

## Soft budget constraints, social burdens, and labor redundancy in China's state industry

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The soft budget constraint hypothesis of Kornai (1980) offers an attractive explanation of over-manning in public enterprises. Sometimes overlooked in the literature is the fact that governments, especially in transition economies, often use state-owned enterprises (SOEs) to pursue non-financial objectives and to finance the resulting social burdens with subsidies and policy loans. In studying a panel of about 700 SOEs, we find that hardening budget constraints, without at the same time relieving SOEs from their social burdens, was a major proximate cause of rising redundant labor in the early 1990s in China. *Journal of Comparative Economics* 31 (1) (2003) 110–133. University of Winnipeg, Winnipeg, MB, Canada R3B 2E9; Brown University, Box B, Providence, RI 02912, USA.

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### 1. Introduction

Overstaffing of public enterprises is widespread and the prospect of large-scale labor force reduction is one of the main political concerns when privatizing or restructuring state-owned enterprises (SOEs). Despite the importance of this problem, the causes of

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labor redundancy have not received adequate analytical and empirical attention. In this paper, we develop a theoretical and empirical framework to investigate the reasons for the increase in labor redundancy in China's state industry in the early 1990s.

Overstaffing of SOEs has been commonly understood as a by-product of soft budget constraints. According to Kornai (1980), SOEs exhibit an almost insatiable appetite for inputs because their managers stand to benefit from any profitable expansion of output, but have little to lose if the enterprise incurs losses. Based on this hypothesis, hardening budget constraints by reducing subsidies and bank loans and exposing SOEs to market competition is expected to reduce labor redundancy and improve the enterprises' productivity and financial performance. Bertero and Rondi (2000) show this to have been the case in Italy in the late 1980s when state firms responded to hardening budget constraints by increasing their productivity and reducing employment.

Sometimes overlooked in the reform literature is the fact that governments, especially in transition economies, often use SOEs to provide public goods and services, with the governments then financing the resulting social burdens on SOEs by means of subsidies and policy loans (Lin and Tan, 1999). This oversight can lead to a distorted reform strategy that focuses on hardening SOEs' budget constraints but pays inadequate attention to relieving them of their social burdens. Instead of fostering greater efficiency, as shown by the experience of the Italian state firms, such a reform strategy is more likely to exacerbate the problem of labor redundancy and reduce SOE productivity. Using a panel of enterprise level data on approximately 700 SOEs, we confirm that overmanning emerged as a widespread phenomenon in China's industrial SOEs in the early 1990s.<sup>1</sup> More importantly, we find that hardening budget constraints without concomitant relaxing of the social burdens of high taxes, employment, and social welfare maintenance was a major proximate cause of the rising labor redundancy.

Our analysis begins with a brief review of SOE reforms. We discuss the potential conflict between the objective of encouraging SOEs to behave more like market entities and the desire of retaining SOEs as the main providers of social security and fiscal revenues. We then present a model of wage and input choice subject to the employment, incentive, and financial constraints. Once the results of the model are derived, we explain the empirical methodologies and introduce the variables that are used to test these hypotheses. Finally, we estimate the equations of the model, focusing on the determinants of redundancy rates in the SOEs from 1991 to 1994. Our main findings are that the increasing unavailability of financial resources caused by growing indebtedness and falling profits affected adversely the enterprises' optimal choice of non-labor current inputs and wages, and that the resultant shortage of non-labor inputs, together with increasing product market competition, downward shifts in demand, wage increases to track increasing wages paid by non-state enterprises, and binding constraints on the downward adjustment of employment, accounts for the rising labor redundancy rates in China's state industry in the early 1990s.

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<sup>1</sup> Dong and Putterman (2001) provide a review of the empirical studies of the pattern of labor utilization in pre- and early post-reform China's state industry.

## 2. SOEs and economic reforms

Prior to reform, SOEs dominated the Chinese economy; on the eve of reform, the SOE sector produced more than three quarters of industrial output, employed more than two thirds of all industrial employees, and contributed nearly ninety percent of national fiscal revenue. Since the late 1970s, China's state industry has undergone a series of reforms to restructure incentives faced by enterprise managers and to enhance the role of the market (Lardy, 1998). Economic reforms have changed the landscape of Chinese industry. The importance of the state sector has decreased dramatically; SOEs now must compete both with other types of firms and among themselves in product and input markets.

While the objective of the reforms is to improve the financial performance of SOEs through market discipline, the state has been hesitant to relieve SOEs of their traditional roles as guarantors of the job security and welfare of their employees. Up until the late 1990s, the managers of SOEs did not have the autonomy to dismiss surplus workers and, consequently, they were unable to adjust their labor forces in response to changes in demand and technology. As a result, the output share of industrial SOEs fell by more than 50%, whereas their employment share declined by less than 20% (NBS, 1998, pp. 431–432). Experts estimated that at least 20 to 30% of those employed by China's industrial SOEs were redundant.<sup>2</sup> SOEs were also obligated to provide a broad range of social services that are financed from the government budget in other countries, and that non-state enterprises were not required to provide.<sup>3</sup> Pension provision was a typical example of the growing, heavy social burdens placed on the SOEs. As their labor force aged, the ratio of the retired to in-post SOE employees rose rapidly, from 1:26 in 1978 to 1:4.6 in 1995 (NBS, 1998, pp. 795, 798). As a consequence, the pension pay-out relative to the total wage bill increased from 6.9% in 1980 to 21.3% in 1995. Moreover, despite their diminishing dominance in the economy, SOEs remained the principal source of revenues for both the central and provincial governments. In 1995, SOEs in industry and other sectors produced about 44% of GDP (Perotti et al., 1999), but contributed 71% of national fiscal revenue.

Over and above the probably deleterious impact on efficiency attributable to those elements of the soft-budget constraint, the heavy social obligations and unfavorable tax position of SOEs made it impossible for them to compete with market entities. Despite the deepening of enterprise reforms, therefore, the financial performance of the SOEs continued to deteriorate as the ratio of their losses to before-tax profits fell from 5% in 1980 to 22.3% in 1995. Due to declining profitability and heavy fiscal obligations,<sup>4</sup> SOEs became more dependent on bank loans, rather than their own retained profits, not only to finance capital investment but also to finance the purchase of current inputs, to pay their

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<sup>2</sup> For example, Hu Xiaoyi, Director of the Social Security Department in the Ministry of Labor, said of the number of redundant employees: "Most people tend to think that about 20 percent of the workers and employees in SOEs are surplus labor; that is 15 million." (Broadman, 1996, p. 125).

<sup>3</sup> This social welfare provision is estimated to have accounted for about 40 percent of the difference in profitability between SOEs and TVEs (Xiao, 1991).

<sup>4</sup> To meet the government's need for tax revenue, the distribution of total profits of industrial SOEs was designated as 85% to various tax obligations and only 15% to be retained by the enterprises under the tax-for-profit scheme introduced in the mid-1980s (Naughton, 1996) and the share of retained profits fell to 13.6% in the early 1990s (NSB, 1992, p. 413).

wage bills, and to meet their pension and tax obligations.<sup>5</sup> The ratio of their financial liabilities to their assets increased dramatically, from 19% in 1980 to 79% in 1994 (Lardy, 1998); as a consequence, the interest obligations of SOEs rose from 2.7% of value-added in 1981 to 15.5% in 1993 (Brandt and Zhu, 2000).<sup>6</sup> Falling profitability and the rise in loan and interest payments made it increasingly difficult for the enterprises to finance their daily operations. The increasing unavailability of financial resources was exacerbated further by the state's reduction of subsidies and the tightening of bank loans to SOEs in the early 1990s as the SOE reform entered a more radical stage. Thus, and not surprisingly, in a survey of managers of 962 industrial SOEs taken jointly by the Chinese Economic System Reform Commission (CESRC) and the World Bank in April 1992, 38.3% identified the shortage of funds and 41.9% considered the shortage of material inputs and electricity to be among the top three major obstacles to raising production efficiency.<sup>7</sup>

In this paper, we look in detail at the determinants of over-staffing in China's SOEs and the role played by dwindling financial resources in escalating labor redundancy in the early 1990s. Our analysis is based on panel data on 681 SOEs for the years from 1990 to 1994.<sup>8</sup> These enterprises are located in four Chinese provinces, Jiangsu, Sichuan, Shanxi and Jilin, and distributed among more than thirty industrial branches. The data were collected by China's Academy of Social Sciences (CASS) with the collaboration of a dozen economists from the University of Michigan, the University of California at San Diego, and Oxford University. A summary of the descriptive statistics of the sample is presented in Table 1.

The information in Table 1 suggests strongly that, in the early 1990s, the ability of SOE managers to make downward adjustment of the workforce was still very limited. Given an average size of 1938 employees per enterprise, the mean number of workers who were laid off or placed on indefinite leave at half or less of their regular pay (*xiagang*) was negligibly low, ranging from 1% to 4%, and from 3% to 8%, respectively. Moreover, the reported incidence of layoffs and *xiagang* was highly concentrated in a few small enterprises in the textile industry that had difficulty surviving. Although the average enterprise's overall employment continued to grow by about 1% or 18 employees a year, the number of employees assigned by the government equaled or exceeded the number of retirees. Moreover, enterprises may have not been able to replace departing workers

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<sup>5</sup> Lardy (1998, p. 39) states that "Whatever its cause, the declining profitability of state-owned enterprises has reduced the share of fixed investment of state enterprises financed with after-tax, retained profits. By 1994, the share was down to one-fifth compared with about three-fifths in 1987."

<sup>6</sup> Some of the rise in the liability/asset ratio was a natural and desirable outgrowth of the reform process because it resulted from the replacement of state grants with bank loans as a means of financing new investments. However, the growing indebtedness to financial institutions as a result of fewer retained earnings has made SOEs highly vulnerable to the instability of macroeconomic policies. It has also made it difficult for SOEs to obtain funds as the banks came under increasing pressure to operate in a more business-like manner and to scrutinize loan applications more carefully.

<sup>7</sup> A detailed description of this survey is given by Xu et al. (1993).

<sup>8</sup> The sample is a follow-up of a random sample of 769 SOEs taken in 1990. It contains about 87% of the enterprises in the earlier sample; some were excluded because of changes in ownership, mergers, and bankruptcy. The problem of enterprise attrition may lead to an underestimate of the scope of resource misallocation in the SOE sector if the exiting enterprises are among the least productive SOEs.

Table 1  
Descriptive statistics of the enterprises in the sample, 1990–1994

	GVIO (10,000 <i>yuan</i> )	NVFA (10,000 <i>yuan</i> )	Materials (10,000 <i>yuan</i> )	Employ- ment (employ- ees)	Layoff (employ- ees)	Waiting worker (employ- ees)	New recruitment (employ- % assigned ees) by govt		Wage ( <i>yuan</i> )	Flexible pay/wage (%)	Profits/ NVFA (%)	Liability/ NVFA (%)	Bank loan/ liability (%)	Interest payment/ value- added (%)
Mean	6589	2733	3086	1938	2.58	5.12	64.74	31.4	2567	32.2	2.07	83.5	87.2	34.1
Std. Dev.	(22,497)	(11,371)	(4797)	(3545)	(11.41)	(13.75)	(523.57)	(0.209)	(3062)	(15.5)	(47.25)	(95.7)	(17.9)	(178.2)
1990	6062	2918	2572	1905	1.65	3.24	52.08	30.8	2509	36.1	7.11	75.4	88.3	N.A.
1991	6201	2824	2938	1925	1.92	4.38	59.08	31.9	2355	34.0	4.31	77.1	87.9	N.A.
1992	6737	2674	3282	1953	2.83	5.96	61.08	31.3	2628	32.4	6.42	82.5	86.5	N.A.
1993	6744	2554	3389	1926	3.83	6.48	54.73	31.1	2691	30.1	0.26	91.6	86.9	25.8
1994	7165	2705	3226	1978	3.25	8.33	96.38	31.8	2638	28.5	-7.23	90.0	86.6	42.4
Number of enterprises	622	622	622	622	604	621	640	640	622	622	622	624	624	676

Notes. GVIO stands for gross value of industrial output, NVFA for net value of productive fixed assets, and Materials for value of purchased materials, fuel, and power. These three series are all measured in 1990 constant *yuan*. Employment is the number of employees. Layoff is the number of employees laid off by the enterprise. Waiting worker is the number of employees who were placed on indefinite leave with reduced pay or *xiagang* workers. Wage is the wage bill divided by the number of employees at 1990 prices.

with the particular skills needed without hiring workers in addition to those assigned.<sup>9</sup> Compared with their limited autonomy in labor utilization, SOEs appear to have had more control over wages. The portion of pay determined by the enterprise, termed flexible pay, accounted for about 32% of the total wage bills on average, although this share declined over time. Consistent with national trends, SOEs in the sample experienced a decline of profitability and a rise in indebtedness, largely to the banks. In 1993 and 1994, the years for which the data are available, the interest payments by the SOEs in the sample accounted for 25.8 and 42.4% of value-added, respectively.

### 3. The model

In this section, we develop a simple model to analyze the immediate causes of labor redundancy in China's state-owned enterprises (SOEs) in the early 1990s. Using this model, we examine how the increasing unavailability of financial resources interacted with an inability to lay off workers and affected resource allocation and levels of surplus labor in SOEs. For the sake of tractability, we focus on the choices of labor, material inputs, and wages. Since the model is a short-run one, we treat capital as fixed, although we allow for changes in the capital stock in our empirical estimation. Resource choices by SOEs are based on maximizing profits subject to two constraints. First, the SOE must provide a given level of employment to maintain social stability. Second, it must cover its expenses on non-labor current inputs and wage bills. We model decision-making as a two-stage process; in the first stage, employment,  $L$ , is determined and, in the second stage, the enterprise chooses material inputs,  $M$ , and wages,  $W$ , taking  $L$  as given.<sup>10</sup> The two sets of decision are not made simultaneously because it is more difficult for the SOE to adjust its labor force than to change its demand for non-labor current inputs and wages.<sup>11</sup> However, solving for an optimal  $L$  involves backward induction given optimal solutions for  $M$  and  $W$ .

The enterprise is assumed to have some monopoly power in the product market, that is, the enterprise's output decision affects negatively the price level,  $P$ , at which the enterprise sells its output,  $Q$ .<sup>12</sup> We assume that the demand exhibits constant price elasticity,  $\varepsilon_P$ , and

<sup>9</sup> While the existence of new hiring might appear to run counter to recognition of labor surplus, such net hiring could reflect inflexibility with respect to dismissals, since an enterprise struggling to survive in a changing market environment might require certain critically skilled workers but, lacking the right to fire, it may have no choice but to expand its payroll to meet its changing needs.

<sup>10</sup> We model labor as a homogeneous factor paid a uniform wage. Potential problems with this approach are acknowledged in Section 6.

<sup>11</sup> The decision-making of SOEs sketched here is, in fact, a one-stage process in which the enterprise chooses material inputs and wages subject to the binding employment constraint. We describe the optimization program of SOEs as a two-stage process because this setup enables us to analyze the effect of changes in exogenous variables on the optimal choice of labor and labor redundancy. For reference on the modeling of a two-stage decision-making process in the labor literature, see Manning (1987).

<sup>12</sup> In Dong and Putterman (2000, 2002), we study the employment behavior of SOEs under the central planning regime and in the first decade of reforms assuming that the state acted as a monopsonist employer for urban workers. In the present paper, we model the enterprise as a monopolist but not a monopsonist. Either monopsony or monopoly can explain the underemployment results found for some enterprises. However, while eroding market power in product markets is an important element of the SOE story in the early 1990s, the assumption of monopsony is implausible for this period (Dong and Putterman, 2001).

that the level of demand is affected by exogenous factors that we summarize by a simple demand shift parameter,  $\sigma$ . Thus, the inverse demand function is specified as  $P = \sigma Q^{-\varepsilon_P}$  and the revenue function is written as  $P(Q)Q$ . The production function is taken to be Cobb–Douglas<sup>13</sup> and written as

$$Q = Q(eL, M, K) = (eL)^{\alpha_1} M^{\alpha_2} K^{\alpha_3}, \quad (1)$$

where  $e = (W - A)^\beta$  is the effort of a worker, which is a function of the enterprise's internal wage,  $W$ , relative to the wage earned by a reference group outside the enterprise,  $A$ , and  $\beta < 1$  is the effort elasticity with respect to the wage premium.<sup>14,15</sup>

The enterprise first determines employment,  $L$ , given its optimal choices for material inputs,  $M^*$ , and wages,  $W^*$  and subject to the employment constraint,  $L \geq \bar{L}$ .  $\bar{L}$ , the minimum employment level, is determined by the local government and is negatively correlated with the availability of alternative employment opportunities to SOE workers,  $E_A$ , i.e.,  $\bar{L}'(E_A) < 0$ . Assuming that the employment constraint is binding, the employment level is exogenously determined<sup>16</sup> at  $\bar{L}$  and the enterprise has redundant labor.

In the second stage of the decision-making process, the enterprise chooses  $M$  and  $W$  given  $\bar{L}$ . The objective function of the enterprise is written as

$$\pi = P(Q)Q(e, \bar{L}, M, K) - W\bar{L} - P_M M, \quad (2)$$

where  $P_M$  is the price of material input. The enterprise faces a binding liquidity constraint, written as

$$W\bar{L} + P_M M = R, \quad (3)$$

where  $R$  is working capital that is determined by bank credit net of the enterprise's interest and loan payment, and the retained profits in the last period.<sup>17</sup> The enterprise chooses  $M$

<sup>13</sup> This functional form is chosen to facilitate the estimation of the efficiency-wage augmented production function assumed in our model.

<sup>14</sup> Due to the downward inflexibility of employment in the period modeled, SOEs are assumed to lack the option of disciplining workers with the threat of dismissal. Rather than being enforced by such a threat, we assume that an efficiency wage operates by way of reciprocity as described by Akerlof (1982), where the morale of workers is determined by a comparison of their compensation to that of a reference group. Akerlof's hypothesis has received considerable support in the experimental literature (see, for instance, Fehr et al., 1997). Empirical studies of China's SOEs suggest a strong link between industrial performance and incentive pay (Groves et al., 1994, Xu and Zhuang, 1996).

<sup>15</sup> In Dong and Putterman (2002), we develop a model to test whether SOEs place a weight on income generation in addition to the efficiency wage consideration in their wage-setting policies in the period from 1980 to 1990. We find no evidence of such a weight, that is, we find no evidence of rent-sharing beyond profit-maximizing behavior. While we do not model explicitly bargaining between the enterprise and its workers in this paper, we do attempt to control for the potential impact of rent-seeking behavior on wages in the regression analysis, which we discuss in the next section. Once again, we fail to find evidence that supports rent-sharing wage pressure.

<sup>16</sup> That the employment of SOEs was determined exogenously by the government has also been assumed by other authors, for instance, see Yin (1998).

<sup>17</sup> In a market economy, the firm balances its budget automatically when it chooses all its input levels so that the marginal product of each input is equal to its marginal cost. Hence the firm's profit maximizing choice is not subject to a financial resource constraint. However, if the firm is required to maintain a level of employment at which the marginal product of labor is below its marginal cost, the firm will find it difficult to balance its budget

and  $W$  to solve the following problem:

$$\text{Max } G = P(Q)Q(e, \bar{L}, M, K) - W\bar{L} - P_M M + \mu(R - W\bar{L} - P_M M), \quad (4)$$

where  $G$  is the Lagrangian function and  $\mu$  is the Lagrange multiplier on profits that measures the effect of a small relaxation of the working capital constraint on profits. The first-order conditions are:

$$\frac{\partial G}{\partial W} = (1 - \varepsilon_P)P \frac{\partial Q}{\partial e} \beta (W - A)^{\beta-1} - (1 + \mu)\bar{L} = 0, \quad (5)$$

$$\frac{\partial G}{\partial M} = (1 - \varepsilon_P)P \frac{\partial Q}{\partial M} - P_M(1 + \mu) = 0, \quad (6)$$

$$\frac{\partial G}{\partial \mu} = R - W\bar{L} - P_M M = 0. \quad (7)$$

Equations (5) and (6) indicate that, if the enterprise suffers from a shortage of working capital, i.e.,  $\mu > 0$ , its choices of work incentives and material inputs will fall below the optimal level at which the marginal revenue equals marginal cost. Combining Eqs. (5) and (6) and using the results that

$$\frac{\partial Q}{\partial e} = \alpha_1 (W - A)^{\beta(\alpha_1-1)} \bar{L}^{\alpha_1} M^{\alpha_2} K^{\alpha_3} \quad \text{and} \quad \frac{\partial Q}{\partial M} = \alpha_2 (W - A)^{\beta\alpha_1} \bar{L}^{\alpha_1} M^{\alpha_2-1} K^{\alpha_3},$$

we obtain the following equation:

$$\beta\alpha_1 P_M M - \alpha_2 (W - A)\bar{L} = 0. \quad (8)$$

From Eqs. (7) and (8), the optimal wage level,  $W^*$ , and the optimal demand for material inputs,  $M^*$ , in the presence of a binding working capital constraint can be solved as follows:

$$W^* = \frac{1}{1 + \gamma} \frac{R}{\bar{L}} + \frac{\gamma}{1 + \gamma} A = W^*(\bar{L}(E_A), R, A) \quad \text{and} \quad (9)$$

$$M^* = \frac{1}{P_M} \frac{\gamma}{1 + \gamma} (R - A\bar{L}) = M^*(\bar{L}(E_A), P_M, R, A), \quad (10)$$

where  $\gamma = \alpha_2/(\beta\alpha_1)$  is the ratio of the material elasticity to efficiency wage elasticity. Equations (9) and (10) indicate that  $W^*$  is increasing in both  $R$  and  $A$  and decreasing in  $\bar{L}$ , whereas  $M^*$  is decreasing in  $P_M$ ,  $A$ , and  $\bar{L}$ , and increasing in  $R$ . Given  $\bar{L}'(E_A) < 0$ , a change in  $E_A$  has a positive effect on both  $W^*$  and  $M^*$ .

We now return to the first stage of the decision-making process to examine the effects of changes in the exogenous variables on the optimal level of employment and consequently labor redundancy, given the optimal choices of  $W$  and  $M$  in the second stage.<sup>18</sup> The optimal

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unless it earns sufficient monopoly profits or receives subsidies or policy loans from the government. Thus, if the SOE faces a binding employment floor, policies which are designed to harden its budget constraint by reducing subsidies and enforcing the principal and interest payments for loans can impose a financial constraint on the firm's choice of wages and material inputs, even though no administrative constraint is imposed directly on the firm's choices over these variables.

<sup>18</sup> Note that actual employment is assumed constrained to equal  $\bar{L}$ , so backward induction affects redundancy through its effect on  $L^*$  rather than on actual employment.

amount of labor,  $L$ , is derived as the solution to the following problem:

$$\text{Max } \pi = P(Q)Q - W^*L, \quad (11)$$

where  $W^* = W^*(\bar{L}(E_A), A, R)$  and  $Q = Q(W^*(\bar{L}(E_A), A, R), A, M^*(\bar{L}(E_A), P_M, R, A), K)$ . The first-order condition of (11) is

$$(1 - \varepsilon_P)P \frac{\partial Q}{\partial L} = W^*, \quad (12)$$

where the term on the left-hand side of (12) is the marginal revenue product of labor,  $MRP_L$ . Note that  $\varepsilon_P$ , the inverse of the demand elasticity, measures the enterprise's monopoly power. When  $\varepsilon_P = 0$ ,  $MRP_L$  is equal to  $P \partial Q / \partial L$ , the marginal value product of labor,  $MVP_L$ .

Let  $L^M$  denote the employment level at which  $MRP_L = \text{wage}$ , which is the optimal solution when the enterprise has positive monopoly power, i.e.,  $\varepsilon_P > 0$ , and let  $L^*$  denote the labor demand derived from the equality of the wage with the marginal value product of labor ( $MVP_L$ ), which is the optimal solution when the enterprise is a price-taker, i.e.,  $\varepsilon_P = 0$ . Note that  $L^* = 1/(1 - \varepsilon_P)^{1/(1-\alpha_1)} L^M$  when  $\varepsilon_P > 0$ . Using the employment level of a profit-maximizing, competitive firm,  $L^*$ , as the benchmark,<sup>19</sup> we define the labor redundancy rate ( $LRR$ ) as  $(\ln \bar{L} - \ln L^*)$ , where  $\ln$  stands for natural logarithm. If the employment constraint is not binding,  $LRR$  equals zero if  $\varepsilon_P = 0$  and is less than zero if  $\varepsilon_P > 0$ . In the presence of a binding employment constraint, however,  $LRR$  can be positive, negative or equal to zero, depending upon how the employment effect of the enterprise's monopoly power compares to the tightness of the employment constraint.<sup>20</sup>

The response of the labor redundancy rate,  $LRR$ , to changes in exogenous variables is derived as follows. With  $\ln L^* = (-1/(1 - \alpha_1)) \ln(1 - \varepsilon_P) + \ln L^M$  and given values for  $\ln L^M$  and  $\ln \bar{L}$ , the larger is  $\varepsilon_P$ , the higher  $\ln L^*$  becomes relative to  $L^M$  and, consequently, the smaller is the observed  $LRR$ . Thus,  $LRR$  is negatively correlated with monopoly power,  $\varepsilon_P$ .  $LRR$  is also inversely correlated with the availability of alternative employment opportunities to SOE workers,  $E_A$ , given that  $\bar{L}'(E_A) < 0$ . Moreover, with

$$\ln L^* = \frac{1}{1 - \alpha_1} (\ln P(\sigma, \varepsilon_P) + \beta \alpha_1 \ln(W^* - A) + \alpha_2 \ln M^* + \alpha_3 \ln K - \ln W^*),$$

it is straightforward to show that  $LRR$  is increasing in  $W^*$  and  $A$ , and decreasing in  $\sigma$ ,  $M^*$ , and  $K$ . Thus, we write a linearized labor redundancy structural equation as

$$LRR = \beta_0 + \beta_1 \sigma + \beta_2 \varepsilon_P + \beta_3 E_A + \beta_4 W^* + \beta_5 A + \beta_6 M^* + \beta_7 K, \quad (13)$$

<sup>19</sup> We define labor redundancy based on  $L^*$  instead of  $L^M$  for two main reasons. Theoretically,  $L^*$  is more consistent with efficiency. Practically,  $LRR$  is derived from  $L^*$  instead of  $L^M$  because the estimation of  $L^M$  requires information on  $\varepsilon_P$  that is unavailable. Note that the comparative static results of  $LRR$  derived from  $L^*$  are qualitatively the same as those derived from  $L^M$  since  $L^*$  is  $L^M$  multiplied by a positive scalar. Although the case could be made that it is the equality of  $MVP_L$  with  $A$ , the alternative wage, rather than with  $W^*$  that defines the socially optimal employment level, a counter-argument is that  $W^*$  reflects better the opportunity cost of effective labor to the firm, taking into account efficiency wage considerations.

<sup>20</sup> To a certain extent, a binding employment constraint acts as a corrective tendency to underemployment under state monopoly. It would also have this corrective tendency if the SOE had monopsony power in the labor market, as analyzed in Dong and Putterman (2000, 2002).

where  $\beta_1 < 0$ ,  $\beta_2 < 0$ ,  $\beta_3 < 0$ ,  $\beta_4 > 0$ ,  $\beta_5 > 0$ ,  $\beta_6 < 0$ , and  $\beta_7 < 0$  as  $LRR$  is decreasing in  $\sigma$ ,  $\varepsilon_P$ ,  $M^*$ ,  $K$ , and  $E_A$  and increasing in  $W^*$  and  $A$ . From Eqs. (9), (10), and (13), we find that the restricted availability of financial resources acts to exacerbate labor redundancy by reducing the use of material inputs but it also decreases labor redundancy by restricting the growth of wages.<sup>21</sup> Substituting (9) and (10) into (13) yields a reduced-form equation of the  $LRR$ , given by

$$LRR = \gamma_0 + \gamma_1\sigma + \gamma_2\varepsilon_P + \gamma_3E_A + \gamma_4R + \gamma_5A + \gamma_6P_M + \gamma_7K. \quad (14)$$

In Eq. (14),  $\gamma_1 < 0$ ,  $\gamma_2 < 0$ ,  $\gamma_3 < 0$ ,  $\gamma_5 > 0$ ,  $\gamma_6 > 0$ , and  $\gamma_7 < 0$  because  $LRR$  is positively correlated with  $A$  and  $P_M$  and negatively correlated with  $\sigma$ ,  $\varepsilon_P$ ,  $E_A$ , and  $K$ .<sup>22</sup> The effect of a change in  $R$  on  $LRR$ ,  $\gamma_4$ , is ambiguous as an increase in  $R$  will increase both  $M^*$  and  $W^*$ , but  $LRR$  is increasing in  $W^*$  and decreasing in  $M^*$ .

Equations (1), (9), (10), (13), and (14) provide a theoretical framework for our empirical investigation. With these equations, we test the following hypotheses. First, the SOE's choice of employment was subject to a binding labor constraint, and hence over-manning was widespread in the early 1990s. Second, the SOE's choice of wages and material inputs was restricted by a binding financial resource constraint in the early 1990s as a result of the SOE's growing indebtedness and falling profits. Third, restricted availability of financial resources, together with binding constraints on the downward adjustment of employment, increasing competition in product markets, downward shifts in demand, and wage increases to track increasing wages paid by non-state enterprises, was one of the major causes of the rise of redundant labor.

The first hypothesis is tested using the production function in Eq. (1). The second hypothesis is tested by examining the estimated effects of changes in  $R$  on  $W^*$  and  $M^*$  in the wage and material inputs Eqs. (9) and (10). The third hypothesis is tested by estimating the  $LRR$  Eqs. (13) and (14). The estimate of Eq. (13) sheds light on the role played by an inefficient choice of material inputs in explaining the rise of  $LRR$ . The estimate of Eq. (14) provides a measure of the net effect of a binding financial resource constraint on  $LRR$ .

#### 4. Statistical methodology

Our empirical analysis proceeds in two steps. We first estimate an efficiency-wage augmented production function as specified by Eq. (1) and use the estimated labor

<sup>21</sup> However, the suboptimal choice of wage worsens the financial performance of the SOEs as indicated by Eq. (5).

<sup>22</sup> Note that, in (14),

$$\frac{\partial LRR}{\partial E_A} = \frac{\partial \bar{L}/\partial E_A}{\bar{L}} - \frac{1}{1 - \alpha_1} \left[ \left( \frac{\beta\alpha_1}{(W^* - A)} - \frac{1}{W^*} \right) \frac{\partial W^*}{\partial \bar{L}} \frac{\partial \bar{L}}{\partial E_A} + \frac{\alpha_2}{M^*} \frac{\partial M^*}{\partial \bar{L}} \frac{\partial \bar{L}}{\partial E_A} \right].$$

A change in  $E_A$  decreases  $LRR$  through its negative effect on  $\ln \bar{L}$  and its positive effect on  $M^*$  and consequently on  $\ln L^*$  but increases  $LRR$  through its positive effect on  $W^*$  and subsequent negative effect on  $\ln L^*$ . Here, we assume that the negative effects of the employment constraint and material inputs dominate the positive wage effect to establish the desired sign.

coefficient to compute *LRR*. Then we estimate the empirical versions of Eqs. (9), (10), (13), and (14). A direct estimation of the efficiency-wage augmented production function is likely to suffer from two types of simultaneity problems. The first, which is common in conventional production function regressions, occurs when the output of a firm is affected by factors that we do not observe but that the managers of the enterprise do observe. In this case, the OLS estimates are biased and inconsistent because the right-hand-side variables are correlated with the error terms as the results of the manager's choice of inputs. With panel data, the standard approach to dealing with these unobserved characteristics of individual enterprises is to estimate the production function as a fixed-effects model by the least squares dummy variable (LSDV) technique (Hsiao, 1986).<sup>23</sup> The LSDV estimates are consistent assuming that unobserved enterprise characteristics are time invariant. The second type of simultaneity bias may result from reverse causality between productivity and the internal wage. Unlike conventional inputs, which are used before output is produced, wages are usually paid after production. The nature of wage payment introduces the possibility that, although a higher internal wage relative to the reference wage is expected to elicit more effort, the productivity of an enterprise may be positively correlated with its wages. We address this second simultaneity problem by instrumenting the wage variable by its predicted value obtained from the wage regression defined by the empirical version of Eq. (9). The hypothesis regarding reverse causality between production and wages is tested by a comparison of the two-stage LSDV and the one-stage LSDV estimates.

The empirical version of Eqs. (9), (10), (13), and (14) is estimated as a limited-information model by the LSDV method, which removes unobserved fixed effects that may be correlated with the error terms of each equation (Hsiao, 1986).<sup>24</sup> The wage and material inputs equations are both estimated in log form. In the wage equation, we take into account the effects of two additional factors, namely, human capital effects and the effect of the pay structure. The wage response to human capital, as its response to the reference wage, can be viewed as an indicator of the extent to which the wage-setting behavior is subject to competitive pressure from labor markets. With regard to the latter, it has been argued that the rise of enterprise autonomy over wages has led to excessive rent-sharing, and thus to the declining financial performance of the SOEs (Woo et al., 1993, Sicular, 1995).

Although the model developed in this paper does not permit us to test this hypothesis rigorously, we can shed some light on it by adding a proxy variable for enterprise autonomy over wages. Had enterprise autonomy resulted in the practice of rent-sharing, we would observe a positive relationship between this proxy variable and wages, holding other variables constant. In the material input equation, the dependent variable is normalized

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<sup>23</sup> An alternative approach is to estimate the profit function or the conditional cost function. However, this dual approach is developed under the assumption of competitive markets, which is probably not appropriate for China in the early 1990s.

<sup>24</sup> The four equations are estimated using a single-equation method because the system estimation program for panel models is not available in the computer software, TSP. The system-equation method, using information on the complete model, is more efficient but less robust to the problems of model misspecification than single-equation methods.

by the level of employment and takes the form of  $\log(M^*/\bar{L})$ . We also control for the fact that the SOEs in more developed provinces may have better access to supplies of material inputs by adding the provincial average of industrial labor productivity to the explanatory variables. In the estimating version of Eqs. (13) and (14), the variables of material inputs and capital are also normalized by the level of employment and introduced in log form. For (13), the explanatory variables,  $W^*$  and  $M^*/\bar{L}$ , are potentially correlated with the error terms; hence, they are replaced by the predicted values of  $W^*$  and  $M^*/\bar{L}$  obtained from the estimates of Eqs. (9) and (10). Instrument validity tests are performed for the estimating versions of Eqs. (1) and (13).<sup>25</sup> When estimating the *LRR* equations, we use the lagged value of capital per employee instead of the current value to avoid the problem of simultaneity between *LRR* and this variable.

## 5. Variables

The estimation of the production function, the first step of our analysis, requires information on output,  $Q$ , labor,  $L$ , material inputs,  $M$ , capital,  $K$ , internal wage,  $W$ , and the reference wage,  $A$ .  $Q$  is measured as gross value of industrial output (GVIO) at 1990 prices.  $M$  is measured by the real value of purchased materials, fuel, and power at 1990 prices. Both GVIO and material input were deflated by the industrial product price indices at the industry level published in *China's Statistical Yearbook* of various years.  $K$  is measured by real net value of fixed assets used in production; the panel data contain information that permits us to exclude the assets associated with non-productive services, following the procedure suggested by Chen et al. (1988). With the data on investment and depreciation, a recursive deflation procedure developed by Jefferson et al. (1992) is applied to derive real net value of fixed assets. This procedure corrects the potential distortion of investment good prices arising from the Chinese convention of calculating the current year's fixed assets. The Chinese capital stock deflators at 1990 prices, which include a separate series for each of ten broadly defined industrial branches, are used. Labor input,  $L$ , is taken to be the total number of year-end employees.

Internal wage,  $W$ , is defined as the sum of basic pay (*jibengongzi*), flexible pay (*fudonggongzi*), welfare and benefits, housing subsidies, and pension contributions for acting employees. Basic and flexible pay, obtained directly from the data set, are calculated as the respective total basic and flexible monetary compensation divided by the number of employees. Basic pay includes fixed wage payment, direct subsidies for food and fuel, and allowance. Flexible pay consists of piece-rate wage, overtime compensation, and bonuses. Welfare and benefits, including health care, disability and maternity, death and emergency aid for active employees, and enterprise-provided services such as day care and transportation, are estimated as the ratio of welfare and benefit payment to total monetary compensation multiplied by the sum of basic and flexible payments. Because the information needed to construct the ratio is not present in our enterprise data, its national annual average is taken from the 1996 issue of *China's Labor Statistical Yearbook* and

<sup>25</sup> For a reference on instrument validity tests, see Davidson and MacKinnon (1993).

multiplied by the enterprise-level payments series. Housing subsidies are calculated as total monetary compensation multiplied by the national average of the ratio of housing subsidies to total wage bills, which is estimated by Yu (1997, p. 269). Pension costs are estimated by multiplying the pension–wage ratio by total monetary compensation. The pension–wage ratio is derived from information on the enterprise’s pension contributions for acting employees obtained directly from the panel data.

Reference wage,  $A$ , is the sum of average wage, welfare and benefits, and pensions costs for the employees of urban collective enterprises (COEs) in a province.<sup>26</sup> The average wage, consisting of both fixed and flexible pay, is taken from various issues of *China’s Statistical Yearbook*. The welfare costs are derived by the same methods as used for individual SOEs. The ratios of welfare payment to total wage bills for the urban collective sector used in this calculation are obtained from the 1996 issue of *China’s Labor Statistical Yearbook*.<sup>27</sup> Because the information on pension contributions for acting employees is not available for urban COEs, the pension costs are estimated based on pension payments for retirees, as the product of the ratio of pension pay-out to wage and the total wage bill. The pension–wage ratio is obtained by multiplying the annual national average ratio of pension and welfare expenses per retiree to total wage per retiree by the annual national average ratio of the retired and resigned persons to active staff and workers in urban COEs.<sup>28</sup> The data involved in the calculation of the pension–wage ratios are obtained from the 1996 issue of *China’s Labor Statistical Yearbook* and the 1998 issue of *China’s Statistical Yearbook*.  $W$  and  $A$  are deflated by the industrial product price indices with 1990 as base year. The units of measurement, means, and standard deviations of the output, inputs, and wage variables are given at the top of Table 2 for reference purposes.

The other variables involved in the empirical analysis of labor redundancy are defined as follows. Given that the production technology of the SOE is assumed to be a Cobb–Douglas specification, competitive employment,  $L^*$ , is defined as  $\alpha_L Q/W$ , where  $\alpha_L$  is the estimate of the labor coefficient,  $Q$  is GVIO, and  $W$  is real internal wage at 1990 prices.<sup>29</sup> The  $LRR$  is derived by subtracting the log of the estimate of  $L^*$  from the log of the total number of year-end employees. The ratio  $M^*/\bar{L}$  is obtained by dividing the real

<sup>26</sup> Although more pressure to increase wages probably emanated from the growing private sector, annual data on that sector’s wages at the provincial levels is unavailable. Wages in COEs should provide an adequate reference point for general provincial wage trends in non-state sectors. We also used the average wage of SOEs, the average wage of all formal employees, and rural income per laborer in place of the wages of COEs and found that the results were fairly robust to the choice of variables.

<sup>27</sup> Some urban collectives also provide their employees with housing subsidies. This part of compensation is not included due to the lack of information.

<sup>28</sup> Note that the pension–wage ratios for urban COEs derived from provincial data are similar to the ratios for the SOEs estimated using the information from the panel. For urban COEs, the ratios are 0.126 in 1991, 0.134 in 1992, 0.144 in 1993, and 0.141 in 1994, whereas the ratios for the SOEs are 0.135, 0.136, 0.142, and 0.145, respectively.

<sup>29</sup> Observed wages are used as a proxy for the constrained optimal wages,  $W^*$ . An alternative proxy variable for the constrained optimal wage is the predicted value of the wage equation. The results of the  $LRR$  analysis with the predicted wage are not qualitatively different from those derived from observed wages. The estimates of  $LRR$  based on observed wages are more compatible to those obtained by other researchers (for example, see Li and Xu, 2001).

Table 2  
Summary statistics of variables involved in the regressions, 1991–1994

Variables involved in the production function regression						
	$Q$ (10,000 yuan)	$M$ (10,000 yuan)	$K$ (10,000 yuan)	$L$ (employees)	$W$ (yuan)	$A$ (yuan)
Mean	6990.07	4183.53	3719.85	1970.13	4506.09	2505.81
Std. Dev.	(24,509.19)	(13,766.62)	(15,389.85)	(3623.33)	(1575.69)	(550.75)
Variables involved in the labor redundancy analysis						
Variables at the enterprise level						
	MLR (10,000 yuan) <sup>a</sup>	$W$ (yuan)	CLR (10,000 yuan) <sup>a</sup>	RLLPA (yuan/yuan)	PLLBL (yuan/yuan)	RPPA (yuan/yuan)
Mean	2.114	4506.09	1.688	0.805	0.863	0.019
Std. Dev.	(2.294)	(1575.69)	(6.219)	(0.630)	(0.189)	(0.632)
	IOR (yuan/yuan)	CUR (%)	RFW (yuan/yuan)	HC (empls/empl)	FMS	
Mean	0.221	77.284	0.313	0.415	0.158	
Std. Dev.	(0.167)	(23.12)	(0.149)	(0.186)	(1.602)	
Variables at the provincial level						
	$A$ (yuan)	PUENS	ILP (10,000 yuan) <sup>a</sup>	GROWTH		
Mean	2505.82	0.328	0.737	0.141		
Std. Dev.	(550.74)	(0.056)	(0.204)	(0.096)		

Note. The definitions of the variables and the sources of the data are given in Section 5. The means of  $Q$ ,  $M$ ,  $K$ , and  $L$  differ from those of GVIO, NVFA, Material inputs and employment reported in Table 1 because they are calculated from the sample omitting the 1990 observations and all missing observations for the variables used in the empirical analysis. Moreover, the mean of  $W$  is higher than that of the average wage reported in Table 1 as a result of including indirectly costs of labor such as collective welfare, housing subsidies and pension contribution by the enterprise.

<sup>a</sup> Per employee.

value of material input by the total number of employees. The ratio  $K/\bar{L}$  is the real net value of productive fixed assets divided by the total number of employees.

We use three measures as proxies for working capital,  $R$ , or the enterprise's ability to cover its variable costs. These are the ratio of long-term liability to productive assets, RLLPA, the proportion of long-term liabilities taking the form of bank loans, PLLBL, and the ratio of profits to productive assets, RPPA, lagged by one period. The first two variables measure the amount of bank credit that is available to the SOE for its daily operation. Other things being equal, the higher are the RLLPA and PLLBL, the less is the bank credit that can be obtained and used by the enterprise to pay for its variable inputs.<sup>30</sup> RPPA is used as a proxy variable for retained profits, the value of which is missing for a large proportion of enterprises in the sample. A time trend is used to control for the effect of the prices of material inputs in Eqs. (10) and (14) because information on this variable is not available.

<sup>30</sup> The data series on interest payments are not used because they are available only for 1993 and 1994 in the panel data.

The inventory–output ratio, IOR, the capacity utilization rate, CUR, and the annual rate of growth in real GVIO in each industrial branch, GROWTH, are used as proxy variables for the demand shifter,  $\sigma$ . We look at shifts in demand facing individual SOEs as well as those for the industrial branch aggregated at the national level. The shift in demand is negatively correlated with IOR and positively correlated with CUR and GROWTH. Hence, a change in IOR is expected to have a positive effect on *LRR*, whereas a change in CUR or in GROWTH should have a negative effect on *LRR*. Human capital, HC, is defined as the proportion of employees with senior–high-school education or higher. The degree of enterprise autonomy over worker compensation is measured by the ratio of flexible pay to total monetary compensation, RFW, lagged by one period. Except for the time trend and GROWTH, all these variables are derived using the information from the panel data. The information on GVIO for each of more than thirty industrial branches is obtained from *China's Statistical Yearbook* of various issues.

Monopoly power,  $\varepsilon_P$ , is measured by the market share of the SOE in an industry, FMS. FMS is defined as the sales revenue of an enterprise divided by the GVIO of the narrowly defined industrial branch, i.e., one of the 30-plus branches, to which the enterprises belongs. The information on sales revenue and for the industrial classification is provided by the panel data set. *LRR* is expected to be negatively correlated with the market share of a SOE, because it is taken as a measure of the market power of the enterprise. The variable used as the proxy for the opportunities of alternative employment available to SOE workers,  $E_A$ , is the percentage of urban employment provided by non-state enterprises in a province, PUENS. This variable is introduced to the wage, material input, and *LRR* regressions to control for the change in the exogenously imposed employment constraint. All of the provincial variables are obtained from *China's Statistical Yearbook* of various years. The data used in the production function regressions and the labor redundancy analysis cover the period from 1991 to 1994. One year of observations was lost because one-period-lagged variables are involved in the material input, wage and *LRR* regressions and the predicted values of wages are used as an instrumental variable for  $W$  in the production function regression. Summary statistics of the variables involved in the labor redundancy analysis are presented in the second part of Table 2.

## 6. Empirical results

### 6.1. Estimates of the labor redundancy rate

The results of the production function regressions are presented in Table 3.<sup>31</sup> For the sake of comparison, we report both two-stage least squares and ordinary least squares versions of the fixed-effects (LSDV) and random-effect (GLS) estimates of the efficiency-wage-augmented production function regression. Judging by the adjusted  $R^2$ s, all the

<sup>31</sup> In these regressions, the coefficients of the production function are assumed to be the same for all industrial branches and to be constant over time. We also tried fitting the production function by allowing the technology to vary across four broadly defined industrial branches, i.e., mining and forestry, light consumer goods, heavy industry, and utilities, and over time with industry dummy variables and year dummies interacted with these industrial dummies. However, the estimates of these industry dummies and interacted dummy variables were not statistically significant.

Table 3  
Production function regressions

Indep. vars. and test statistics	Dependent variable = $\text{Log}(Q)$			
	Fixed-effects	Random-effects	Fixed-effects	Random-effects
	LSDV	GLS	LSDV	GLS
$\text{Log}(M)$	0.877 (78.744)*	0.835 (91.438)*	0.872 (79.191)*	0.829 (92.039)*
$\text{Log}(K)$	0.079 (5.521)*	0.087 (7.667)*	0.072 (5.019)*	0.083 (7.351)*
$\text{Log}(L)$	0.131 (4.369)*	0.069 (3.726)*	0.144 (4.852)*	0.078 (4.196)*
$\log(\widehat{W} - A)$	0.048 (3.774)*	0.046 (4.715)*	–	–
$\text{Log}(W - A)$	–	–	0.039 (6.949)*	0.039 (7.298)*
1992	–0.022 (–3.251)*	–0.017 (–2.618)*	–0.024 (–3.753)*	–0.021 (–3.152)*
1993	–0.028 (–4.085)*	–0.029 (–4.183)*	–0.032 (–4.727)*	–0.031 (–4.632)*
1994	–0.049 (–6.565)*	–0.054 (–7.508)*	–0.046 (–6.434)*	–0.050 (–7.134)*
Hausman test I		68.27		71.29
$p$ -value		0.0		0.0
Hausman test II		210.53		–
$p$ -value		0.0		–
Instrument-validity tests				
$\chi^2$	3.934	–	–	–
$p$ -value	0.685			
Adjusted $R^2$	0.992	0.989	0.993	0.989
Observations	2249	2249	2249	2249

Notes. 1. The table presents regression coefficients. The numbers in parentheses are  $t$ -statistics. The symbols \*, \*\*, and \*\*\* indicate significance at the 1, 5, and 10 percent levels, respectively.

2.  $\widehat{W}$  is the predicted value of the full wage,  $W$ .

3. Hausman test I is the test value for the specification of the random and fixed effects models and Hausman test II is the test value for the null hypothesis that the full wage is not correlated with the error term.

regressions fit the data very well and all the estimates are fairly similar. Specifically, all the estimates of input coefficients have the expected signs and are significant at the 1% level. However, as expected, the Hausman test based on a comparison of the LSDV and GLS estimates rejects the random effects model in favor of the fixed effects model. Hence, the test for instrument validity is performed only on the fixed-effects equation. This test fails to reject the hypothesis that the instrumental variables are valid at any conventional level of significance. Moreover, the Hausman test based on a comparison of the two-stage LSDV and LSDV estimates rejects the null hypothesis that the wage variable,  $W$ , is uncorrelated with the error terms. These test results suggest that, among the four regressions, only the two-stage LSDV estimates, reported in the first column of Table 3, are consistent. Hence we use the two-stage LSDV estimate of the labor coefficient to compute  $LRR$ .

Before discussing the labor redundancy analysis, we consider the results of the production function regression using the two-stage LSDV method. The estimates of year dummies show that the total factor productivity of SOEs in the sample fell at a rate of 1.6% per year from 1991 to 1994.<sup>32</sup> The estimate of returns to scale, i.e. the sum of the first three estimated coefficients in column 1, is 1.09, indicating that the production technology used by the sample SOEs displayed increasing returns to scale. The estimate of the wage elasticity provides strong support for the efficiency wage thesis, showing that a 1% increase in the internal wage relative to the average wage of the urban collectives would increase effort by 0.35% and output by 0.048%.

Using the two-stage LSDV estimates of the factor coefficients in column 1 of Table 3, we calculate the marginal products of factor inputs and the labor redundancy rates (*LRRs*) and present the results in Table 4.<sup>33</sup> As the table indicates, the mean value of the marginal product of labor (*MPL*) rose from 3846 *yuan* in 1991 to 4135 *yuan* in 1992 and then fell to 3988 *yuan* in 1994. In contrast, total worker compensation grew more steadily and rapidly, from 4076 *yuan* to 4736 *yuan*. The mean of *LRR* was 28.6% in 1991 and increased to 44.4% in 1994. In 1991, 65.0% of the SOEs in the sample had redundant workers. Like the mean value of *LRR*, the median value of *LRR* and the proportion of the SOEs with surplus workers grew over time. In 1994, the median of *LRR* reached 42.6%, and about 73% of the SOEs in the sample had redundant workers.<sup>34</sup> These estimates of *LRR* are consistent with the assessment that at least some 20 to 30% of the workforce employed by China's industrial SOEs were redundant.<sup>35</sup> Column 9 of Table 4 displays the *t*-statistics for the difference in the population means between actual employment and estimated optimal employment,  $L^*$ , using the paired sample method (Kvanli et al., 1996). The *t*-test rejects the null hypothesis that a typical SOE employed workers to the point where the marginal product of labor was equal to its wage rate with a *p*-value approaching zero for all years combined and *p*-values at the 5% level or better for each year. These test results confirm that overstaffing, using as a benchmark the commercial viability of enterprises in a competitive market environment, had become a widespread phenomenon in China's industrial SOEs in the early 1990s.

<sup>32</sup> Dividing the estimated 1994 dummy value of  $-0.049$  by 3, we obtain the instantaneous annual rate of growth as  $-0.0163$ .

<sup>33</sup> The use of average factor coefficients for the entire sample to calculate marginal products of individual enterprises is admittedly restrictive. However, this approach does not necessarily bias the analysis of labor redundancy. Since *LRR* is defined in log form and  $\ln L^* = \ln \alpha_1 + \ln Q - \ln W^*$ , the variation in the labor coefficient,  $\alpha_1$ , across enterprises will become a part of time-invariant firm-specific effects that are eliminated from the regression of *LRR* by the LSDV method. Moreover, despite the application of a single estimate of factor coefficients for all enterprises, the estimated marginal products of factor inputs vary considerably over the sample as indicated by the size of their standard deviations relative to their mean values in Table 4.

<sup>34</sup> In Dong and Putterman (2001), we estimate the production function without the efficiency wage term using the same panel of SOEs from 1980 to 1994. We find that the estimated fraction of SOEs with redundant labor was less than one third from 1983 to 1990 and exceeded 50% for the first time in 1993.

<sup>35</sup> Using aggregate data at the provincial level, Li and Xu (2001) estimate that the mean and median rates of labor redundancy in the SOEs from 1993 to 1996 are 23.5% and 26.3%, respectively. Marukawa (2000), estimating redundant labor and capital in SOEs by assuming that they have the same production functions as foreign-invested enterprises, concludes that 34% of industrial SOE employees were redundant in 1995.

Table 4  
Profits, marginal products, full wage, and labor redundancy rates, 1991–1994

Year	MPK (yuan/ yuan)	MPM (yuan/ yuan)	MPL (yuan)	W (yuan)	Mean LRR (%)	Median LRR (%)	% of SOEs with RL (%)	<i>t</i> -statistics	No. of SOEs
Mean	0.213	1.614	3984	4510	36.5	34.2	69.9	5.742 (0.0)	556
S.D.	0.146	0.600	3211	1576	72.0	–	–	–	
1991	0.223	1.634	3846	4076	28.6	26.3	65.0	2.291 (0.021)	546
1992	0.229	1.615	4135	4485	32.6	27.3	67.9	2.848 (0.004)	552
1993	0.215	1.622	4030	4718	39.8	37.9	73.2	3.256 (0.001)	556
1994	0.189	1.582	3988	4736	44.4	42.6	73.3	3.485 (0.001)	528

Notes. 1. The statistics reported in this table are calculated by omitting all missing observations and all observations that lie outside the range of three standard deviations from the mean of each variable.

2. MPK, MPM, and MPL are the average marginal product of capital, materials, and labor, respectively.

3. *W* is full wage.

4. Mean or Median *LRR* is, respectively, the mean or median value of the labor redundancy rate of all enterprises in the sample.

5. The % of SOEs with RL is the percentage of the sample SOEs with redundant labor.

6. The *t*-statistic is computed to test the null hypothesis that the employment level of the SOEs is equal to the level of employment derived from the equality of the wage with the marginal product of labor. The number in parentheses is the *p* value.

The trend of rising labor redundancy was concomitant with the trend of declining TFP and falling profits per *yuan* of productive capital assets in these enterprises. Moreover, the mean value of the marginal product of material input (MPM) was consistently greater than unity from 1991 to 1994, indicating that SOEs purchased less material input than the quantity at which marginal returns of factors were equal to marginal costs. This result is consistent with the widespread shortage of material inputs and energy supplies among SOEs reported in the manager survey mentioned earlier. The causes of the suboptimal allocation of material input in SOEs as well as the impact of the shortage of material inputs on the allocative efficiency of labor are examined next in the analysis of labor redundancy.

## 6.2. Analysis of the rise of labor redundancy

The LSDV estimates based on Eqs. (9), (10), (13), and (14) are reported in Table 5. All four equations fit the data well with each explaining between 80 and 93% of the variation in the respective dependent variable. The primary purpose of the wage and material input regressions is to examine how the increasing unavailability of financial resources affected the choice of material inputs and wages by SOEs in the early 1990s. The estimates indicate that the material–labor ratio of an enterprise was negatively correlated with its debt–assets ratio and bank loan–debt ratio and positively correlated with its lagged value of profits per *yuan* of productive fixed assets. The effects of debt–assets ratio and lagged profitability are significant at the 5% level or higher. These results confirm that a shortage of working capital resulting from the escalation of SOEs' interest and loan payments to the banks and from falling profits, played an important role in explaining the SOEs' suboptimal demand for material inputs in the early 1990s. The estimate of the time trend shows that the

Table 5  
Regression analysis of rising labor redundancy, 1991–1994

Indep. vars. and test statistics	Dependent variables			
	Log( <i>MLR</i> )	Log( <i>W</i> )	<i>LRR</i>	<i>LRR</i>
	Fixed-effects LSDV	Fixed-effects LSDV	Fixed-effects LSDV	Fixed-effects LSDV
Time trend	−0.085 (−8.885)*	−0.048 (−3.914)*	0.030 (2.107)**	0.038 (2.684)*
RLLPA	−0.018 (−2.197)**	−0.009 (−1.681)***	–	−0.034 (−0.924)
PLLBL	−0.089 (−1.451)	−0.045 (−1.121)	–	−0.095 (−1.027)
Lagged RPPA	0.154 (6.163)*	0.035 (2.156)**	–	−0.119 (−3.626)*
Log( <i>A</i> )	0.040 (0.308)	1.051 (25.718)*	−0.013 (−0.047)	0.518 (2.706)*
Log (ILP)	0.558 (5.168)*	–	–	−0.156 (−0.954)
Lagged RFW	–	−0.195 (−3.024)*	–	−0.298 (−1.901)***
HC	–	1.119 (8.723)*	–	0.626 (2.027)**
PUENS	−0.284 (−0.637)	−1.107 (−3.914)*	−0.346 (−0.501)	−0.803 (−1.207)
Predicted Log( <i>MLR</i> )	–	–	−0.743 (−4.962)*	–
Predicted Log( <i>W</i> )	–	–	0.806 (3.287)*	–
Lagged CLR	–	–	−0.284 (−6.432)*	−0.299 (−6.279)*
IOR	–	–	0.083 (3.525)*	0.091 (3.831)*
CUR	–	–	−0.001 (−2.896)*	−0.001 (−2.962)*
Growth	–	–	−0.138 (−1.336)	−0.161 (−1.554)
FMS	–	–	−4.670 (−2.319)**	−4.818 (−2.377)**
Hausman test	20.427	75.381	25.499	28.765
<i>p</i> -value	0.005	0.0	0.008	0.036
Instrument-validity tests				
$\chi^2$	–	–	11.327	–
<i>p</i> -value	–	–	0.125	–
Adjusted $R^2$	0.928	0.805	0.878	0.877
Observations	2361	2361	1215	1215

Notes. 1. The table presents regression coefficients. Numbers in parentheses are *t*-statistics. \*, \*\*, and \*\*\* indicate significance at the 1, 5, and 10% levels, respectively.

2. RLLPA is the ratio of long-term liability to productive assets, PLLBL is the proportion of long-term liability in the form of bank loans, RPPA the ratio of profits to productive assets, *A* the reference wage, ILP the provincial average of industrial labor productivity, RFW the ratio of flexible pay to total monetary compensation, HC the proportion of employees with senior-high school education or higher, PUENS the percentage of urban employment provided by non-state enterprises, *MLR* material-labor ratio, *W* full wages, CLR capital-labor ratio, IOR inventory-output ratio, CUR capacity utilization rate, Growth annual rate of growth in *GVIO*, and FMS the market share of a SOE in an industry.

3. The Hausman test is the test value for the specification of the random and fixed-effects models.

material–labor ratio of the SOEs fell at a rate of 8.5% per year from 1991 to 1994, capturing perhaps the impact of the rising prices of materials, power and fuel. That absolute scarcity of material inputs also played a role cannot be ruled out and is supported by the highly significant coefficient on province-level industrial labor productivity if, as we conjecture, more developed provinces had more adequate input supplies. The reference wage,  $A$ , and the share of urban employment by non-state sectors,  $PUENS$ , did not have a significant effect on the allocation of material inputs.

The estimates of the wage equation show that the debt–assets ratio and loan–debt ratio both have a negative effect on wages, as predicted by the model, but only the debt–assets ratio is significant at the 10% level. Lagged profits per *yuan* of productive assets have a significant positive effect on wages. Thus, as with their choice of material inputs, the SOEs' wage decision appears to have also been subject to financial discipline in the early 1990s, as the enterprise's ability to pay for its variable costs became important in both cases. The wage equation also contains some other interesting results. The estimates of the reference wage, the pay structure and the human capital factor are all significant at the 1% level. The reference wage appears to have been an important driving force in the rise of wages as a 1% increase in the reference wage raises the wage by more than 1%. The wage was also responsive to the change of human capital as a 1% increase in the proportion of employees with a senior high school education or higher would result in a more than 1% increase in the wage. These findings indicate that SOEs began to pay competitive wages in order to maintain the work morale of their employees and retain skilled laborers in the emerging industrial labor market.<sup>36</sup> The lagged ratio of flexible pay to total monetary compensation is negatively correlated with the wage, which seems to suggest that managers used their autonomy to impose wage discipline rather than to extract rents for their employees. The significant and negative estimate of the percentage of urban employment by non-state sectors,  $PUENS$ , is puzzling because it contradicts the prediction that a rise in the availability of alternative employment opportunities reduces the exogenously imposed employment level and consequently enables the enterprise to pay a higher wage.<sup>37</sup> With all these factors held constant, the real wage fell at an annual rate of 4.8% from 1991 to 1994, according to the estimate of the time trend in the wage equation.

Having shown that the shortage of working capital was an important determinant of the SOEs' suboptimal choice of non-labor current inputs and wages, we now examine how the inefficient choice of these variables affected allocative efficiency of labor using the estimates of the structural labor redundancy equation in column 3 of Table 5.<sup>38</sup> As

<sup>36</sup> Derived from data at the enterprise level, our estimates of the wage response to the human capital variable do not, however, shed light on whether individuals with greater training were paid more and whether there was a return to education at the individual level within the enterprise.

<sup>37</sup> This result may reflect the fact that provinces with more vibrant non-state sectors in the cities, such as Sichuan and Shanxi, are less developed regions and have lower wages, compared with Jiangsu and Jilin, the other provinces in the sample.

<sup>38</sup> In this regression, the predicted values of wages and the material–labor ratio in Eqs. (9) and (10) are used as instrumental variables for  $W^*$  and  $M^*/L$ . The instrument validity test reported at the bottom of column 3 in Table 5 fails to reject these variables as valid instruments at any conventional level of significance.

predicted, the labor redundancy rate (*LRR*) is negatively correlated with the material–labor ratio and positively correlated with wages, with both estimates being significant at the 1% level. Quantitatively, *LRR* increases by 0.74% for a 1% decrease in the materials–labor ratio and decreases by 0.81% for a 1% decrease in wages. The shortage of material inputs, resulting in part from a scarcity of funds, was evidently an important contributing factor to the rise of labor redundancy. However, wage restraint due to the shortage of funds appears to have acted to dampen the rise of *LRR*.

The estimates of the structural equation also shed light on other major determinants of *LRR*. As expected, the capital–labor ratio (*CLR*) has a significant negative effect on *LRR*. A comparison of the size of the estimates of the material–labor ratio (*MLR*) and the capital–labor ratio (*CLR*) indicates that there is a greater complementarity between material input and labor than between capital and labor. Moreover, *LRR* is positively correlated with the inventory–output ratio, *IOR*, and negatively correlated with the capacity–utilization rate, *CUR*, and the annual rate of growth in *GVIO* of the industrial branch, indicating that the rise of *LRR* was associated with the SOEs' inability to adjust its workforce to downward shifts in demand. The estimates of the proxy variables for monopoly power confirm that the rising competition in product markets played a role in explaining the growth of surplus labor in SOEs. Specifically, the *LRR* declines when an enterprise's output share, *FMS*, increases, and this effect of output shares is significant at the 5% level. Finally, the opportunities of alternative employment available to SOE employees in the cities, *PUENS*, has a negative effect on *LRR* as expected but this effect is statistically insignificant.

The last column of Table 5 reports the estimates of the reduced-form labor redundancy equation to examine the net effect of a change in the liquidity constraint on *LRR*. Recall that an increase in working capital can either reduce *LRR* by raising the demand for material inputs or increase *LRR* by raising wages. Empirically, among the three proxy variables for financial resource constraints, only the lagged profits–assets ratio is statistically significant and has the expected negative sign. This result indicates that the shortage of working capital contributed to the rise of labor redundancy in SOEs on balance.

The reduced-form regression also sheds light on other determinants of *LRR* and reconfirms the findings of the structural equation for the effects on *LRR* of the capital–labor ratio, shifts in demand, monopoly power, and the availability of alternative employment. The estimates of the reduced-form regression also show that the reference wage, *A*, has a significant positive effect on *LRR* as a 1% increase in *A* will increase *LRR* by 0.52%. Evidently, the wage pressure from non-state sectors contributed to the growing labor redundancy in SOEs as hypothesized. The human capital variable, *HC*, which is found to have a positive effect on wages, also has a significant positive impact on *LRR*. One possible explanation is that, faced with considerable wage compression, paying higher wages to more educated workers required SOEs also to pay higher wages to less educated ones, increasing the gap between the average wage and the marginal product of labor. Finally, *LRR* is negatively correlated with the lagged ratio of flexible pay to total monetary compensation, *RFW*. Perhaps SOEs used downward wage flexibility to absorb surplus laborers that they were unable to dismiss. This finding is consistent with the observations that firms in transition economies display employment stickiness and absorb shocks by fluctuations in wages (Standing, 1996).

## 7. Conclusion

Most analysis of state-owned industry in China and in other formerly planned economies adopts some version of a soft budget constraint, according to which SOEs are doomed to be inefficient because they expect to be protected from the consequences of inefficiency by government support. A somewhat different view is that SOEs in China have achieved some increased efficiency, but have been prevented from achieving even greater improvements because of the unequal policy burdens placed upon them by the state (Perotti et al., 1999; Bai et al., 2000).<sup>39</sup> The focus of this paper is not on the issue of endemic inefficiency of state-owned enterprises, but rather on the causes of the sharp upturn in labor redundancy in those enterprises in the early 1990s in China. Our production function estimates indicate declining total factor productivity for the period. However, our main finding is that the increase in labor redundancy was the result neither of a short-term expansion of employment or increased wages fostered by budgetary laxness nor of an accession to workers' rent-sharing demands. Rather, the immediate causes of redundancy were a growing shortage of non-labor inputs resulting partly from the increasing unavailability of financial resources, from binding constraints on downward adjustment of employment, from increasing product market competition, from downward shifts in demand, and from wage increases driven by the need to track increasing wages paid by non-state enterprises. Financial and employment constraints forced SOEs to reduce input use, which both reduced output and profits and exacerbated the financial and employment constraints.

The problems of growing labor redundancy, indebtedness, and financial losses in state industry in the early and mid-1990s attracted considerable policy attention in China. In the 15th National Congress of the Chinese Communist party held in late 1997, China's leaders decided to reform the SOE sector further by retaining state ownership only in large- and medium-scale enterprises and by privatizing most small state enterprises. The leaders pledged to reverse the money-losing situation of large and medium-scale SOEs within three years by a large-scale reduction of the workforce, among other measures. In 1997, the Ministry of Labor projected that an average of 4.3 million SOE employees would be laid off in each of the next three years. In the meantime, measures were taken to reduce the burden of loan payments and debt service resulting from policy obligations born by the enterprises.<sup>40</sup> According to the Chinese media, the financial performance of SOEs in the late 1990s has improved.<sup>41</sup> However, whether such a trend of improvement is sustainable and what factors are responsible for the reversal of loss-making in the SOE sector remain controversial. Our estimates suggest that lay-offs of the magnitudes

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<sup>39</sup> On the efficiency gains resulting from reform, see Chen et al. (1988) and Jefferson et al. (1992). Putterman (1992) predicts that SOEs will be consigned to an undynamic and inefficient role in the economy so long as the government uses them to maintain social stability.

<sup>40</sup> See "The Government Work Report" by Li Peng in the first plenary meeting of the 9th Congress of China's People Representatives on March 5, 1998 in *People's Daily* of March 21, 1998.

<sup>41</sup> For example, it was reported by the National Bureau of Statistics (NBS) that the index of industrial economic efficiency rose by 17.1 percentage points in the first three quarters of 2000 in comparison with the index of 1999, see *People's Daily* of November 1, 2000.

mentioned above would leave many enterprises still facing binding employment constraints and thus dependent upon some combination of subsidies and inefficient input choices to meet their employment obligations. Therefore, chronic inefficiency might be expected to continue to plague many if not most SOEs.

Two limitations of our analysis should be mentioned. First, although the production function estimates display a good fit and tests of differences by sector show aggregation to be permissible statistically, characterizing SOEs in so many industries by a common technology is a heroic assumption. Second, the treatment of labor as a homogeneous factor of production may abstract from important aspects of wage setting and effort supply. For example, although we found average wages to be responsive to changes in average human capital at the enterprise level and average effort to be responsive in turn to average wages, the wage differential between skilled and unskilled workers may have remained smaller than required by an efficient incentive system. The fact that an efficiency wage relationship between wages and effort is indicated by our results does not rule out the possibility that wages remained too low to motivate effectively and retain the most skilled workers, but higher than necessary to retain and motivate the least skilled ones.

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