Dynamic Labor Demand in China: Public and Private Objectives*

Russell Cooper† and Guan Gong‡ and Ping Yan §

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Abstract

This paper studies dynamic labor demand of private and state-controlled manufacturing plants in China. A goal of the paper is to characterize adjustment costs for these plants. As our sample includes private and state-controlled plants, our analysis uncovers differences in both objectives and adjustment costs across these types of plants. We find evidence of both quadratic and firing costs at the plant level. The private plants operate with lower quadratic adjustment costs. The higher quadratic adjustment costs of the state-controlled plants may reflect their internalization of social costs of employment adjustment. State-controlled plants appear to be maximizing the discounted present value of profits without a soft-budget constraint. Private plants discount the future more than state-controlled plants.

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†Department of Economics, European University Institute and Department of Economics, University of Texas at Austin, russellcoop@gmail.com

‡School of Economics, Shanghai University of Finance and Economics

§CCER, National School of Development, Peking University

1 Motivation

This paper studies dynamic labor demand of private and state-controlled manufacturing plants in China.[1] These results can be used to study a wide variety of policy interventions, such as labor market regulations and the relaxation of financial market constraints, which impact directly on factor demand at the plant-level. To predict the effects of these and other interventions requires answers to two fundamental questions: (i) what are the adjustment costs faced by plants in China and (ii) what are the objectives of plant managers? This paper answers both of these questions.

There are a couple of features making this analysis unique. First, our attention is on plants in China rather than labor market aggregates. Second, the Chinese data include both private and state-controlled enterprises (SCE). While it is natural to assume the privately owned plants maximize profits, the objective of a SCE is less clear. Our approach is to specify a couple of alternative objectives and determine which one better matches pertinent data facts.

We estimate the costs of labor adjustment and the objectives of private plants and SCE using a simulated method of moments (SMM) approach. The idea is to use some key moments of labor input, output and productivity at the plant level to infer the parameters of the dynamic optimization problems.

In looking at the behavior of private and SCE, there are some striking similarities. First, the SCE, like the private plants, appear to be maximizing the discounted expected value of profits. Importantly, labor demand is not a static decision: adjustment costs are present and imply forward looking behavior by plants. Second, the costs of adjusting hours is relatively small for all plants though higher for private than SCEs. Third, the best fitting model entails a non-convex firing cost along with linear and quadratic adjustment costs. For both types of plants, this non-convex adjustment cost applies if job destruction rates exceed 20%.

However, there are some notable differences. The quadratic adjustment costs are much larger for the SCE, perhaps reflecting an internalized gain to employment stability. The cost of adjusting hours is also lower for the public plants.

Finally, public plants discount considerably less than do private plants. For our analysis,

[1] As discussed in section 3, a state-controlled plant is determined by sharing holdings rather than registration. We sometimes refer to these as public plants as well.

this is not an assumption but is instead a result of our estimation.

In terms of the objective of the SCE, they are best described as profit maximizers with an added quadratic cost of employment adjustment. We allow public plants to operate under a soft budget constraint where profits are non-negative. This does not improve the fit of the model.

2 Dynamic Optimization Problem

This section discusses the dynamic optimization problems for the privately owned plants and SCEs. The generic dynamic optimization problem is

$$V(A, e_{-1}) = \max_{h,e} \Gamma(A, e, h, e_{-1}) + \beta E_{A'|A} V(A', e) \tag{1}$$

for all (A, e_{-1}). Employment adjustment is assumed to be completed within a period. The function $V(A, e_{-1})$ is the value function of a plant continuing in operation.[2] The state vector contains two elements: A is stochastic profitability of the plant and e_{-1} is the stock of workers in the previous period. The control variables are the hours worked per worker, h, and the number of workers for the current period, e.

The function $\Gamma(A, e, h, e_{-1})$ represents the current payoff to the plant. Imbedded in this function are the adjustment costs as well as the objective function. Ultimately, the differences between privately owned plants and SCE are captured by this function.

2.1 Privately Owned Plant

The generic model in (1) can be tailored to study a privately-owned profit maximizing plants.[3] The objective function for a privately-owned plant is

$$\Gamma(A, e, h, e_{-1}) = R(A, e, h) - \omega(e, h) - C\left(A, e_{-1}, e, h\right). \tag{2}$$

Here $R(A, e, h)$ is the revenue flow of a plant employing e workers, each working h hours in profitability state A. The revenue function has the form

[2] At this stage, we do not consider entry and exit decisions.

[3] The model follows the approach of Cooper, Haltiwanger, and Willis (2004) study of dynamic labor demand for privately-owned US plants. A main difference emerges in modeling the behavior of the SCEs.

$$R(A, e, h) = A(eh)^{\alpha}. \tag{3}$$

This revenue function is the product of a production function, defined over the total labor input eh, and the demand curve facing the plant. The parameter α captures the curvature of the production process along with the elasticity of demand. Other factors of production, which are assumed not to entail any adjustment costs, are chosen optimally as well but are implicit in revenue and thus in the optimization problem we study.[4]

The function $\omega(e, h)$ in (2) is total compensation paid to the e workers each working h hours. The compensation function takes the form

$$\omega(e, h) = e(\omega_0 + \omega_1 h^{\zeta}). \tag{4}$$

The parameters characterizing this function will be part of our estimation.[5]

The cost of adjusting the stock of workers is given by $C(A, e_{-1}, e, h)$. Following Cooper, Haltiwanger, and Willis (2004), we consider a cost of adjustment function given by:

$$C(A, e_{-1}, e, h) = F^{+} + \gamma^{+}(e - e_{-1}) + \frac{\nu}{2}\left(\frac{e - e_{-1}}{e_{-1}}\right)^2 e_{-1} + (1 - \lambda^{+})R(A, e, h) \tag{5}$$

if there is job creation $e > e_{-1}$. Similarly

$$C(A, e_{-1}, e, h) = F^{-} + \gamma^{-}(e_{-1} - e) + \frac{\nu}{2}\left(\frac{e - e_{-1}}{e_{-1}}\right)^2 e_{-1} + (1 - \lambda^{-})R(A, e, h) \tag{6}$$

if there is job destruction $e < e_{-1}$.

If $e = e_{-1}$, so there are no *net* changes in employment, then $C(A, e_{-1}, e, h) \equiv 0$. This specification assumes that there are no costs of filling a vacancy created by a quit. Put

[4] That is, one can think of $R(A, e, h)$ as the revenue obtained less the costs of the other inputs. Since the quantities of those other inputs are dependent on (A, e, h), the $R(A, e, h)$ captures these choices. The functional form in (3) can be derived from a plant optimization problem over flexible factors with a constant returns to scale technology and a constant elasticity demand curve for plant output.

[5] This functional form is often used to characterize compensation, including overtime, in US data. The Chinese Labor Law enacted in 1995 stipulates that employees work no more than 8 hours per day, and no more than 44 hours per week. In addition, overtime hourly pay needs to be no less than: 1.5 times straight-hour pay on weekdays; 2 times on Saturday and Sunday; 3 times on national holidays. The functional form provides a smooth approximation to these requirements. For further discussion of compensation functions and their representation see Bils (1987).

differently, the adjustment costs are on net not gross employment changes. This assumption is consistent with the observation of zero net employment changes at a significant fraction of plants.

There are four forms of adjustment costs, with differences allowed for the job creation and job destruction margins. The first is a quadratic adjustment cost, parameterized by ν. There are two types of non-convex costs considered. One, parameterized by λ is an opportunity cost of adjustment: the plant losses a fraction $(1-\lambda)$ of its revenues when it adjusts its labor force. A second, parameterized by F, is a more traditional fixed cost of adjusting the work force. In previous work on labor adjustment, Cooper, Haltiwanger, and Willis (2004) found evidence in U.S. plants in favor of the opportunity cost model relative to the fixed cost form of non-convex adjustment costs. Finally, we allow linear adjustment costs, parameterized by γ to capture, for example, severance payments to workers. Here we will study how well each of them matches key features of the data.

In addition to the differences in adjustment costs of hiring and firing workers, this study adds another feature: the use of thresholds for the non-convex adjustment costs. So, as a leading example, the fixed cost of firing (F^{-}) may apply only if the job destruction rate exceeds a bound. Through this modification of (6), we are able to capture certain institutional features that may generate nonlinearities in adjustment costs.

The optimization generates choices along a couple of dimensions. First there is the discrete choices of job creation, job destruction or inaction. The latter is an important option given plant-level observations of no net employment changes. Second, there is the continuous choice of job creation (destruction). If the job creation (destruction) rates exceed the threshold, additional non-convex adjustment costs might apply. Third, there is the adjustment of hours. Variations in hours will reflect both the state of profitability and the choices on the extensive and intensive employment margins. If there is an opportunity cost of employment adjustment, so that either $(1-\lambda^{-})<1$ or $(1-\lambda^{+})<1$, then the decreased productivity will also affect the hours choice.

2.2 State-Controlled Enterprise

The dynamic optimization problem for a SCE is potentially different from (1). The idea is to infer the objectives of these enterprises from their actions.[6]

The key difference we highlight is in the objective function of the SCE. In general, the objective of the SCE is given by:

$$\Gamma(A, e, h, e_{-1}) + S(A, e, h, e_{-1}) \tag{7}$$

Here $\Gamma(A, e, h, e_{-1})$ is the same as in (2). Profits are here both because a SCE could be interested in maximizing profit and also because tax revenues flow to state and local governments. The second term in the objective function, $S(A, e, h, e_{-1})$, covers objectives of the SCE beyond profit maximization.

We consider a couple of models of $S(A, e, h, e_{-1})$. The first, termed the "employment stabilizer", asserts that the SCE is interested in employment stability. Thus there is an additional cost, beyond the adjustment cost already included in $\Gamma(A, e, h, e_{-1})$ of employment variability. In this case,

$$S(A, e, h, e_{-1}) = -\frac{\nu^S}{2}\left(\frac{e - e_{-1}}{e_{-1}}\right)^2 e_{-1}. \tag{8}$$

In this specification, the cost of employment adjustment is parameterized by ν^S. This term is exactly like the quadratic adjustment cost term already included in $\Gamma(A, e, h, e_{-1})$ through $C(A, e, e_{-1})$. Hence the quadratic cost of adjustment for a SCE is straightforward to estimate and compare to the adjustment costs for private plants.

A second model, termed the "job creator" adds a benefit of job creation to the SCE's objective function and penalizes the SCE for job losses. In this case,

$$S(A, e, h, e_{-1}) = \tilde{F}^+ \tag{9}$$

when $e > e_{-1}$ and

$$S(A, e, h, e_{-1}) = \tilde{F}^- \tag{10}$$

[6] A similar approach underlies Gowrisankaran and Town (1997) who study the behavior of not-for-profit hospitals, and estimate an objective function which includes both profits and quality. Sapienza (2002) studies public and private banks in Italy.

when $e < e_{-1}$. If there are gains to job creation and costs to destruction, we would expect: $\tilde{F}^{+} > 0$ along with $\tilde{F}^{-} < 0$.

In many descriptions of SCE, the theme of a "soft budget constraint" arises. One interpretation of this is that by following other objectives, imbedded in $S(\cdot)$, the SCE may in fact operate in a non-profitable fashion.[7] In that case, the government may provide a subsidy.

We model this by assuming that the first term in the objective function (1) is given by

$$\tilde{\Gamma}(A, e, h, e_{-1}) = max\{0, \Gamma(A, e, h, e_{-1})\} \tag{11}$$

where $\Gamma(A, e, h, e_{-1})$ is defined in (2). With this subsidization, the SCE can undertake other objectives, such as employment stability, without incurring sustained losses. Further, under this objective, the SCE has no incentive to exit.

Finally, we estimate the discount factor for both private plants and SCEs. As suggested by Cull and Xu (2005), it might be that SCEs operate with subsidized loans, from banks and the government, which leads to them to discount less than private plants. This is potentially a very interesting and important difference between plants.

Our approach is to estimate the parameters for these specification of the SCE objective. In some cases, we use the estimates from the profit maximizing plants to create a baseline and to attribute SCE patterns of dynamic labor demand that differ from those of private profit maximizing plants to these difference in objectives.

3 Data

The data are from Annual Surveys of Industrial Production (1998-2007), conducted by the National Bureau of Statistics (NBS) of China. The raw data consist of all private plants with more than five million Yuan in revenue (about \$700,000) and all public plants.[8]

[7] This draws upon the discussion of soft budget constraints in Lin and Li (2008). In that analysis, the state imposes a "policy burden" on a SCE, such as employment stability, and must support the SCE in order for it to remain in operation.

[8] Each observation in the raw data has a unique physical address. For example, in 2006, 17 observations in 17 different locations, share the brand name of one of the biggest dairy product makers, Mengniu. Brandt, Biesebroeck, and Zhang (2009) study productivity at the firm level over the 1998-2006 period. The data are similar though since they note that about 95% of the firms own a single plant. From Brandt, Biesebroeck, and Zhang (2009), the cut-off on private plants of five million Yuan in revenues is likely to eliminate less

The number of plants grows from over 160,000 in 1998 to above 330,000 in 2007. Since there are numerous mergers, acquisitions, entry and exit, and public-to-private transformations before 2005, we focus on a balanced panel of plants excluded from the above changes and in operation during the period 2005-2007.[9] Another reason to look at the data after 2005 is that the year 2004 is characterized by many economic policies at the macro level to curb the overheating of the economy.

The classification of the plants as public or private is an important element in our analysis. The Annual Surveys of Industrial Production has two variables defining whether an enterprise is public or private. One is "enterprise type", representing state-owned, collective, domestic private, joint venture, and foreign (including Hong Kong, Macao and Taiwan) private enterprises. State-owned means the enterprise is owned by all the people in the country, while collective means the enterprise is owned by part of the people in the country. According to the Chinese constitution, both state-owned and collective enterprises are classified as public. An enterprise is termed as a joint venture if part of its shares is owned by foreign investors or companies, no matter how big the fraction is. Enterprise type is the type that the enterprise is registered with the Administration of Business and Commerce, as well the Administration of Taxation. It does not have any information on who among shareholders makes decisions. The decision maker of a joint venture can be either public shareholders or private shareholders.

The other variable is "control of shares", representing state controlled, collectively controlled, domestically privately controlled, and foreign (including Hong Kong, Macao and Taiwan) privately controlled enterprises. "Control" means holding over 50% of total shares, or being pivotal in decision making if not holding over 50% of total shares. By this standard, a joint venture is public if it is state controlled or collectively controlled, even if it is not registered as a state-owned or collective enterprise according to the enterprise type criterion. For example, Volkswagen, Ford, and Honda in mainland China are all state-controlled joint ventures. On the other hand, in our data we do see a large fraction of enterprises that are registered as collective but are controlled by domestic private shareholders.

To make a clear distinction between public and private, we rely on the variable **control**

than 1% of the private plants. The analysis of Hsieh and Klenow (2009) covered the 1998-2005 period.

[9] This transformation in manufacturing is summarized in `http://www.carnegieendowment.org/publications/?fa=view&id=22633`.

of shares to determine the type of an enterprise. In the balanced panel we are looking at, there are 13,255 state-controlled enterprises and 14,374 collectively-controlled enterprises, both classified as public. Our private category consists of 120,719 domestically privately controlled enterprises and 35,466 foreign (including Hong Kong, Macao and Taiwan) privately controlled enterprises.

Table 1 summarizes capital, employment (number of workers employed), revenue, and value-added by enterprise type for the 2005-2007 period.[10] All monetary terms are deflated to thousand Yuan in 2005 using CPI. The survey includes a measure of plant-level "net capital" constructed using a perpetual inventory method. Hours information is not available.

The columns split the sample into public and private plants. The columns called "trimmed" are a subsample in which the top and bottom 2.5% of the plants, by employment size, are removed to deal with outliers. For the public plants, the column marked large reports statistics for this top 2.5% group. Unless stated otherwise, we will focus on the trimmed sample.

About 85% of the sample consists of private plants, most of them are domestic not foreign owned. In terms of numbers of workers (Emp.), the private plants are typically about half the size of the public plants. Yet the public plants have value added (VA) and revenue (Rev.) more than twice that of the private plants. The public plants are also considerably more capital intensive (Cap./Emp.) on average.

In terms of average revenue per worker, the public plants are more productive than the private plants on average. The foreign plants have the highest revenue per worker among private plants but this is still less than the productivity in the large public SCE. In terms of average revenue per unit of capital, the public plants are about as productive as the private ones. In fact the revenue per unit of capital is almost identical for the large public SCE and the foreign private plants.

As noted earlier, we focus on the 2005-07 period to exclude periods of substantial change in the structure and ownership of plants. For purpose of comparison, Table 2 provides similar data for public and private plants from an earlier period, 1998. In this earlier period, the fraction of public plants is 69% of the total, compared to only 15% in the later period.[11] The

[10]Because the Annual Surveys of Industrial Production is a census conducted by the NBS and not by the Administration of Taxation, we believe the information reported is unlikely to be contaminated by tax evasion incentives.

[11]This period is reflected in the discussion in Bai, Lu, and Tao (2006) which emphasized the presence of large relatively inefficient public plants.

		Public			Private			
	Total	All	Trimmed	Upper 2.5%	All	Trimmed	Domestic	Foreign
# plants	183,814	27,629	26,325	691	156,185	148,390	120,719	35,466
Value added	35,534	99,446	48,657	2,107,979	24,228	17,665	18,146	44,931
	(357,553)	(850,625)	(361,262)	(4,448,673)	(147,014)	(53,062)	(96,231)	(251,206)
Revenue	124,270	306,272	152,329	6,411,032	92,074	64,290	66,417	179,407
	(1,059,366)	(2,134,162)	(718,712)	(1.11e+7)	(712,869)	(205,842)	(356,131)	(1,340,289)
Employment	284	618	337	11,587	224	172	180	385
	(1,604)	(3,696)	(504)	(20,003)	(751)	(190)	(569)	(1,186)
Capital	46,557	186,776	89,995	4,014,534	21,752	15,397	15,362	43,502
	(686,797)	(1,726,791)	(582,536)	(9,546,431)	(153,506)	(69,207)	(124,991)	(223,570)
Cap./Emp.	125	310	242	308	92	88	80	136
	(3,528)	(8,926)	(4,757)	(741)	(636)	(430)	(422)	(1,108)
VA/Emp.	144	207	160	209	133	127	127	155
	(1,730)	(4,349)	(1,324)	(404)	(376)	(309)	(277)	(613)
VA/Cap.	5.6	6	5.4	4.5	5.5	5.3	5.6	5.3
	(96)	(118)	(109)	(145)	(92)	(89)	(80)	(125)
Rev./Emp.	504	601	508	688	487	461	467	561
	(3,708)	(7,402)	(2,261)	(1,139)	(1,166)	(1,18)	(934)	(1,769)
Rev./Cap.	23.5	24.9	22.7	20.3	23.2	22.2	24.1	20.2
	(353)	(505)	(491)	(506)	(319)	(312)	(332)	(267)

Table 1: Characteristics of Plants by type, 2005-2007 balanced panel.

All monetary terms are in 1,000 RMB, deflated to 2005 level. The trimmed sample is the public (private) sample excluding the upper and lower 2.5% tails by employment size. Standard deviations are parenthesized.

public plants in the total sample were larger than private plants in terms of value added, revenue, employment and capital. The large public enterprises were considerably larger. Productivity, measured either as the average revenue product of capital or labor was much lower in public than private plants. This is particularly true for the large SCE, which are particularly unproductive. These large differences in productivity are not apparent in the recent sample.

As we shall see as our analysis proceeds, the public plants are not that different from the private ones. Given the results in Tables 1 and 2, perhaps this reflects privatization and modernization of public plants.[12]

4 Quantitative Analysis

The estimation follows two procedures. As in Cooper and Haltiwanger (2006), some of the parameters are estimated directly from data on revenues. The remainder are obtained through a simulated method of moments approach.

4.1 Parameter Estimates of Revenue Function

Using data on revenues and the labor input at the plant level for the trimmed sample, we can estimate α from $R_{it} = A_{it}L_{it}^{\alpha}$, where L_{it} is the total labor input at plant i in period t.[13] In addition, we use these regression results to back-out the profitability shock, A_{it}, as a residual and from this we can infer the process for this shock. We then create a discrete representation of the process as an input in computing conditional expectations for the dynamic optimization problem at the plant level. This procedure is followed for both public and private plants.

The results of the IV estimation are shown in Table 3. Here α is the curvature of the revenue (profit) function and ρ is the serial correlation of the profitability shock process.[14]

[12]This is consistent with Table 3 of Brandt, Biesebroeck, and Zhang (2009) though our determination of private vs. public differs.

[13]These regressions used plant-level wages and initial capital stock to control for some of the plant-level heterogeneity. For the case of opportunity costs, the estimation included a dummy variable for employment adjustment to control for the effects of disruption costs. Those results are close to the ones reported in Table 3. The data appendix provides more detailed discussion of this estimation.

[14]Though we use only three years of data, the number of observations used to estimate the serial correlation

		Public				Private	
	Total	All	Lower 2.5%	Trimmed	Upper 2.5%	All	Trimmed
# plants	134,947	93,455	2,298	88,825	2,332	41,492	39,465
Value added	14,149	15,175	2403	8,947	264,964	11,838	9,575
	(169,708)	(200,798)	(17,605)	(37,281)	(1,224,402)	(53,371)	(27,667)
Revenue	47,385	47,960	7,940	30,383	756,879	46,091	37,056
	(326,117)	(368,715)	(47,517)	(95,051)	(2,141,935)	(199,213)	(90,883)
Employment	384	441	8.8	277	7,095	256	206
	(1,972)	(2,345)	(2.7)	(359)	(13,038)	(491)	(212)
Capital	34,533	40,818	4,117	21,432	815,391	20,379	16,470
	(397,298)	(470,763)	(47,914)	(148,461)	(2,725,265)	(117,982)	(99,387)
Cap./Emp.	92	93	1102	67	83	89	82
	(4,009)	(4,811)	(30,552)	(431)	(148)	(395)	(307)
VA/Emp.	62	59	608	46	37	69	63
	(1,751)	(2,101)	(13,348)	(163)	(106)	(193)	(145)
VA/Cap.	3.4	3.02	6.9	2.99	0.49	4.3	4.2
	(57)	(38)	(34)	(38)	(0.97)	(86)	(88)
Rev./Emp.	230	208	1,934	166	110	281	251
	(5,611)	(6,723)	(42,699)	(571)	(201)	(758)	(518)
Rev./Cap.	16.4	15.3	28.1	15.3	2.1	18.8	18.4
	(307)	(341)	(135)	(349)	(8)	(214)	(218)

Table 2: Characteristics of Plants in 1998

All monetary terms are in 1,000 RMB, deflated to 2005 level. The trimmed sample is the public (private) sample excluding the upper and lower 2.5% tails by employment size. Standard deviations are parenthesized.

The instruments for IV estimates were twice lagged inputs. The details for the IV estimates are in the Appendix.

	α	ρ
private	0.3198	0.9082
public	0.4324	0.9513

Table 3: Results from Revenue Function IV Estimation

From these results, we see that the curvature of the revenue function is larger for public plants, compared to private ones. If we impose constant returns to scale in the production function, then the curvature of the revenue function is

$$\alpha = \frac{\frac{\eta-1}{\eta}\alpha_e}{1-\frac{\eta-1}{\eta}(1-\alpha_e)} \tag{12}$$

where η is the elasticity of demand and α_e is the coefficient on the labor input in the Cobb-Douglas production function.[15] Thus differences in α must either reflect differences in the elasticity of demand or factor shares.

As noted in Table 1, private plants have a higher labor to capital ratio than the public plants. If all plants face the same factor prices, then α_e is higher for the private plants. Thus to explain the lower value of α in Table 3, η, the elasticity of demand, of the private plants must be lower. That is, private plants have more market power and thus larger markups than public plants.

Alternatively, Song, Storesletten, and Zilibotti (2009), among others, argue that public plants have easier access to capital markets. All else the same, this would translate into higher capital to labor ratios for the public plants without there being any differences in technology. Still a lower η is needed for private plants to explain the lower α.

is large since ρ is estimated from panels of private and public plants separately.

[15] As discussed in Cooper, Haltiwanger, and Willis (2004) and the related literature, α is given from the optimization over capital in the fully specified production function $\tilde{R}(A,e,h,K) = \left(\tilde{A}(eh)^{\alpha_e} K^{\alpha_K}\right)^{\frac{\eta-1}{\eta}} - rK$ where α_e and α_K are the respective labor and capital shares, η is the price elasticity of demand for the good, and r is the rental rate on capital. Maximization with respect to capital leads to the reduced form revenue function over total hours with an exponent given in (12).

Finally, from the perspective of the analysis in Hsieh and Klenow (2009), differences in capital to labor ratios may reflect different frictions in factor allocation. The higher capital to labor ratio in public sector would indicate a lower friction in capital **relative** to labor for the SCE.

The estimates in Table 3 pertain to data pooled across all sectors of the economy. Sectoral differences in technology and/or the elasticity of demand could also account for the estimates reported in Table 3.

The profitability shocks are highly serially correlated for both types of plants. The processes of the profitability shocks are stationary. Given the costs of hiring and firing workers, the serial correlation of these shocks is important for the choice between adjusting hours and the number of workers in response to variations in profitability.

The variability of the shocks to profitability are set to match the size distribution of plants in the trimmed data set. The minimum size of the plants in the private and public (trimmed) data set is about 50 workers and the largest is about 1500. The standard deviation of the shocks, along with the (ω_0, ω_1) are set to produce an employment distribution within this range and to match the median establishment size.[16]

4.2 SMM Estimation Approach

The remained parameters are estimated via SMM. This approach revolves around finding the vector of structural parameters, denoted Θ, to minimize the weighted difference between simulated and actual data moments. That is we solve $min_{\Theta}\pounds(\Theta)$ where

$$\pounds(\Theta) \equiv (M^d - M^s(\Theta))W(M^d - M^s(\Theta))'. \tag{13}$$

The weighting matrix, W, is obtained by inverting an estimate of the variance/covariance matrix obtained from bootstrapping the data. The resulting estimator is consistent.[17]

In this expression, M^d are the data moments for private and public plants, $M^s(\Theta)$ are the simulation counterparts. The moments are listed as the columns in Tables 5 and 7.

[16]For the public plants, the standard deviation of the innovation of the profitability shocks is set at 0.45, which is just about the estimate inferred from the estimation of the revenue functions. For the private plants, the standard deviation of the innovation is much larger, 0.90, in order to match the size distribution of the plants. This difference in variability of the shocks appears to stem from the lower value of α in the revenue function for the private plants.

[17]See, for example, the discussion and references in Adda and Cooper (2003).

The $std(r/e)$ is the standard deviation of the log of revenue per worker. The moment sc is the serial correlation in employment. The distribution of the job creation (JC) and job destruction (JD) as well as the inaction rate (zero net employment change) are the remaining seven moments. These are averages across plants and years. The inaction rate of nearly 40% for the private plants and 28% for the public plants motivates the inclusion of non-convex adjustment costs.

The simulated moments are obtained by solving the dynamic programming problem in (1) for a given value of Θ. The resulting decision rules are used to to simulate a panel data set. The simulated moments are calculated from that data set.[18]

The parameters estimated by SMM are $\Theta \equiv (\zeta, \nu, \lambda^+, \lambda^-, F^+, F^-, \gamma^+, \gamma^-, \beta)$.[19] The moments were selected in part because they are informative about these underlying parameters. Roughly speaking, the curvature of the compensation function is identified from the standard deviation of the log of revenue per worker.[20] An increase in ζ will lead to a larger variation in employment relative to hours and thus a reduction in this moment. The quadratic adjustment cost parameter, ν, is identified largely from variations in the serial correlation of employment and from the prevalence of employment adjustments in the 10% range. The distribution of employment changes, particularly the inaction and the large adjustments, act to pin down the non-convex adjustment costs. Finally, variations in β influence all the moments, particularly the standard deviation of the log of revenue per worker. When, for example, β is low, the future gains from employment adjustment are more heavily discounted and so the plant relies more on hours adjustment.

We do not attempt to estimate and identify all the elements of Θ simultaneously. Instead, we consider leading cases for both private and public plants. Accordingly, one specification studies different forms of firing costs and then we look at different forms of hiring costs. Relative to others studies, our approach is more flexible in that we allow for asymmetric adjustment costs and, as noted earlier, allow for the non-convex costs to apply only after critical levels of employment adjustment. Further, our study includes the estimation of the discount factor, which is potentially different between public and private plants.

[18]The simulated panel as 350 time periods and 400 plants. As the process is ergodic, the simulated microeconomic moments are determined by the total observations.

[19]Cooper, Haltiwanger, and Willis (2004) do not estimate asymmetric adjustment costs.

[20]We do not have direct information on hours in the data set.

4.3 Private Plants

Results for private plants are summarized in Tables 4 and 5. The first table presents parameter estimates and the second contains the associated moments.

	ζ	ν	λ^+	λ^-	F^+	F^-	γ^+	γ^-	β
firing	1.76	0.010	na	na	na	0.02	na	0.036	0.862
hiring	1.68	0.013	na	na	-0.001	na	0.048	na	0.889
oppt.	1.545	0.272	0.9993	0.9034	na	na	0.0	0.0	0.975

Table 4: Parameter Estimates: Private Plants

Instead of trying to estimate all of the adjustment costs parameters at once, we have chosen to study some leading sub-cases. The first focuses on firing costs. These costs have two components: a linear cost which captures, among other things, any severance pay obligations of the firm. The second is a fixed cost of firing which we assume is incurred if the job destruction rate exceeds a critical value.

The motivation was to consider some of the institutional ramifications of large job destruction rates. These might range from the need to justify these adjustments to government authorities, labor unrest in response to large firings and future effects on government regulation from large job destruction rates. [21]

In our estimation, we experimented with a number of critical values, ranging from 0 to 25%. The results reported here are for a 20% critical job destruction value which fits the data best.[22] The Labor Contract Law enacted in 2008 stipulates that job destruction in excess of 20 employees and/or 10% of total employment needs to be justified to the plant's Employees' Convention and the local administration office of the State Ministry of Human Resource and Social Security. While this law was passed after our sample, it is supportive of the theme that large job destruction was associated with a political response and hence an additional adjustment cost.

[21] The extend of labor unrest in China is well documented at `http://factsanddetails.com/china.php?itemid=363&catid=9&subcatid=60#06` and `http://www.solidarity-us.org/current/node/26`.

[22] To be precise, we estimated the model for these different critical values $(0.0.05, 0.10, 0.15, 0.2, 0.25)$ and are reporting the best fitting model.

Looking first at firing costs, there is evidence of both fixed and linear firing costs. By a normalization, the estimated fixed firing cost is 2% of steady state revenues. The linear adjustment cost is estimated to be 0.036 which is about 0.04% of steady state revenue. From Table 1, this cost is about 25,000 RMB per worker, a little less than two years of median wages in the sample. Since the fixed cost only applies for job destruction in excess of 20 %, the linear cost is important for obtaining inaction in adjustment since the adjustment cost function is not differentiable at zero net employment growth. There is also a sizable cost of adjusting as $\zeta = 1.43$ but this cost is lower than that typically used in studies of US plants.[23] Finally, the model allows for some quadratic adjustment cost but the estimate of ν is very small.

As noted earlier, one important feature of our estimation is that we include estimates of the discount factor. The estimate of $\beta = 0.862$ for the best fitting model implies a marginal borrowing cost of about 16%. This is certainly suggestive of some friction in capital markets, particularly since this rate is substantially higher than the implied cost of funds for public plants, as seen in Table 6 below.

	std(r/e)	sc	JC30	JC1020	JC10	inaction	JD10	JD1020	JD30	£/1000
Data	0.975	0.922	0.151	0.073	0.119	0.37	0.101	0.051	0.056	
firing	0.989	0.935	0.189	0.050	0.117	0.402	0.049	0.022	0.070	8.76
hiring	0.994	0.938	0.186	0.051	0.114	0.411	0.047	0.027	0.090	11.51
oppt.	1.024	0.978	0.066	0.116	0.140	0.436	0.00	0.004	0.094	48.18

Table 5: Moments for private plants

In this table, std(r/e) is the standard deviation of the log of revenue per worker, sc is the serial correlation in employment, JC30 is a job creation rate in excess of 30%, JC1020 is a job creation rate between 10% and 20% and JC10 is a job creation rate greater than 0 and less than 10%. The job destruction (JD) moments are defined symmetrically. The entries are the fractions of observations with these rates of job creation and job destruction.

The moments for this case, presented in Table 5, show how the model with seven parameters fits the nine moments. The model does well on the average standard deviation of the log of revenue per worker and the serial correlation of employment. It also does well in terms of matching the overall job creation rate though the model produces a bit too much

[23] See the discussion in Cooper and Willis (2004) and the references therein.

job creation in excess of 30%. The linear cost of firing produces inaction, a bit in excess of the observed rate. The model struggles to match the intermediate levels of job destruction, though it matches the tail of the job destruction distribution quite well.

The fit of the model, reported in the final column, is very far from zero. In a statistical sense, the model does not match the moments. This is partly because we are estimating a single model for all of manufacturing. Further, the moments are quite accurately measured so that the variance/covariance matrix has very small elements. Consequently, the weighting matrix used in the objective function has very large elements. All of the elements along the diagonal of the weighting matrix have an order of magnitude equal to 6.

The hiring cost model is shown in the second row of Tables 4 and the third row of Table 5. In this case, there is a linear hiring cost of about the same magnitude of the linear firing cost estimated in the first model. But there is no evidence of a fixed hiring cost.[24] For this model, we did not see any rationale for considering different job creation levels at which the fixed hiring would apply. As in the firing cost model, the quadratic adjustment cost is quite small. Compared to the firing cost model, there is a slightly smaller cost of hours adjustment.

Looking at the moments for this case, the fit of the model with hiring costs is not as good as the firing cost model. The relative standard deviation and serial correlation moments are matched reasonable well. The model also matches the overall job creation and destruction rates but misses on the composition, putting too much of the distribution in the tails relative to the data.

The issue of distinguishing hiring from firing costs is not new. If there are costs of firing workers, then a firm has a reduced incentive to hire workers. In effect, the firing cost appears to be a hiring cost. In their estimation of a structural search model, Cooper, Haltiwanger, and Willis (2007) find that many of the moments can be explained by a model with firing costs and that neither specification can match all the moments of the employment growth distribution.

The final specification focuses on the contribution of opportunity costs of adjustment, rather than fixed costs. In this case, labor adjustment entails the shut-down of a plant for a period of time represented by $(1-\lambda^i)$ for $i=+,-$. As discussed in the data appendix, we re-estimated the revenue functions for this model since the adjustment parameter interacts

[24]In fact, the point estimate indicates a slight fixed benefit for hiring.

with the flow of revenues. In this case we also allowed for a linear firing and hiring cost and estimated β as well.

The results are shown in the row labeled "oppt." in the two tables. The parameter estimates again indicate a cost of varying hours and more of a quadratic adjustment cost than the previous model. The main source of non-convexity in this case is in the opportunity cost associated with job destruction. The estimated lost revenue is large: almost 10%. There is no evidence of either linear hiring or firing costs in this specification. In this case, the estimated $\beta = 0.975$, much higher than in the other specification.

As a consequence, for this specification the job destruction rates, shown in Table 5, are all very tiny. Along that dimension, this model fails to match the data. The fit is not as good as the firing cost model.

Overall, the best fitting model is one with linear and fixed firing costs. Importantly, the non-convex adjustment cost applies when the job destruction rate exceeds 20%. And the estimated discount factor is 0.862 for private plants.

4.3.1 Other Implications

There are some other properties of the estimated model with firing costs worth noting. While these are not part of the formal estimation exercise, they indicate other dimensions along which the model matches features of the data.

Returning to Table 3, we use the IV estimates to parameterize the private plant dynamic optimization problem. At the estimated parameters, we simulated data and estimate using OLS the relationship between revenue and the labor input and compare this against the OLS estimate in Table 12. In the simulated data, the OLS estimation of the revenue function has a curvature of 0.57, well above the value of $\alpha = 0.3198$ used to parameterize this function. The difference, of course, reflects the endogenous labor decision. The bias in the estimate is not quite as large in the simulated data as in the actual data.

Our estimate does not utilize data on compensation. Yet the model has implications for the cross sectional distributions of wages. These differences arise from the plant-specific profitability shocks leading to differences in hours across plants and through the estimated compensation function to differences in wages. The (time series) average of the coefficient of variation of compensation, which equals the standard deviation of compensation divided by the mean of compensation, is about 1.3 in the model. In the data, it is slightly over 1.0.

This difference between model and data may reflect excessive heterogeneity across plants in the model relative to the data, less hours variation in the data relative to the model or less sensitivity of compensation to hours variation in the data relative to the estimates.[25]

Finally, there is considerable employment inaction in the data which is replicated in the model. One interesting question about the inaction is whether it is size dependent. In our specification, the fixed cost of firing is proportional to the average revenue and so does not vary with the size of a particular plant. That is, the fixed cost is not state dependent. This contrasts with the opportunity cost model where the adjustment cost is state dependent and is higher for larger plants. This suggests that looking at the pattern of inaction across plant size might be informative about the nature of adjustment costs.

To do so, we looked at the correlation between size and inaction. In the data, the correlation between inaction and size (measured as the number of workers) is -0.09. In the simulated data this correlation is -0.0019. Thus the fixed firing cost model is replicating the independence of inaction from size found in the data.

4.4 Public Plants

Tables 6 and 7 present results for public plants. As we did for the private plants, we consider some leading specifications, indicated by the rows of these tables. The next section compares the results for public and private plants.

The first case is firing costs. As with the private plants, the best fitting model had the firing cost starting with a 20% job destruction rate. For that model, the cost of adjusting hours is present but smaller than for the private model. The fixed firing cost and the linear firing costs are modest. We estimated $\beta = 0.9242$ for the firing cost model. It does seem that the profit maximizing motive is an effective way to model the choices of these plants.

The overall job creation rate matches the data well but the model does not produce the burst of job creation found in the data. The model has about the same inaction as in the data. As with job creation, the overall job destruction rate is close but the model does not have the bursts of job destruction.

As was the case with the private plants, the other two leading specifications do not fit the data as well. The opportunity cost model highlights firing costs and thus is unable to

[25] As we do not have data on hours variation, it is not possible to check these explanations directly.

match the pattern of job destruction found in the data.

The hiring cost model also does not fit the data quite as well as the firing cost specification. Note that this specification estimates a positive cost of hiring rather than a fixed benefit to hiring as discussed earlier as an alternative objective for public plants. This is evidence against the "job creator" objective of SCEs.

Finally, we estimated the model allowing for a soft-budget constraint. As described earlier, in this specification, the public plant receives a transfer from the government to cover any losses. Of the adjustment cost cases with the soft-budget constraint, the opportunity cost model was closest to the data and is reported in the tables. This is quite different from the results without the soft budget constraint. The estimated model has only an opportunity cost of firing workers. The estimate of β in this case was 0.915.

However, as seen in Table 7 adding in the soft-budget constraint did not improve the fit of the model compared to the case of firing costs and no soft budget constraint. Thus we conclude that the soft budget constraint is not influencing the labor demand decisions of these public plants.

	ζ	ν	λ^+	λ^-	F^+	F^-	γ^+	γ^-	β
	Trimmed public plants								
firing	1.21	0.485	na	na	na	0.022	na	0.056	0.9242
hiring	1.327	1.069	na	na	0.001	na	0.11	na	0.975
oppt.	1.629	1.70	1.0	0.813	na	na	0.0	0.0063	0.9985
	Trimmed public plants with sbc								
oppt.	1.93	1.05	0.999	0.987	na	na	0	0.008	0.993

Table 6: Parameter Estimates: Public Plants

4.5 Comparing Public and Private Plants

Given the large number of cases it is useful to highlight key findings. Here we focus on a comparison of public and private plants.

For both public and private plants, the specification with firing costs fits the moments best, with the fixed cost of firing occurring with job destruction rates in excess of 20%. Com-

	std(r/e)	sc	JC30	JC1020	JC10	inaction	JD10	JD1020	JD30	£/1000
Data	1.118	0.952	0.085	0.068	0.173	0.278	0.227	0.063	0.044	
	Trimmed Public plants									
firing	1.084	0.992	0.003	0.078	0.215	0.331	0.271	0.083	0.000	2.806
hiring	1.034	0.993	0.001	0.0751	0.225	0.338	0.279	0.069	0.00	3.167
oppt.	1.166	0.967	0.045	0.127	0.197	0.393	0.00	0.024	0.065	7.110
	Trimmed Public plants with sbc									
oppt.	1.202	0.841	0.027	0.145	0.230	0.273	0.124	0.064	0.051	6.946

Table 7: Moments: Trimmed Public Plants

pared to private plants, public plants have lower costs of adjusting hours, higher quadratic adjustment costs and higher linear adjustment costs.

Since one interpretation of the linear adjustment costs is severance payments, the larger estimates of γ^- for the public plants is consistent with the higher wages paid by these plants. Returning to our discussion of the objectives of SCEs, we find some support for the "employment stabilizing" objective, seen here as higher quadratic adjustment costs for public plants.

Finally, estimating β improves the fit of the model slightly relative to the standard practice of assuming a discount factor. More importantly, we find that public plants discount considerably less than the private plants. This is consistent with accounts of financial frictions for private plants within China. Cull and Xu (2003) and Cull and Xu (2005), for example, discusses the flow of (subsidized) funds to SCEs from public banks and the government. Among other things, they point out that the allocation of credit by state-owned banks contains, in part, the bailout of SCEs. Hale and Long (2010) find that the ratio of interest expense to debt is almost twice as high for private plants compared to SCEs.

4.6 Sectoral Results

Our estimates thus far pertain to all manufacturing plants. This approach constrains the parameters to be the same across sectors. We now study a couple of specific sectors: autos (and parts) as well as steel and iron.

Table 8 is comparable to Table 1 in terms of providing some basic statistics on the (trimmed) public and private plants in the two sectors. Most of the plants in these sectors are private. The public plants are considerably larger than the private ones. This is true in terms of value added, revenues, employment and the capital stock. Public plants are more capital intensive. The revenue per worker and revenue per capital measures of productivity are all higher in the public plants. The difference in productivity is most evident in the revenue per capital measure in steel and iron.

Table 9 provides IV estimates of the revenue function for these sectors. Clearly there are differences across sectors in the curvature of the revenue functions and the persistence of the shocks. For both private and public plants, the sectoral estimates of α are larger than for total manufacturing.

The following two tables present estimate for the firing cost model by sector. For these results, we estimated the model with firing costs, which was the best fitting model for all sectors.

Some of the basic patterns from total manufacturing appear in the sectoral results as well. The public plants have significantly larger quadratic adjustment costs and higher linear adjustment costs. This is particularly true for the public steel and iron plants. Those plants also have substantially larger fixed firing costs.

One interesting difference from the previous results is in the discount factors. For the public auto plants, there is almost no discounting while the public steel and iron plants discount more than the private plants. In the steel and iron sector, concern over excess capacity has led the government to restrict credit to these plants and this may explain the lower discount rate.[26]

In these two sectors, the discount factor for the private plants is much higher than it is for overall manufacturing. It might be that the private plants in these sectors are parts of firms with relatively easy access to capital markets.

As indicated in Table 11, the sectoral models fit better. This is both because the parameter estimates are sector specific. In addition, with a smaller number of observations, the terms in the variance/covariance matrix are larger and thus the terms in the weighting matrix are smaller.

[26]This policy is discussed in: http://industry.oursolo.net/data/steel-industry-iron-capacity/ and http://www.robroad.com/light-industry/index.php/capacity-industry-million/.

	Autos and Auto Parts			Steel and Iron		
	All	Public	Private	All	Public	Private
# plants	4,650	778	3,652	3,969	539	3,237
Value added	62,687	122,387	21,196	133,159	268,128	36,341
	(524,559)	(684,604)	(60,372)	(1,027,953)	(1,024,121)	(78,114)
Revenue	257,884	493,999	77,084	480,585	1,092,618	151,529
	(2,078,417)	(2,509,979)	(230,453)	(2,944,061)	(3,548,125)	(334,305)
Employment	336	537	177	534	1,110	168
	(1,574)	(808)	(179)	(3,406)	(2,899)	(207)
Capital	50,383	97,665	17,056	158,850	380,198	21,248
	(365,652)	(444,121)	(47,459)	(1,593,874)	(1,432,630)	(58,250)
Cap./Emp.	91	105	85	127	172	114
	(158)	(155)	(153)	(269)	(509)	(198)
VA/Emp.	127	128	120	235	234	229
	(288)	(252)	(279)	(509)	(559)	(507)
VA/Cap.	4.3	5.4	4	10.3	20.9	8.9
	(43)	(94)	(22)	(215)	(543)	(86)
Rev./Emp.	461	492	427	1,004	1,169	955
	(958)	(850)	(919)	(2791)	(5838)	(1940)
Rev./Cap.	15.1	16.1	14.7	43.6	78.4	38.8
	(103)	(173)	(84)	(854)	(1942)	(517)

Table 8: Types and Characteristics of Plants by Sector: 2005-2007

All monetary terms are in 1,000 RMB, deflated to 2005 level. The trimmed sample is the public (private) sample excluding the upper and lower 2.5% tails by employment size. Standard deviations are parenthesized.

	α	ρ
Autos and Auto Parts		
private	0.4195	0.9162
public	0.5765	0.9412
Steel and Iron		
private	0.3376	0.8557
public	0.6051	0.9227

Table 9: Sectoral Results from IV Revenue Function Estimation

	ζ	ν	F^{-}	γ^{-}	β
	Autos and Auto Parts				
private	1.26	0.049	0.005	0.040	0.968
public	1.12	0.27	0.001	0.060	0.999
	Steel and Iron				
private	1.86	0.0161	0.013	0.033	0.956
public	1.39	0.827	0.037	0.499	0.907

Table 10: Parameter Estimates by Sector

5 Conclusion

This paper estimates labor adjustment costs for private and public plants. For all of these plants, we find evidence of adjustment costs in the form of fixed and linear firing costs along with quadratic adjustment costs. These fixed firing costs apply when the job destruction rate exceeds 20%. The quadratic adjustment costs for the trimmed sample of public plants are larger than those for the private plants. Private plants discount the future more heavily than do public plants.

Turning specifically to the objectives of the public plants, we see no evidence of soft-budget constraints influencing the labor demand of public plants. Nor do we see evidence of a positive benefit to hiring for these plants. Instead, we see support for public plants acting to stabilize employment, as reflected by larger estimated quadratic adjustment cost

	std(r/e)	sc	JC30	JC1020	JC10	inaction	JD10	JD1020	JD30	£/1000
Autos and Auto Parts										
					Private					
Data	0.863	0.932	0.185	0.098	0.137	0.304	0.107	0.039	0.039	
Sim.	0.759	0.963	0.085	0.076	0.147	0.370	0.097	0.062	0.041	0.442
					Public					
Data	1.012	0.967	0.084	0.104	0.201	0.231	0.206	0.061	0.031	
Sim	0.999	0.981	0.055	0.103	0.185	0.256	0.146	0.102	0.032	0.038
Steel and Iron										
					Private					
Data	0.943	0.933	0.173	0.075	0.107	0.361	0.098	0.050	0.054	
Sim	0.960	0.910	0.197	0.067	0.094	0.354	0.054	0.045	0.079	0.136
					Public					
Data	1.154	0.982	0.094	0.0565	0.215	0.253	0.242	0.063	0.024	
Sim	1.172	0.978	0.084	0.088	0.128	0.359	0.089	0.081	0.034	0.037

Table 11: Moments by Sector: Firing Cost Model

parameters for public plants.

This estimation exercises uses data prior to the introduction of worker protection regulations in China. That intervention, in part, reflected concerns about hours variation and the lack of severance pay to workers. One interpretation of the fixed firing costs for excessive job destruction was a political one that may have been manifested in the recent regulations.[27] Studying the impact of those new regulations on labor demand using our estimated model is of considerable interest.

The results are also useful as inputs into an analysis of gains to reallocation. Given our focus on private versus public plants, reallocation can occur within and across ownership classes. We plan to use our model to study productivity implications of reallocation, both in the present and in the earlier years of our sample. The theme of reallocation is

[27] See the discussion of the motivation for current regulations in `http://www.carnegieendowment.org/publications/?fa=view&id=22633` and `http://www.law.com/jsp/law/international/LawArticleIntl.jsp?id=1202430131324`.

clearly important as well in considering the effects of the introduction of worker protection regulations.

Appendix

This section discusses measurement of key variables and estimation of the revenue function in (3) and section 4.1. "Revenue" in (3) refers to output price times quantity of output, net of variable costs on inputs excluding labor. The data provide direct measures of output in monetary terms, i.e. output price times quantity of output, which can be deflated to base-year measures using the consumer price index.

Although the "revenue" (hereafter referred to as "net revenue") in (3) is not directly observed from the data, we can use the output price times quantity (hereafter referred to as "gross revenue") in the data to estimate the curvature of the net revenue function (α) and back out the profitability shock. This approach is common in the dynamic factor demand literature. The appendix of Cooper and Haltiwanger (2006) presents a detailed discussion of the derivation and measurement issues in the context of a capital adjustment problem.

Assume a Cobb-Douglas production function is given by $y = \tilde{A}(eh)^{\alpha_e} K^{\alpha_K}$, where K denotes inputs other than labor. These other inputs (hereafter referred to as capital) are rented and incur no adjustment cost, with r being the rental rate. It is straightforward to extend the production function with capital to a function with multiple variable factors. Assume the plant faces an inverse demand function $p = y^{-1/\eta}$. Here η is the price elasticity of demand for the good. The net revenue function is given by

$$\tilde{R}(\tilde{A}, e, h, K) = [\tilde{A}(eh)^{\alpha_e} K^{\alpha_K}]^{1-\frac{1}{\eta}} - rK, \tag{14}$$

where the first term on the right-hand side is gross revenue. After optimization over K the above equation yields

$$\tilde{R}(\tilde{A}, e, h, K) = (1-\phi)[\tilde{A}(eh)^{\alpha_e} K^{\alpha_K}]^{1-\frac{1}{\eta}}, \tag{15}$$

where $\phi = \alpha_K(1-\frac{1}{\eta})$. Note that the net revenue function and the gross revenue function are the same up to a factor of $1-\phi$. Substituting the first-order condition of the optimization problem for K in equation (15) we obtain the net revenue function of the following form:

$$R(A, e, h) = A(eh)^{\frac{\alpha_e(1-1/\eta)}{1-\phi}}, \tag{16}$$

where $A = (1-\phi)\tilde{A}^{\frac{1}{1-\phi}}(\frac{r}{\phi})^{\frac{\phi}{\phi-1}}$. If the production technology is constant returns to scale, then the curvature of net revenue on employment in equation (16) is exactly the same as (12).

We estimate the revenue function via generalized method of moments (GMM). Specifically, we regress gross revenue from the data on total labor inputs (using total compensation on labor as proxies for unobserved human capital differences in workers). Plant-level initial wage and initial capital stock are used as instruments to control for some of the plant-level heterogeneity. The total labor inputs is the number of workers (quality adjusted using the initial wage) as hours worked is not observed. The lag of revenue is not used as an instrument as current profitability is correlated with lagged profitability and thus lagged revenue.

The OLS and IV results are shown in Table 12. The curvature estimates are considerably lower once we instrument for endogenous input variations.

	α	ρ
OLS		
private	0.6695	0.8975
public	0.8272	0.9305
IV		
private	0.3198	0.9082
public	0.4324	0.9513

Table 12: Results from Revenue Function Estimation

As China is a rapidly growing economy and our model is stationary, we include year dummies as instruments to control aggregate profitability shocks. In the case of opportunity costs, the estimation incorporates a dummy variable for employment adjustment to control for the effects of disruption costs. In this case, we find $\alpha = 0.3968$ for private plants and $\alpha = 0.5593$ for public plants, in comparison to the results in Table 3 for the fixed cost case.

We infer the profitability shock from the revenue function and the estimated coefficient for α. The serial correlation (ρ) is obtained from an AR(1) process of the logarithm of inferred profitability shock.

References

Adda, J., and R. Cooper (2003): *Dynamic Economics Quantitative Methods and Applications*. MIT Press.

Bai, C., J. Lu, and Z. Tao (2006): ".The multitask theory of state enterprise reform: empirical evidence from China.," *American Economic Review*, 96, 353–57.

Bils, M. (1987): "The Cyclical Behavior of Marginal Cost and Price," *The American Economic Review*, 77(5), pp. 838–855.

Brandt, L., J. V. Biesebroeck, and Y. Zhang (2009): "Creative Accounting or Creative Destruction? Firm-Level Productivity Growth in Chinese Manufacturing," NBER Working Paper No. w15152.

Cooper, R., and J. Haltiwanger (2006): "On the Nature of the Capital Adjustment Costs," *Review of Economic Studies*, 73, 611–34.

Cooper, R., J. Haltiwanger, and J. Willis (2004): "Dynamics of Labor Demand: Evidence from Plant-level Observations and Aggregate Implications," NBER Working Paper #10297.

——— (2007): "Search frictions: Matching aggregate and establishment observations," *Journal of Monetary Economics*, 54(Supplement 1), 56 – 78.

Cooper, R., and J. Willis (2004): "A Comment on the Economics of Labor Adjustment: Mind the Gap," *American Economic Review*, 94, 1223–1237.

Cull, R., and L. Xu (2003): "Who gets credit? The behavior of bureaucrats and state banks in allocating credit to Chinese state-owned enterprises," *Journal of Development Economics*, 71(2), 533–559.

——— (2005): "Institutions, ownership, and finance: the determinants of profit reinvestment among Chinese firms," *Journal of Financial Economics*, 77(1), 117–146.

Gowrisankaran, G., and R. Town (1997): "Dynamic Equilibrium in the Hospital Industry," *Journal of Economics & Management Strategy*, 6(1), 45–74.

Hale, G., and C. Long (2010): "What are the Sources of Financing of the Chinese Firms?," Hong Kong Institute for Monetary Research, Working Paper No. 19.

Hsieh, C.-T., and P. Klenow (2009): "Misallocation and Manufacturing TFP in China and India," *Quarterly Journal of Economics*, CXXIV(4), 1403–1448.

Lin, J., and Z. Li (2008): "Policy burden, privatization and soft budget constraint," *Journal of Comparative Economics*, 36(1), 90–102.

Sapienza, P. (2002): "What do State-Owned Firms Maximize? Evidence from Italian Banks," Available at http://ssrn.com/abstract=303381.

Song, M., K. Storesletten, and F. Zilibotti (2009): "Growing Like China," CEPR Discussion Paper No. DP7149.