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ARTICLE

Deregulation as a source of China's economic growth

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Abstract

We develop a simple two-sector neoclassical growth model in which the upstream sector produces intermediate goods, and the downstream sector produces final goods with outputs from the upstream. While the downstream sector features perfect competition, firms in the upstream sector engage in Cournot competition and charge a markup. We show that the deregulation and the introduction of competition in the upstream goods sector not only increases the productivity in the sector but also has a substantial spillover effect on the productivity of the downstream sector and factor prices. We calibrate the model to the Chinese economy and use the calibrated model to quantitatively evaluate the extent to which the deregulation in the upstream market in China from 1998 to 2006 can account for the rapid economic growth and the high and rising returns to capital in China over the same period. Our quantitative experiments show that the deregulation in the upstream sector can account for a significant share of economic growth in China during the study period. In addition, our model delivers implications that are consistent with several other relevant observations in China during the same period.

Keywords: Deregulation; growth; the Chinese economy

1. Introduction

The Chinese economy has experienced continual deregulation and increasing market competition ever since the implementation of the "reform and open up" policy in 1978.[1] Meanwhile, China has enjoyed approximately 10% economic growth on average over the past several decades. On the other hand, economists have long argued that market competition promotes efficiency and prosperity.[2] Was deregulation and increasing market competition an important cause of China's remarkable economic growth? In this paper, we address this question and quantitatively evaluate the aggregate and growth effects of deregulation and increasing market competition in China in a dynamic general equilibrium model. We highlight the vertical structure of the Chinese economy. That is, the (highly regulated) upstream sector produces intermediate goods which are in turn used in the production of final goods in the downstream sector. In this economy of vertical structure, deregulation in the upstream sector does not only affect its own productivity but also generates a spillover effect on the downstream sector. An important goal of this paper is to quantitatively evaluate this spillover effect and its implication for the aggregate economy.

We develop a two-sector neoclassical growth model of vertical structure. In it, the upstream produces intermediate goods, and the downstream sector produces final goods using intermediate goods (i.e. the outputs from the upstream sector). While the downstream sector features perfect competition, firms in the upstream sector engage in Cournot competition and charge a markup on intermediate goods. In such a model, we show that increasing competition (due to deregulation)

in the upstream sector does not only increase the productivity of that sector but also increase the productivity of the downstream sector by lowering the price of intermediate goods.

To assess the quantitative importance of the aforementioned mechanisms, we calibrate the model to the Chinese economy and use the calibrated model to quantify the aggregate impact of deregulation in the Chinese economy over the last few decades. Since 1998, China has gradually deregulated its intermediate goods sector and the level of competition in this sector has substantially increased. Meanwhile, it is well-known that the Chinese economy has grown rapidly over the last three decades. Was the deregulation (especially in the intermediate goods market) an important cause of China's growth? To what extent can it account for the rapid growth in China's TFP from 1998 to 2006? We address these quantitative questions in a version of the model that is calibrated to match some key moments of the Chinese economy. Our quantitative experiments show that the deregulation in the intermediate goods market in China since 1998 can account for up to 18.14% of China's growth. In addition, our model can also match the high return to capital and several relevant observations during the same period.

This paper contributes to the growing literature that studies the Chinese economy using quantitative dynamic general equilibrium models.[3] We differentiate our paper from the literature by introducing a model of vertical structure and emphasizing the spillover effect from the upstream sector on the downstream sector. We find that capturing this spillover is quantitatively important for understanding the aggregate impact of deregulation and competition.

This paper is closely related to a paper by Li et al. (2015), who study the "state capitalism" in China. They also consider a vertical structure of production and study how the government (and state-owned enterprises) by monopolizing the upstream sector can extract rents from the downstream sector mainly consisting of private enterprises. However, they abstract from any dynamic issues by studying a static model.[4]

This paper is also related to the large literature that study the macro effects of monopolistic competition [examples include Bils (1987), Rotemberg and Woodford (1991, 1995), Jaimovich and Floetotto (2008)] Most studies in this literature focus on the short-term business cycle implications of monopolistic competition. We instead focus on the long-term growth effects of monopoly.

The remainder of the paper is organized as follows. Section 2 presents some important stylized facts that motivate this paper. Section 3 presents the benchmark model, and the quantitative exercises and results are presented in Section 4. Section 5 is the concluding remarks.

2. Motivating facts

2.1. Deregulation and increasing market competition

We motivate our study by first examining changes in the degree of market competition in 28 industrial sectors in China, for the period from 1998 to 2006. In Figure 1, each line represents the sectoral Herfindahl–Hirschman Index (HHI) of a specific two-digit sector, with the HHI of 1998 being normalized to 1 for all sectors.[5] Out of 28 sectors, only 4 sectors have a HHI that is greater than 1 in 2005, which means that other 24 sectors (86.7% of total) in China's economy have experienced higher degrees of market competition in 2006 compared to 1998.[6] In addition, a breakdown

The increasing market competition in China can also be confirmed by examining the changes of sectoral average markups for the period between 1998 and 2006.[7] Figure 2 plots the average markup of each sector for the period between 1998 and 2006, where each line represents a specific two-digit sector. As the figure clearly shows, all 28 sectors have experienced significant declines in average markups during the aforementioned period, which is also evidence of higher market competition in China's Economy.

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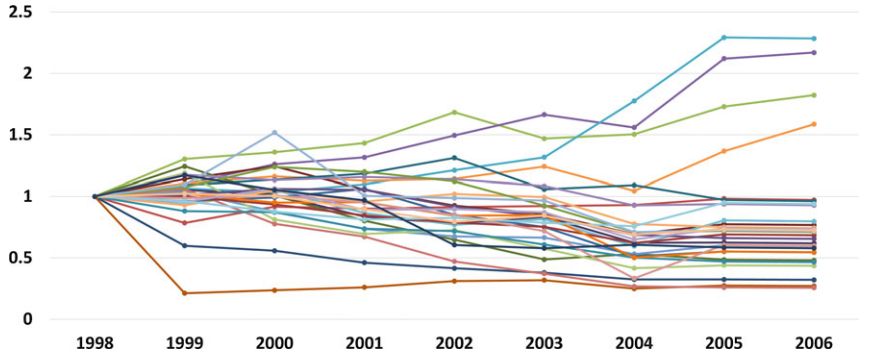

Figure 1. Deregulation in China: changes in sectoral Herfindahl–Hirschman Index.

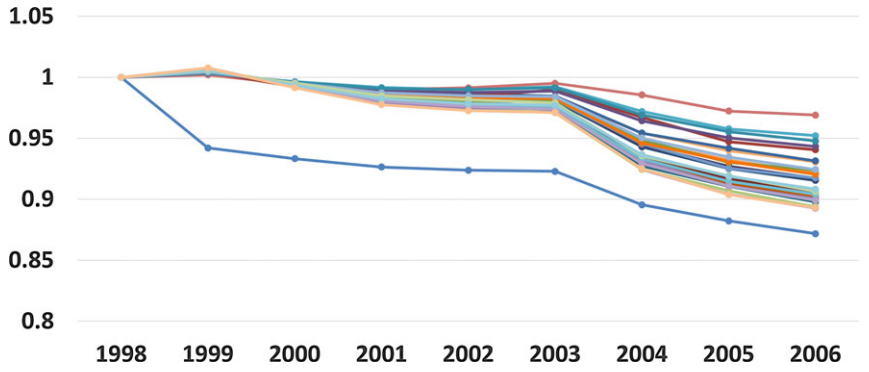

Figure 2. Deregulation in China: changes in sectoral average markups.

The findings reported in Figures 1 and 2 suggest that the degree of market competition in China's industrial sectors has substantially increased between 1998 and 2006. In the rest of the section, we examine the potential causes of this phenomenon.

2.2. The declines of SOE's share in the upstream and downstream sectors

Coincided with the increasing market competition is the substantial decline in the share of State-Owned Enterprises (SOE). As Table 1 shows, while both upstream and downstream sectors have witnessed similar large declines in SOE's share, the upstream sectors in China have noticeably higher HHI than the downstream sectors.[8] This indicates that the degree of market competition is lower in the upstream sectors.

Another interesting and important observation is that SOEs in the upstream sector on average have substantially lower productivity than non-SOEs, whereas such differences in productivity do not exist in the downstream sector. To see this, we first compute TFP at the firm level and then normalize each firm's TFP to its respective sector's median TFP. Doing so allows us to consistently compare the productivity differences between SOEs and non-SOEs across different sectors. The results are summarized in Table 2. For instance, in 1998 the SOE's TFP was 31% lower than the Non-SOE's TFP in the upstream sector while the TFPs of the SOEs and Non-SOEs are much closer to each other in the downstream sector. Similar patterns of TFPs are also observed in other years during 1998–2006.

The findings from Table 2 highlight the important differences between the upstream and downstream sectors in China.[9]

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Table 1. Share of SOE and degree of competition (weighted by revenue)

	HHI_{1998}	State $share_{1998}$	HHI_{2006}	State $share_{2006}$
Downstream	0.00294	32.0%	0.00223	2.0%
Upstream	0.00592	25.5%	0.00387	1.8%

Table 2. % Difference of SOE's TFP and non-SOE's TFP

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2006
Downstream	0.20%	−0.39%	−0.90%	−1.72%	−1.88%	−3.02%	−1.29%	−2.83%	−4.14%	−7.80%
Upstream	−31.48%	−30.73%	−33.15%	−32.00%	−31.87%	−36.60%	−23.16%	−18.64%	−24.83%	−36.48%
All Industry	−10.68%	−10.69%	−10.83%	−11.89%	−10.97%	−13.47%	−9.40%	−9.63%	−10.01%	−18.69%

Note: these numbers are referring to the TFP difference between SOE and non-SOE as a percentage of non-SOE's TFP.

2.3. Notable events leading to deregulation

Given the facts outlined in the previous sections, one might ask whether we can point to specific events or policies that were directly responsible for the deregulation in China. Although we do not believe that a single policy or event had led to all the deregulation we have outlined previously, we argue that a number of policies can be viewed as sources of deregulation. In this section, we give a brief discussion of these events or policies.

First, between 1995 and 2002, the Chinese government had attempted to reform the massive SOE sector by instituting a policy known as "Guan Ting Bing Zhuan." Quite literally, it means that the government asked a large number of SOEs to shut down, pause production, merge with other SOEs, or change production. As a result of this policy, large number of SOEs had disappeared and large number of workers had been laid off. Many believe that this reform represented a pivotal moment for SOEs' development in China.

Closely related to the "Guan Ting Bing Zhuan" reform, the Chinese government in 1997 proposed a strategy called "Zhua Da Fang Xiao," which is widely known as "grabbing the large ones and letting go the small ones." Essentially, the goal of this strategy is to correct the fact that there were too many SOEs in too many industries, which created two main problems. First, a large number of SOEs means most SOEs were small with inefficient scale of production. Second, the presence of SOEs in almost all industries reduced the level of specialization. While SOEs could play a vital role in certain industries (e.g., industries deemed "strategic"), there was no doubt that non-SOEs were more competitive in many industries (e.g., manufacturing sectors such as textile or electronics). As a response to these two problems, the Chinese government had tried to make small SOEs to either merge with other small SOEs to take advantage of scale economies or exit the industries that SOEs were not competitive.

Perhaps more on the idealogy side and less on the policy side, the National Congress of China had made an important amendment to the constitution, clearly stating that "the non-public sector is an important component of the socialist market economy" (to be added: when). Although there were no immediate policies following the amendment, this event was significant to the development of China's market economy as it provided the necessary foundation for the proliferation of the non-SOEs in China's many industries.

As a milestone of China's "reform and open up" policy, in 2001 China formally became a member of the World Trade Organization (WTO). In order to join the WTO, China had accepted a large number of conditions and promised to open its markets and reduce tariffs. It is difficult to overstate the importance of China's entry to WTO. While our paper does not specifically model this event, our results do partly capture the profound impact of China's entry into WTO on the Chinese economy.

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3. Model

3.1. Household

We consider a model inhabited with infinitely lived individuals of measure one. Time is discrete and denoted by $t \in \{0, 1, \ldots, \infty\}$. We assume that individuals are endowed with one unit of labor in each period and supply it inelastically. They make decisions of consumption and saving to maximize their lifetime discounted utility which are specified as,

$$\sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma}}{1-\sigma}$$

where β is the time discount factor.

The individual solves the following problem:

$$\max_{\{c_t, k_{t+1}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma}}{1-\sigma}$$

subject to

$$c_t + a_{t+1} = w_t + (1 + r_t)a_t + N\pi_{mt},$$

where c_t denotes consumption, a_t is asset holdings, and $N\pi_{mt}$ is the upstream firms' profits. w_t and r_t are representing wage rate and interest rate, respectively.

3.2. Production

The production side of the model features a vertical structure. That is, there are two sectors, the upstream and downstream sectors, with the upstream sector producing intermediate goods which in turn are used in the production of final goods in the downstream sector. In the following, we describe each of the two sectors respectively.

3.2.1. Downstream sector

The downstream sector is of perfect competition and features a representative firm. The downstream firm produces according to a Cobb-Douglas technology with capital, labor, and intermediate goods as its inputs, and the output can be used as either final consumption good or capital. Specifically, the representative firm solves the following profit-maximization problem:

$$\max_{K_{dt}, L_{dt}, M_t} \pi_{dt} = A_{dt}\left(K_{dt}^{\alpha} L_{dt}^{1-\alpha}\right)^{\theta} M_t^{1-\theta} - (r_t + \delta)K_{dt} - w_t L_{dt} - P_{mt} M_t,$$

where K_d and L_d are the capital and labor used in the downstream sector. Here, M is intermediate goods with P_m representing its price, and A_d is the TFP in the downstream sector.

The profit-maximizing behaviors of the firm imply that,

$$w_t = (1-\alpha)\theta A_{dt}\left(K_{dt}^{\alpha} L_{dt}^{1-\alpha}\right)^{\theta-1} M_t^{1-\theta}\left(\frac{K_{dt}}{L_{dt}}\right)^{\alpha}$$

$$r_t = \alpha\theta A_{dt}\left(K_{dt}^{\alpha} L_{dt}^{1-\alpha}\right)^{\theta-1} M_t^{1-\theta}\left(\frac{K_{dt}}{L_{dt}}\right)^{\alpha-1} - \delta$$

$$P_{mt} = (1-\theta)A_{dt}\left(K_{dt}^{\alpha} L_{dt}^{1-\alpha}\right)^{\theta} M_t^{-\theta}$$

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3.2.2. Upstream sector

To capture the highly regulated feature of China's upstream sector, we assume that the upstream sector in the model features Cournot competition.[10] Specifically, we assume that there exist N symmetric firms in the upstream sector. Each of these firms produces a homogenous intermediate good, which can be used in the production of final goods in the downstream sector.

Denote q_t as an upstream firm's output at t which is produced according to $q_t = A_{mt}k_{mt}^{\alpha}l_{mt}^{1-\alpha}$ and P_{mt} as the price of intermediate good (or the output of the upstream sector) at t. An upstream firm solves the following problem:

$$\max_{q_t} \pi_{mt} = P_{mt}q_t - (r_t + \delta)k_{imt} - w_t l_{mt},$$

with $q_t = A_{mt}k_{mt}^{\alpha}l_{mt}^{1-\alpha}$.

It is important to note that the upstream firms engage in Cournot competition when making their production decisions. That is, at each period t, upstream firms internalize the fact that its choice of q_t will impact the price of intermediate good P_{mt} and will choose q_t that maximizes its profit π_{mt}. Upstream firms' optimal choices are determined in the equilibrium, which we will discuss further at the end of this section.

3.3. Competitive equilibrium

A competitive equilibrium consists of prices $\{w_t, r_t, P_{mt}\}_{t=0}^{\infty}$ and allocations for the representative household $\{c_t, a_{t+1}\}_{t=0}^{\infty}$, for upstream firms $\{k_{mt}, l_{mt}\}_{t=0}^{\infty}$, and for the downstream firm $\{K_{dt}, L_{dt}, M_t\}_{t=0}^{\infty}$ such that:

(a) Given prices $\{w_t, r_t\}_{t=0}^{\infty}$ and dividends from the upstream firms $\{\pi_{mt}\}_{t=0}^{\infty}$, allocations $\{c_t, a_{t+1}\}_{t=0}^{\infty}$ solve the household's problem.

(b) Given prices $\{w_t, r_t, P_{mt}\}_{t=0}^{\infty}$, allocations $\{K_{dt}, L_{dt}, M_t\}_{t=0}^{\infty}$ solve the downstream firm's problem.

(c) Given prices $\{w_t, r_t\}_{t=0}^{\infty}$ and the number of upstream firms N, allocations $\{k_{m,t}, l_{m,t}\}_{t=0}^{\infty}$ solve individual upstream firms' problem.

(d) Markets clear:
Intermediate Goods Market:

$$Nq_t = M_t;$$

Labor Market:

$$1 = L_{dt} + Nl_{mt};$$

Capital Market:

$$a_t = K_{dt} + Nk_{mt}.$$

3.4. Equilibrium analysis

The detailed analysis of the upstream and downstream firms' optimization problems in the equilibrium can be found in the appendix. Their optimizing behaviors imply that in the equilibrium, the aggregate amount of labor employed in the upstream sector is given by

$$L_{mt} = \left(1 - \frac{1}{N}\right)(1 - \theta)$$

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where $L_{mt} = Nl_{mt}$, and $l_{mt} = \left(\frac{N-1}{N^2}\right)(1-\theta)$. Let Υ denote the share of aggregate labor allocated to the downstream sector. It is easy to see that $\Upsilon = 1 - L_{mt}$.

Note that a key component of the production side is the Cournot competition among N symmetric firms in the upstream sector. Here, we consider a few special cases of the Cournot competition to gain further understanding of the problem.

3.4.1. The case of pure upstream monopolist

The case of $N = 1$, which means that there exists a pure upstream monopolistic firm in the upstream firm, presents an extreme case. In this case, $L_{mt} \to 0$.[11]

3.4.2. The case of perfect competition

In the case of perfect competition in the upstream market, $N \to \infty$. In this case, $L_{mt} = 1 - \theta$. That is, in the case of perfect competition, the share of aggregate labor allocated to the upstream sector (or the intermediate goods sector) is equal to the income share of intermediate goods in the production of final goods.

3.4.3. The degree of competition in the upstream market

One common measure of the degree of competition in a given market is the HHI. It is defined as

$$HHI = \sum_{i=1}^{n} s_i^2,$$

where s_i is firm i's output share of the industry. In the case of symmetric firms as in this model, $s_i = 1/N$ for all i. Therefore, the HHI implied in the model is simply $HHI = \frac{1}{N}$.

4. Quantitative analysis

4.1. Calibration

We calibrate the model to the Chinese economy. Specifically, our calibration strategy consists of two steps. In the first step, we predetermine the values of some standard parameters based on the existing literature. In the second step, we calibrate the rest of the parameters to match key moments of the Chinese economy from 1998 to 2006. We discuss the details of our calibration strategy in the following.

One period is assumed to be one year. The utility function is assumed to take the following form: $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$ where σ is set to 2.0. The subjective time discount factor β is set to 0.95. The capital depreciation rate δ is set to 10% and the capital share α is set to 0.5 based on the estimates in Bai et al. (2006), and Song et al. (2011). The TFPs A_{mt} and A_{dt} in 1998 are normalized to one.

Our main goal is to study the impact of deregulation on the Chinese economy from 1998 to 2006. Thus, we assume that the initial steady state of the benchmark model mimics the Chinese economy in 1998 with the value of θ, which is the value-added share of the downstream sector, chosen to match its counterpart in 1998.

The key step in our calibration procedure is to obtain reasonable estimates of the level of competition in the upstream sector in 1998 as well as that in 2006. To do this, we set the value of N_{1998}, which is the number of firms in 1998 as well as the inverse of the HHI in 1998, so that the labor share of the upstream sector in the benchmark matches that in the data (0.9353). The rationale behind this calibration strategy is that this labor share is directly impacted by the level of competition in the upstream sector in the model. To be specific, as a higher level of competition will lead to higher output in the sector, the employment share of the upstream sector will also be higher.

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Table 3. Parameter values and calibration

Parameter	Description	Value
σ	Intertemporal substitution of consumption	2
α	Share of capital	0.5
$1-\theta$	Share of intermediates in final production	0.7178
δ	Depreciation	0.1
β	Time discount factor	0.95
A_{m0}	Upstream firm's TFP at $t=0$	1
A_{d0}	Downstream firm's TFP at $t=0$	1
r_{ss}	Real interest rate at steady state	19.52%
g_A	TFP growth rate from 1998 to 2006	4.12%

Table 4. Comparisons of steady state

Year	HHI	N_{ss}	$L_{m,ss}$	k_{ss}	y_{ss}	$\frac{y_{ss,2006}}{y_{ss,1998}}$
1998	0.327	3.06	0.4831	0.4743	0.3391	1
2006	0.1899	5.27	0.5815	0.8382	0.4852	1.4308

Lastly, we calculate the percentage change of HHI in China's upstream sector in the data. We then obtain the value of N_{2006}, which is the number of firms in 2006, by applying the same percentage change.

The key parameter values are summarized in Table 3.

4.2. Comparisons of steady state

A comparison of two steady states (N_{1998} and N_{2006}) is summarized in Table 4. As the table shows, the differences in the level of competition in the upstream market can lead to about 43% differences in *steady states*.

Of course, comparing steady states is somewhat misleading as China is clearly *not* on steady states. To further examine the impacts of deregulation *as well as* the importance of the vertical structure, we conduct two counterfactual exercises in which we vary upstream sector's level of competition and the structure of the model.

In order to conduct the two counterfactual exercises, we first need to derive the evolution of TFP growth between 1998 and 2006. For this purpose, we assume the following: the Chinese economy was at a steady state with $N=N_{1998}$ in 1998, and the number of firms in the upstream market increased linearly to $N=N_{2006}$ in 2006 and will remain at that level after 2006. We assume that the economy takes 50 years to transition to the new steady state. With the assumptions above, we can derive the average TFP growth rate from 1998 to 2006, which was 4.12%.

4.3. Counterfactual 1: the importance of increased competition in the upstream sector

To examine the importance of increased competition in the upstream sector, we simply run a counterfactual exercise where the only difference with the benchmark case is that the number of firms did not increase between 1998 and 2006 (and keep the evolution of TFP derived from calibration).

Comparing the evolution of real GDP between the benchmark case and the counterfactual exercise lets us examine the effect of deregulation in the upstream sector. The quantitative results

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Table 5. Comparisons of transition path

Year	Actual Change	Actual % Change	Counterfactual Change	Counterfactual % Change
1998	1		1	
2006	1.99	8.99%	1.75	7.18%

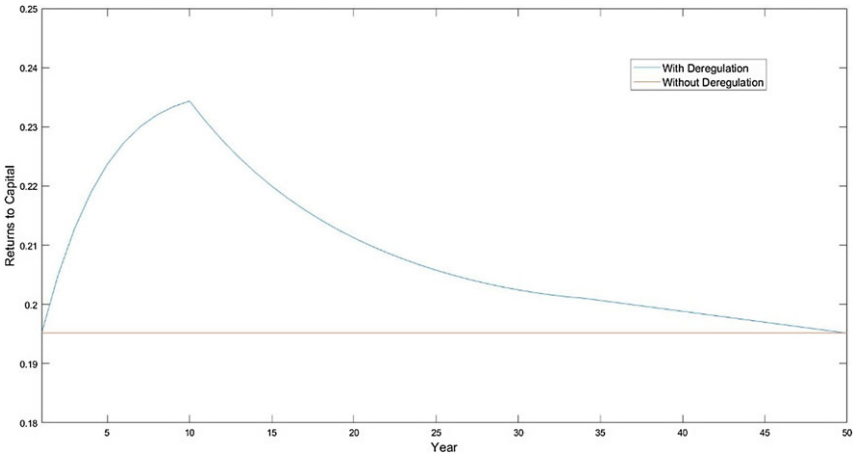

Figure 3. Returns to capital: deregulation in the upstream sector.

are included in Table 5. We can see that, assuming no changes in the upstream sector has occurred, the percentage growth rate per year has decreased from 8.99% to 7.18%, which is about 20% drop in annual growth rate. This result suggests that the increased competition in the upstream sector can account for about one-fifth of China's growth between 1998 and 2006.

4.4. China's high returns to capital

Song et al. (2011) have documented an increase of the returns in capital during the transition period of China's economy. Their paper has provided an explanation, in which the authors argue that financial frictions were the main reason that not only that returns to capital did not decrease has China accumulated more capital, but increased instead. In this paper, we provide an alternative explanation. Namely, the increase in competition in the upstream sector can sustain a period of high return to capital despite the increase in aggregate capital stock.

To see this, we compare calculate the returns to capital assuming deregulation occurred in the upstream sector. Figure 3 shows this case. If this did not happen, returns to capital in China would simply remain at a constant level.

4.5. Further discussion

Our main focus in this paper is on the role of the deregulation in upstream sectors in understanding China's growth experience, with special attention to its spillover effects on downstream sectors. To keep the model tractable, we have abstracted away from modeling some other potential drivers of economic growth during this period of time. For instance, our model cannot separately identify the effects of increased competition in downstream sectors on economic growth, as it features a perfectly competitive downstream sector. However, our model does not necessarily exclude

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these other drivers of growth that we did not specifically model. Note that our quantitative strategy assumes the residual (i.e. the part of growth cannot be accounted for by upstream deregulation) is all attributed to TFP growth. Thus, the other possible drivers we do not explicitly model, such as increased competition in downstream sectors, are implicitly captured by this residual (TFP growth), which accounts for a major share (i.e. 80%) of growth between 1998 and 2006 in our benchmark model.

One concern about our current modeling strategy is that we equally attribute the TFP change between downstream and upstream sectors, while other possible drivers of growth, such as increased competition in downstream sectors, are more likely to concentrate in the downstream sector. To address this concern, we conduct additional robustness check exercises in this section. Specifically, we consider an alternative model in which we assume that the TFP change consists of two components: (1) a component equally attributed across sectors, and (2) a component only occurring in downstream sectors to mimic the effect of increased competition in this sector. Quantitatively, we set the value of the second component of TFP change so that its effect on growth is the same as that of deregulation in the upstream sector. We then attribute the rest of growth to the first component of TFP change (the residual). Compared to our benchmark model, this alternative model features extra TFP changes in the downstream sector to capture the increased competition in it. In this alternative model, we redo the same experiments and recalculate the same statistics as in our benchmark model. We find that the effect of deregulation in upstream sectors on growth between 1998 and 2006 remains similar. In addition, the alternative model delivers similar implications for returns to capital over time.[12]

5. Conclusion

In this paper, we study a simple two-sector neoclassical growth model in which the upstream sector produces intermediate goods, and the downstream sector produces final goods with outputs from the upstream. While the downstream sector features perfect competition, firms in the upstream sector engage in Cournot competition and charge a markup. We show that the deregulation in the upstream goods sector does not only increases the productivity in the sector but also has a substantial spillover effect on the productivity of the downstream sector and factor prices. Using a version of the model calibrated to the Chinese economy, we quantitatively evaluate the extent to which the deregulation in the upstream sector in China from 1998 to 2006 can account for the rapid economic growth over the same period. We find that the deregulation in the upstream market can account for approximately 20% of China's economic growth from 1998 to 2006. In addition, our model delivers implications that are consistent with several other relevant observations in China during the same period.

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Notes

1 See Section 2.3 for a detailed description of deregulations in China in the past several decades.

2 For example, see Holmes and Schmitz (2010).

3 Song et al. (2011), Hsieh and Song (2015), Chen and Wen (2017), Imrohoroglu and Zhao (2018a, 2018b, 2020), Lee et al. (2022), and among many others.

4 Another notable paper highlighting the vertical structure in China is Cun et al. (2022), who study the macro implications of a credit expansion in a model featuring the vertical structure of production.

5 HHI is a commonly used measure for the amount of competition among firms. Please refer to Rhoades (1993) for a detailed explanation of the index.

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6 All 4 sectors with higher HHI in 2006 are down or mid-stream sectors (i.e. food processing, beverage manufacturing, textile, tobacco).
7 We calculate markup of each two-digit sector according to Lu and Yu (2016).
8 We divide the sectors into upstream and downstream according to Antras et al. (2012).
9 Such differences are also emphasized in Li et al. (2015).
10 There exists large literature on Cournot competition, including Maskin and Tirole (1987) and Allaz and Vila (1993).
11 Clearly in the case of $N = 1$, L_{mt} will be 0. This means that there is no labor employed in the upstream sector, which would in turn implies zero output in the upstream as well as the entire economy. This is an extreme case that we do not consider the subsequent analysis.
12 The detailed results from this robustness check are available from the authors upon request.

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