.95%
Guangxi	1.02	1.03	1.00	0.99	1.00	1.00	0.99	0.98	1.02	1.04	1.01	1.01	2.35%	3.12%	0.06%	-1.24%
Guizhou	0.99	1.00	1.02	1.04	0.97	0.96	0.98	1.03	1.02	1.04	1.04	1.01	-0.57%	0.02%	1.57%	4.02%
Hainan	0.99	1.06	1.05	1.04	0.98	0.99	1.01	1.02	1.01	1.07	1.04	1.01	-0.56%	5.66%	4.94%	3.53%
Hebei	1.00	1.02	1.02	1.01	0.99	1.00	0.98	0.99	1.02	1.03	1.04	1.02	0.34%	2.29%	2.36%	1.46%
Heilongjiang	0.98	1.02	1.04	1.03	0.98	0.98	0.98	1.01	1.01	1.03	1.06	1.02	-1.79%	1.82%	3.75%	2.77%
Henan	1.01	1.03	1.04	1.02	1.00	1.00	0.99	0.98	1.02	1.03	1.05	1.04	1.33%	3.45%	3.54%	1.96%
Hubei	1.00	1.03	1.04	1.07	0.98	0.99	0.99	1.02	1.01	1.03	1.05	1.04	-0.16%	2.61%	4.10%	6.54%
Hunan	1.00	1.02	1.04	1.05	0.98	0.99	0.99	1.01	1.02	1.03	1.05	1.04	-0.41%	2.30%	3.53%	5.26%
lnn Mongolia	0.99	1.01	1.08	1.04	0.98	0.97	1.01	1.01	1.01	1.04	1.07	1.03	-0.67%	0.53%	7.86%	3.91%
Jiangsu	1.06	1.13	1.12	1.07	0.99	1.01	1.00	1.00	1.07	1.12	1.12	1.07	6.37%	12.83%	11.68%	6.50%
Jiangxi	1.00	1.00	1.04	1.05	0.99	0.98	0.99	1.02	1.01	1.03	1.05	1.04	-0.04%	0.47%	4.48%	5.48%
Jilin	0.98	1.02	1.02	1.00	0.97	0.98	0.98	0.99	1.01	1.04	1.04	1.01	-1.93%	1.85%	1.97%	0.00%
Liaoning	1.05	1.05	1.06	1.04	1.04	1.00	1.00	1.01	1.01	1.05	1.05	1.02	5.17%	5.03%	5.62%	3.80%
Ningxia	1.01	1.00	0.99	0.99	1.01	0.97	0.98	1.02	1.01	1.04	1.02	0.97	1.36%	0.16%	-0.90%	-0.77%
Qinghai	1.00	1.02	0.99	0.99	1.00	0.99	0.98	1.02	1.00	1.04	1.02	0.97	0.09%	2.37%	-0.64%	-0.84%
Shaanxi	1.02	1.04	1.05	1.05	1.01	1.00	0.99	1.03	1.01	1.04	1.06	1.02	2.17%	3.73%	4.53%	4.93%
Shandong	1.07	1.11	1.08	1.04	1.03	1.00	0.99	1.00	1.04	1.11	1.09	1.04	6.72%	10.57%	8.26%	3.99%
Shanghai	1.01	1.08	1.07	1.02	1.00	1.00	1.00	1.00	1.01	1.08	1.07	1.02	1.37%	7.59%	7.22%	1.58%
Shanxi	0.97	1.04	1.07	1.03	0.96	0.99	1.01	1.00	1.00	1.05	1.06	1.03	-3.37%	4.44%	6.96%	2.77%
Sichuan	1.03	1.03	1.03	1.03	1.00	1.00	1.00	1.00	1.03	1.03	1.03	1.03	3.11%	3.05%	3.11%	3.10%
Tianjin	0.98	1.05	1.06	1.03	0.98	0.99	1.02	1.03	1.00	1.06	1.04	1.00	-2.08%	5.10%	6.25%	2.56%
Xinjiang	1.01	0.98	1.04	1.02	1.01	0.94	0.98	1.01	1.01	1.04	1.06	1.01	1.46%	-1.81%	3.82%	2.26%
Yunnan	1.03	1.00	1.01	1.02	1.01	0.97	0.96	0.98	1.01	1.04	1.06	1.04	2.74%	0.37%	1.35%	1.80%
Zhejiang	1.09	1.13	1.12	1.05	1.01	1.01	1.00	0.97	1.08	1.13	1.12	1.08	8.69%	13.38%	11.65%	4.52%
Average	1.01	1.04	1.04	1.03	1.00	0.99	0.99	1.00	1.02	1.05	1.05	1.02	1.41%	3.94%	4.39%	2.77%
By region																
Central	0.99	1.03	1.04	1.05	0.98	0.99	0.99	1.01	1.01	1.04	1.05	1.04	-0.64%	3.06%	4.37%	4.60%
East	1.03	1.07	1.07	1.03	1.00	1.00	1.00	1.00	1.03	1.07	1.07	1.03	2.96%	7.46%	6.63%	2.76%
Northeast	1.00	1.03	1.04	1.02	1.00	0.99	0.99	1.00	1.01	1.04	1.05	1.02	0.48%	2.90%	3.78%	2.19%
West	1.01	1.01	1.02	1.02	1.00	0.98	0.98	1.01	1.01	1.04	1.04	1.01	1.38%	1.26%	2.35%	1.86%

Appendix Table 3

National TFP Change, Efficiency Change, Technical Change and TFP Growth

Year	TFP Change	Efficiency Change	Technical Change	TFP Growth
1985	1.05	1.01	1.05	5.38%
1986	1.00	1.03	0.98	0.44%
1987	1.03	1.00	1.03	3.25%
1988	1.03	1.00	1.03	3.02%
1989	0.97	0.99	0.98	-2.95%
1990	0.98	0.97	1.01	-2.06%
1991	1.03	0.97	1.06	2.80%
1992	1.07	0.99	1.08	6.99%
1993	1.06	0.98	1.09	6.19%
1994	1.05	0.98	1.06	4.61%
1995	1.03	0.99	1.04	3.12%
1996	1.04	1.00	1.03	3.59%
1997	1.03	1.00	1.03	2.91%
1998	1.02	0.99	1.03	2.30%
1999	1.02	0.99	1.03	1.81%
2000	1.02	0.99	1.03	2.20%
2001	1.03	0.99	1.04	3.04%
2002	1.04	0.98	1.06	3.59%
2003	1.05	1.00	1.05	4.83%
2004	1.05	1.00	1.05	5.19%
2005	1.05	0.99	1.07	5.14%
2006	1.05	0.99	1.06	5.28%
2007	1.06	0.99	1.06	5.87%
2008	1.04	1.01	1.02	3.61%
2009	1.03	0.99	1.04	3.40%
2010	1.05	1.01	1.04	5.11%
2011	1.04	1.02	1.02	3.72%
2012	1.02	1.00	1.02	1.62%
2013	1.01	1.00	1.01	1.50%
2014	1.00	1.00	1.00	0.44%
Average	1.03	0.99	1.04	3.20%

Appendix Table 4

TFP Change, Efficiency Change, Technical Change and TFP Growth with subsidies and without subsidies in each province from 1991-2006

Province	With Subsidies				Without Subsidies			
	TFP change	Efficiency Change	Technical Change	TFP Growth	TFP change	Efficiency Change	Technical Change	TFP Growth
Anhui	1.05	1.00	1.03	4.96%	1.03	1.00	1.03	2.96%
Beijing	1.03	1.00	1.03	3.02%	1.03	1.00	1.03	2.67%
Fujian	1.16	1.00	1.02	16.25%	1.02	1.00	1.02	1.74%
Gansu	1.03	0.99	1.02	2.71%	1.01	0.99	1.02	1.24%
Guangdong	1.10	1.00	1.07	10.42%	1.07	1.00	1.07	6.64%
Guangxi	1.07	1.01	1.01	7.25%	1.00	1.00	1.01	0.29%
Guizhou	1.07	1.00	1.03	7.12%	1.01	0.97	1.03	0.66%
Hainan	1.17	0.98	1.02	16.87%	1.01	0.99	1.02	1.12%
Hebei	1.03	1.00	1.02	3.24%	1.01	1.00	1.02	1.17%
Heilongjiang	1.04	1.01	1.02	3.78%	1.03	1.01	1.02	3.40%
Henan	1.05	0.99	1.03	5.03%	1.02	1.00	1.03	2.29%
Hubei	1.02	1.00	1.02	1.60%	1.02	1.00	1.02	1.77%
Hunan	1.04	0.99	1.03	3.75%	1.02	0.99	1.03	1.78%
lnn Mongolia	1.04	1.02	1.01	4.34%	1.01	1.00	1.01	0.98%
Jiangsu	1.14	1.00	1.12	14.48%	1.12	1.00	1.12	12.27%
Jiangxi	1.01	0.99	1.02	1.01%	1.01	0.99	1.02	1.21%
Jilin	1.01	1.00	1.01	1.28%	1.01	1.00	1.01	1.32%
Liaoning	1.12	1.02	1.03	12.04%	1.04	1.01	1.03	4.29%
Ningxia	1.01	0.99	1.01	0.75%	1.00	0.99	1.01	0.19%
Qinghai	1.02	1.01	1.02	2.35%	1.02	1.00	1.02	1.65%
Shaanxi	1.04	1.01	1.02	3.82%	1.02	1.01	1.02	2.49%
Shandong	1.11	0.99	1.10	11.22%	1.10	1.00	1.10	9.71%
Shanghai	1.13	1.00	1.07	13.18%	1.07	1.00	1.07	7.13%
Shanxi	1.09	0.99	1.02	9.42%	1.02	1.00	1.02	2.24%
Sichuan	1.06	1.00	1.02	5.87%	1.02	1.00	1.02	2.26%
Tianjin	1.15	1.01	1.04	14.57%	1.04	1.01	1.04	4.33%
Xinjiang	1.05	0.98	1.01	4.63%	0.99	0.98	1.01	-0.73%
Yunnan	1.01	0.98	1.03	0.93%	1.00	0.97	1.03	-0.12%
Zhejiang	1.14	1.00	1.12	14.28%	1.13	1.01	1.12	12.69%
Average	1.07	1.00	1.03	6.90%	1.03	1.00	1.03	0.03
By region								
Central	1.04	0.99	1.02	4.30%	1.02	1.00	1.02	2.04%
East	1.12	1.00	1.06	11.75%	1.06	1.00	1.06	5.95%
Northeast	1.06	1.01	1.02	5.70%	1.03	1.01	1.02	3.00%
West	1.04	1.00	1.02	3.98%	1.01	0.99	1.02	0.89%

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