CES Working Paper Series

AUTONOMY AND INCENTIVES
IN CHINESE STATE ENTERPRISES

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Working Paper No. 42

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CES Working Paper No. 42
August 1993

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Abstract

When the responsibility for output decisions was shifted from the state to the firm, and when firms were allowed to retain more of their profits, managers of Chinese state-owned enterprises strengthened workers' incentives: paying more in bonuses, and hiring more workers on fixed-term contracts. The new incentives were effective: productivity increased with incresases in bonus payments and in contract workers. The increase in autonomy raised workers' incomes (but not managers' incomes) and investment in the enterprise, but tended not to raise remittances to the state.

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I. CHINA'S INDUSTRIAL REFORMS

In deciding the best way to reform a planned economy, one of the crucial questions is about the prospects for improvements in state-owned firms' notoriously low productivity. Can changes in policy induce state firms to perform better? We will offer evidence that in one reforming economy, China, state-owned firms' productivity has been significantly improved by the introduction of some elementary incentives.

Beginning in 1978 and continuing throughout the 1980s, China reformed its industrial sector. Enterprises that had been largely controlled by the state were given some market or market-like incentives (though by the end of the decade, twelve years into the reforms, they were still a long way from looking like capitalist firms). State-owned enterprises were allowed to keep some fraction of their profits, where before all profits had to be remitted to the state; enterprises began to sell some of their outputs and buy some of their inputs in free markets, rather than selling and procuring everything at state-controlled prices; managers were given monetary rewards explicitly based on their firm's performance; and the right to decide what to produce, how much to produce, and how to produce it was shifted down from the state to the enterprise [Byrd, 1991; Naughton, 1994].

Workers' lack of motivation has been a major problem in Chinese enterprises. That productivity could be improved by strengthening the workers' incentives is suggested by anecdotal accounts of inactivity in pre-reform Chinese factories; of workers idling away the day after fulfiling some minimal quota. One of the reforms tried in China was the shifting of responsibility for output decisions from the level of the state to the level of the firm. Another was to increase the fraction of its profits that the firm could retain. The hypothesis to be developed and tested here is that a firm's manager should respond to these increases in autonomy by strengthening the workers' performance incentives; and, as a result, the firm should become more productive.

Reforms can be ineffective. Managers may fail to respond to the opportunities created by their expanded autonomy. Partial efforts at reform may be contradictory either with themselves or with the remnants of the planning system. It is often argued that partial reforms are useless. "I am relatively pessimistic about the effectiveness of reforms that rely on shifting decision making and financial responsibility to the enterprise level until there is a fundamental reform of the price system," says Johnson [1988, pp. S241-S242], for example: "Planned control by the center of inputs and output may well be a superior *n*th best solution to decentralized decision making with an inappropriate price structure." We ask whether China's partial reforms--shifting decision responsibilities to managers while leaving the firms state-owned--has resulted in perceptible improvements in enterprise productivity.

Our empirical analysis will ask whether, when the responsibility for deciding output levels was shifted down from the state to the firm, and when the firm's marginal profit-retention rate was increased, managers of Chinese state-owned enterprises responded by strengthening the discipline imposed on workers (by increasing the proportion of the workers' income paid in the form of bonuses, or by increasing the fraction of workers whom, being on fixed-term contracts, it was in principle possible to fire). We will then ask whether the new incentives were effective: did productivity increase significantly with the stronger incentives? The next set of questions will be about who benefited from the reforms. Did the increased autonomy result in higher incomes for workers and/or managers? Was autonomy followed by more investment by the enterprises? Did autonomy result in smaller subsidies or larger remittances to the state?

Chinese industrial productivity growth accelerated markedly in the reform period of the 1980s. Before the reforms, industrial productivity had been almost stagnant: total factor productivity grew at an annual rate of only 0.4 percent between 1957 and 1978 (according to Chen et. al. [1988]). This changed after the reforms began: between 1978 and 1985 industrial productivity grew at an annual rate of 4.8 percent (Chen et. al. [1988]);

and it continued to grow strongly after 1985. For the firms in our sample, between 1980 and 1989 total factor productivity rose at an average annual rate of 4.5 percent. [1]

Not all of this improvement in productivity is attributable to the particular reforms we investigate here. A large number of reforms were introduced in gradual and piecemeal forms; changes in behavior were the result of the total impact of these incremental reforms. An important source of gains is the extra discipline resulting from the increased product-market competition that these firms have faced, both from other state firms and from new, nonstate firms [McMillan and Naughton, 1992]. Gains also came from better methods of selecting managers and from linking managers' pay and career prospects to their firms' performance [Groves, Hong, McMillan, and Naughton, 1993a]. The reforms we analyze here are only part, but an important part, of a broad process of change.

II. THE COSTS OF HIERARCHY

In order to learn about costs so as to decide on appropriate output quantities, and in order to to learn how to organize production so as to minimize costs, the ultimate decision-maker (the central planner in a planned economy, or the firm's manager in a decentralized economy) must rely in part on information that comes from below. Information about how high costs are, whether workers could be reassigned to increase productivity, whether excessive inventories are being held, what improvements in production techniques could feasibly be introduced, how well newly introduced techniques are working, and so on must be gathered from workers and foremen. Information inevitably becomes distorted as it moves up through the organization: bargaining costs are created as people try to use any information they have to influence the decisions that will be based on that information (as Milgrom and Roberts [1988, 1990] noted in their theory of influence costs). Costs of hierarchy arise from the fact that information becomes distorted within the firm as it is transmitted from production floor to management; and, in the case of firms subject to

central planning, the information is further distorted in the communications between the firm and state agencies, as has been noted by observers of Chinese enterprises. "The basic problem is that the narrow channels connecting subordinates to superiors become clogged with pseudo-information, which is often intentionally distorted. While the system continues to report thousands of 'bits' of data, the actual information content is quite limited" [Naughton, 1991]. "In their dealings with industrial bureaus and government agencies, managers engage in continual face-to-face bargaining over the setting of mandatory production plans ..., and in procuring low priced supplies, subsidized credit and tax breaks. The bargaining, invariably including a measure of deception, and sometimes the cultivation of official favor, has several goals" [Walder, 1987, p. 36].

People's proclivity to exploit any information they have affects the incentive system offered within a firm. In the McAfee-McMillan [1991] model of the interaction of hierarchy and incentives, informational asymmetries and the rents they create result in workers being given incomplete performance incentives. The incentives imposed on production workers will be more stringent, according to this analysis, the shorter the hierarchical distance between the production floor and the ultimate decision-maker. The logic of this result is that informational distortions increase cumulatively as information moves up a hierarchy, as each person through whose hands the information passes uses the information to gain some bargaining advantage. The shorter the hierarchy, therefore, the less concerned the top decision-maker need be about giving incentives for information transmission, so the more the decision-maker can focus on providing performance incentives. The mere fact that the right to make output decisions is shifted down from the state to the enterprise ought by itself to result in stronger worker incentives and consequently improved productivity.[2] In what follows we use data on reform-era Chinese state enterprises to test this proposition.

Managerial decision-making autonomy would be meaningless, however, if the enterprise were required to remit all its profits to the center. Conversely, the larger the

fraction of its profits the enterprise is allowed to retain, the stronger the manager's incentives to improve productivity. We shall look at the effects on internal incentives of increases in the enterprise's marginal profit-retention rate.

Differences in managers' and bureacrats' objectives provide an additional reason why the grant of output autonomy will be followed by a strengthening of workers' incentives. The industrial bureau may want to maintain excessive employment.at the expense of productive efficiency [Boycko, Shleifer, and Vishny, 1993]. The shifting of decision-making rights to the manager will result in production being organized more efficiently, provided the manager is at the same time given a stake in the firm's profits (which increases in the marginal profit-retention rate and other managerial reforms did achieve--see Groves et. al. [1993a].)

Bonuses, having been denounced in China as politically unacceptable in 1966, were revived in 1978 [Walder, 1987, pp. 23-24]. But giving managers the right to offer bonuses to workers did not ensure that they were immediately used: bonus payments did not suddenly increase but rather rose steadily through the 1980s. It is personally costly for a manager to institute an incentive-payment scheme, in that it creates contention between workers and management, as well as among different groups of workers. Rewarding performance usually means increasing disparities among different workers' remuneration. Disputes arise over how to assess performance, how much to reward seniority, whether it is fair to create income inequalities, and so on. In the wage adjustments that occurred in 1977-1978 and 1979-1980, for instance, the "evaluations often became conflict-ridden, dragging on month after month, affecting morale, and creating dissatisfaction among those not chosen to receive rises" [Walder, 1987, p. 27]. Thus managers may be reluctant to introduce incentive schemes, even if they are being encouraged to do so by the state. The managers must be given some positive inducement to bear the costs involved in introducing worker incentives. In addition, the rules that govern bonuses may affect the ability of managers to institute effective incentive-payment schemes. When bonuses were first

revived, the total amount that could be paid in bonuses was fixed at a specified percentage of the wage bill, typically 10 percent. With total incentive payments limited, and growing only as rapidly as the basic wage, workers correctly treated bonus distribution as a zero-sum game and resisted differentiation. In 1984, the limit on bonuses was replaced by a progressive bonus tax paid by the enterprise. With this change, workers may have begun to perceive bonus distribution as a positive-sum game, reducing the costs incurred by management in instituting effective incentive-payment schemes. During the course of the 1980s, increased authority and autonomy granted to managers may have increased the effectiveness with which bonuses were used to elicit work effort.

Granting the manager autonomy changes the manager's incentives over the design of the workers' incentive system, according to the McAfee-McMillan [1991] model. Making it the manager's role to decide output, rather than merely to pass information up to the center, changes the manager's personal calculus. When decisions are made at the center, they are made using information supplied by the manager. It is in the manager's interest to exploit whatever bargaining power is to be obtained from his information; thus the information on which the center bases its decision is distorted. When the buck stops at the manager, more efficient decisions are made, because there are now fewer steps in the information-transmission chain. In particular, the manager would be expected to introduce performance payments to induce more effort from workers.

As well as immediate monetary rewards, workers can be given effort incentives by facing the prospect of losing their job. An additional consequence of output autonomy, therefore, is that managers will expand their ability to fire workers. Most workers in Chinese state enterprises have permanent jobs; but an increasing number have been hired on fixed-term contracts. It is easier for a manager to refuse to renew a worker's contract at the end of his term than it is to fire a permanent worker. According to aggregate data, a contract worker in 1989 was six times as likely to have a contract terminated than a permanent worker was to quit or to be fired [State Statistical Bureau, 1990a, pp.204, 218].

The introduction of an incentive-payment mechanism does not by itself guarantee that a factory's productivity will rise. It might be that in practice bonuses are paid out equally, regardless of individual productivity, so that they have no incentive effect. Often it is difficult to define adequate output measures; and basing payment on the wrong measures of performance can be counterproductive. Workers might collude against management, subverting attempts to reward good performers by imposing social sanctions on anyone who works too hard. Similarly, although workers on contracts in principle can be laid off at the end of their term so that they have some incentive to exert effort, in practice it may be that their contracts are always renewed, and thus they are effectively the same as permanent workers. Thus it is necessary to look at the data to see whether the strengthening of worker incentives was real or just apparent; whether the new incentives actually succeeded in improving productivity.

III. TRENDS IN AUTONOMY, INCENTIVES, AND PRODUCTIVITY

The data we use come from surveys conducted by the Institute of Economics, Chinese Academy of Social Science (CASS), in consultation with the authors of this paper as well as economists from the University of Michigan and Oxford University. Annual data for 1980-1989 for 769 enterprises in four provinces (Sichuan, Jiangsu, Jilin, and Shanxi) give details of the firms' internal incentives, the firms' cost and revenue accounts, and the nature of the relationship between the firms and the state. The questionnaires were sent out by the provincial System Reform Commissions (which are responsible for assessing and implementing reform measures) to 800 enterprises, and 769 valid questionnaires were returned. The System Reform Commission does not directly supervise enterprise activity, but it is an official government body with which the enterprise has regular interactions, which may account for the high response rate. The questionnaire had two parts. The first part, directed specifically to the factory manager, asked 70

questions, mostly qualitative, relating to the firm's incentive system and its relation to governmental supervisors. The second part, designed to be answered by the enterprise accountant, asked 321 quantitative questions covering almost every aspect of enterprise activity during the years 1980 through 1989.

All the firms sampled are state-owned, and large firms are overrepresented in comparison to state-owned firms in general. The sample therefore covers the core of the traditional state-run economy, the set of enterprises for which it is generally held that progress in reforms has been modest, compared to the small-scale, nonstate sector. The sample appears reasonably representative of state-run industry as a whole in dimensions other than enterprise size. Output per employee in 1980, the first year of the sample, was 11,329 yuan, 6 percent below the national average; by 1989, output per employee had increased to 18, 891 yuan (in constant 1980 prices), and was now 3 percent above the national average. Between 1980 and 1989, output per employee increased 67 percent in the CASS sample, slightly better than the 52 percent increase recorded for state-run industry as a whole.

Beginning in 1979, the Chinese government began granting expanded autonomy provisions to selected enterprises nation-wide. Initially, enterprises were granted rights to retain a share of profits and to sell some output outside state delivery quotas. Additional autonomy provisions were extended throughout the 1980s. Most state-owned firms in China are controlled by provincial and municipal governments, and expansion of autonomy occurred unsystematically. The factory managers answering the questionnaire were asked when they achieved autonomy to plan activity in six areas: value of output; physical quantity of output; product mix; production technology; production scheduling (quarterly or monthly); and exports. With the exception of production scheduling, which came earlier, and exports, which came later, the answers to the questionnaire show that the other four types of autonomy were tightly clustered, usually being achieved simultaneously. In the

regressions reported below, we take as one of our main explanatory variables the date of achieving autonomy to plan output value.

Autonomy is a multidimensional construction; but output autonomy is a crucial element, particularly in the Chinese context. The grant of output autonomy implies the enterprise's production activity is clearly separated from the obligation to turn over a certain amount of output to state delivery channels. With production autonomy, the state delivery plan is a compulsory contract, rather than the basis for surveillance and control of firm activity by government superiors. In other respects, the firms achieved a measure of "autonomy" very early in the reform process. By the early 1980s, nearly all firms were retaining a share of profits and had the authority to sell some portion of their output outside the plan. We hypothesize that, in such an environment, the grant of output autonomy was a crucial component required for a qualitative increase in overall autonomy, since it allowed firms to integrate incentives, sales, and production. (Conversely, most firms by the end of the 1980s still did not have clear rights to fire permanent workers.)

There is considerable diversity across the firms in the CASS sample as to when they were granted output autonomy. The number of firms in the sample receiving output autonomy in each year is shown in Figure I. In each year between 1980 and 1989 some firms were granted output autonomy, but it occurred most commonly between 1984 and 1988. While a few of the firms had output autonomy before 1980, some had not received it by the end of 1989.

Firms with output autonomy still operate with a number of obligations to bureaucratic superiors. Firms must deliver output at state-set prices according to contracts signed with their superiors: these contracts are in practice compulsory, and are typically tied to the supply of inputs, also at state-set prices. Such contracts are, however, invariably set at below full capacity levels. Firms then establish production schedules for additional output, typically transacted at market or near-market prices, using inputs also purchased from the market. Firms with output autonomy have the authority to establish

their own production schedules for all output, subject only to the constraint that they fulfil their contracts. The proportion of enterprise transactions carried out at planned prices, which reflects the share of compulsory state contracts, is shown in Table I for 1989. Enterprises in all five industries listed in Table I report that state controls affect a larger proportion (in value terms) of their outputs than their inputs: but all industries report a large volume of transactions outside state contracts and price controls. (For more on the dual-track system, see McMillan and Naughton [1993].)

Additional autonomy came through increases in the proportion of profits that the enterprises were allowed to retain.[3] The CASS survey gives data on ex ante marginal profit-retention rates, which is the appropriate measure of profit retention from the point of view of economic incentives. (Marginal profit-retention rates are given directly in the survey: the survey asks the firm's manager for the "ex ante rate of profit sharing from profit increase.") Most enterprises operated under a profit-contract system, in which marginal retention rates differed from -- and were generally higher than -- average retention rates. In the extreme case, some enterprises had a lump-sum profit delivery obligation and 100 percent retention on the margin. Marginal profit-retention rates steadily increased over the decade, rising from a mean (across firms) of 24 percent in 1980 to a mean of 63 percent in 1989 (see Figure II). In other words, by 1989 the typical firm was remitting 37 percent of its marginal profits to the state. The average numbers conceal considerable variation across enterprises in marginal profit-retention rates, however: while some enterprises were retaining 100 percent of their marginal profits by 1989, others were still remitting all their profits to the state.

Worker incentives changed steadily over time. The proportion of worker income received as bonuses, averaged over all the firms in the sample, doubled over the decade, increasing from just over 10 percent of remuneration in 1980 to over 19 percent in 1988, and dropping back slightly to just over 18 percent in 1989 (see Figure III). (Bonuses are distinguished from base wages, which a worker receives merely for showing up, in that

they are, in principle, discretionary from the standpoint of the manager. The worker receives a bonus only if he meets some performance standard. Of course, there is nothing that prevents the manager from setting the performance standard so low that everyone qualifies. But, as a matter of definition, there is a clear distinction between bonuses and base wages: bonuses are contingent on some kind of performance standard; base wages are absolutely not contingent.) The fraction of workers on fixed-term contracts[4], averaged over all the firms in the sample, increased from 8 percent of total workers in 1980 to 23 percent in 1989 (see Figure IV). Evidently, in these two respects, the instruments available to managers potentially to provide worker incentives were strengthened over the reform period (though, as noted, they need not necessarily have been used in such a way as to generate effective incentives).

Total factor productivity for the firms in our sample rose at an annual rate of 4.5 percent between 1980 and 1989, as already noted. Considerable variation across industries underlies this aggregate growth. Total factor productivity (measured as described in the next section) rose between 1980 and 1989 at annual rates of 2.5 percent in the textile industry, 2.7 percent in the chemicals industry, 3.4 percent in the building-materials industry, 6.1 percent in the machinery industry, and 7.9 percent in the electronics industry.

IV. ESTIMATION METHOD

We look econometrically at three questions. Did managers respond to autonomy by strengthening worker's incentives? Did the stronger workers' incentives translate into higher productivity? Did autonomy result in higher returns to the stakeholders: workers, management, and the state?

We use a subset of the CASS sample: the five industries for which the industry-level sample sizes are reasonably large (textiles, with 103 enterprises; chemicals, with 80 enterprises; building materials, with 52 enterprises; machinery, with 158 enterprises; and

electronics, with 44 enterprises; for each of which we have a ten-year time series, 1980-1989).

We use two different econometric models. The regressions not involving productivity estimates are as follows. (Models of this sort underlie Tables II, IV, and V to follow.) The reforms are characterized by a set of indices or variables. Let X_{it} be a k-vector representing the reforms affecting firm i at time t, i= 1, 2, . . . , N, and t = 1, 2, . . . , T; the grant of autonomy, for example. Let Y_{it} represent the results of the actions of firm i at time t; bonus payments, for example. In order to look for the effects of X_{it} on Y_{it}, we use the following program-evaluation model:

$$(1) \qquad Y_{it} = \alpha_i + \beta_{tj} + \gamma_j' X_{it} + \zeta_j d_{it} + \varepsilon_{it}; \quad i = 1, \ldots, N; \; j = 1, \ldots, 5; \; t = 1, \ldots, T_i.$$

The α_i, the individual time-invariant coefficients, are the same for a given firm through time but differ across firms; examples are the technology of firm i and the attributes of firm i's management. The β_{tj}, the industry-specific time dummies, are the same for all firms in a given industry at a given point in time but change through time and across industries; examples are prices and interest rates that are the same for all firms, technological progress, and government policies that are common to all firms. The elements of the p-vector γ_j are assumed to be parameters that are constant over time for all firms within a given industry, the j subscript denoting the industry (the prime denotes a transpose). The ε_{it} represent the effects of the omitted variables that are peculiar to both firms and time periods. We allow for different total time periods T_i for different firms in order to be able to handle possibly missing data.

Autonomy may not be randomly assigned by the industrial bureau. Conceivably firms that are unusually productive might pay out more than other firms in bonuses; and they might be selected by the government for earlier autonomy than other firms. This might produce correlations between bonuses and productivity that seem to support our

theoretical model, but such support would be spurious (because good firms might pay more in bonuses, rather than autonomy generating bonuses, as our model predicts). To try to avoid the effects of this possible selection bias on the estimation of γ_j, we include a dummy variable d_{it} representing autonomy occurring two years in the future (with an industry-specific coefficient ζ_j): in other words, d_{it} is equal to one if firm i receives autonomy in year t+1 or t+2. If it is the case that a firm that did well in the previous two years is given autonomy, and that good firms pay more in bonuses, then this dummy will help filter out this source of correlation (compare with Heckman and Hotz [1989]).

Some of our regressions (those underlying Table III to follow) involve estimates of productivity. We seek a measure of productivity that accounts for the effects of increases in capital stock and materials inputs, technical innovation, and reforms other than those investigated here. We run regressions that simultaneously estimate a production function for each industry and test for any efficiency changes attributable to the reforms. We use the loglinear production function

$$(2) \qquad \ln Y_{it} = \alpha_i + \beta_{tj} + \gamma_j' X_{it} + \delta_j' Z_{it} + \varepsilon_{it},$$

where $\ln Y_{it}$ is the log of output (in 1980 constant prices); $X_{it} = (L_{it}, K_{it}, M_{it})$ are labor, capital and material inputs; and Z_{it} represents potential determinants of increased productivity (such as bonus payments and contract workers). The industry-specific time dummy is included to capture the effects of technological change and other, nonmodeled reforms. We estimate a joint production function for all five industries together, with coefficients γ_j and δ_j, corresponding to industry j.

Some manipulation of the data was required before the production function (2) could be estimated. The questionnaire gives gross output data in 1980 constant prices; the enterprise accountant who answered the questionnaire was required to convert output sold at varying current prices into constant prices based on an official list of 1980 prices.

Measurement of material inputs and fixed capital required a more elaborate deflation procedure. The questionnaire collected data on prices paid for material inputs and investment goods. Material input deflators were then calculated for each of the five sectors. In calculating the fixed capital stock, the increment to productive fixed capital in each year was deflated by that year's investment-goods deflator and added to the previous year's deflated capital stock. In this way a new series of fixed capital at 1980 prices was created. Labor is measured as the number of workers, averaged over the year. (For more details on the data, see Groves et. al. [1993b]).

Equation (2) is a structural equation, with causality going from incentive mechanisms to productivity. If the theory outlined above holds, then the coefficient δ_j should be strictly positive; thus we shall test the hypothesis that the vector δ_j is equal to zero.

A difficulty with equation (2) is that the disturbance term ε_{it} may not be uncorrelated with the independent variables Z_{it}. This arises from the possibility that, while the incentive mechanism such as bonus payments may indeed have effects on productivity as our model predicts, any increases in productivity may in turn increase the bonus payments (simply because more productive firms are able to pay their workers more). If this is the case, the ordinary-least-squares estimator for δ_j will be biased. To correct for this, we use instrumental-variable estimators for δ_j. Specifically, we use one-year lagged variables $Z_{i\,t-1}$ as instrumental variables: these work as instruments because the increased productivity in the current period cannot cause increases in the previous year's bonuses and contract workers, so the $Z_{i\,t-1}$ are uncorrelated with ε_{it}; also, $Z_{i\,t-1}$ is highly correlated with $Z_{i\,t}$ and so it will give efficient estimates. It is also possible that ε_{it} is serially correlated. If this is the case then $Z_{i\,t-1}$ will still be correlated with ε_{it} and it would therefore not be a valid instrument variable. For this reason, we also tried using a two-year lag, $Z_{i\,t-2}$, as the instrumental variable, and found similar results, so that our results seem to be robust to first-order serial correlation.

V. ESTIMATION RESULTS

Table II shows the estimation results for the effects of autonomy on the provision by management of worker incentives. (Table II also shows, for the sake of completeness, the estimated coefficients for the loglinear production functions: that is, the γ_j of equation (2).) The two independent variables, X_1 and X_2, are, respectively, a dummy variable representing the presence or absence of output autonomy, and the enterprise's ex ante marginal profit-retention rate. (Thus, for example, the variable X_1 takes on the value 0 for the years prior to and including the granting of output autonomy to the firm, and 1 for all subsequent years.) These are the regressors for, first, real[5] bonuses per worker; and second, the number of contract workers as a fraction of the total number of workers. In the following discussion, we take 10 percent as the cut-off level for significance tests. (In the tables, a single asterisk denotes 10 percent significance, a double asterisk 5 percent significance, and a triple asterisk 1 percent significance.) Our model suggests that autonomy increases productivity. An alternative possibility is that some firms are inherently better than others; and good firms both pay more in bonuses and are granted autonomy early. Our regressions include firm-specific fixed effects, so that any positive association we find cannot be attributed to inherent firm characteristics. In two of the five industries (machinery and electronics) bonuses as a fraction of total wage bill were significantly positively associated with output autonomy; and in three (chemicals, building materials, machinery) bonuses as a fraction of total wage bill were significantly positively associated with the profit-retention rate. With a different normalization, bonuses per worker were positively associated with output autonomy in two industries (again, machinery and electronics), and positively associated with the profit retention rate in all five industries. In one industry (chemicals), the fraction of contract workers was significantly positively associated with output autonomy; and in one (textiles), it was significantly

positively associated with the profit-retention rate. There is some evidence, therefore, that managers were induced to strengthen worker discipline by receiving output autonomy and by having their profit-retention rate increased.

What is the effect of worker incentives on total factor productivity? Our two measures of worker incentives are the fraction of employee remuneration paid as bonuses, X_1, and the fraction of contract workers, X_2. A positive correlation between bonuses and productivity is, of course, consistent with both directions of causality: higher bonuses could generate higher productivity; and an increase in productivity could be paid out to workers as higher bonuses. (For the incentives to work, the causality has to be working in both directions: the promise of bonuses might lead to greater productivity; but if the incentives are genuine, the higher productivity must then result in higher actual bonus payments.) Conceivably, however, a correlation between bonuses and productivity might merely reflect the fact that the workers get a share of any rents that go to the firm, and the bonuses may not be awarded in such a way as to generate incentives. To check whether the causality goes from bonuses to productivity--that is, whether there is an incentive effect as Section II's model suggests--we use instrumental-variable estimation (as described in the previous section) to filter out the opposite causality. The instruments we use are bonuses and contract workers lagged by one year. The regressions include firm-specific fixed effects, so the effects of any variations across firms in inherent productivity are filtered out. Table III shows the estimation results based on equation (2). The first three rows of Table III show the production-function coefficient estimates for labor, capital, and materials. The last two rows show the effects of the incentive variables. In four of the five industries (all except chemicals), bonuses are significantly positively associated with productivity. In three industries (chemicals, building materials, electronics) contract workers are significantly positively associated with productivity.[6] To check whether our results seem to be robust to first-order serial correlation, we repeated these regressions using two-year lagged bonuses and contract workers as the instruments: the results (not reported here)

were similar. Additionally, we tried omitting the instrumental variables and running an ordinary-least-squares panel regression of productivity on bonuses, together with firm and time dummies--that is, equation (2). In this case, not reported here, all five industries were found to be very strongly positively significant, suggesting, as would be expected, that causality goes both ways: from productivity to bonuses as well as from bonuses to productivity.

The results in Tables II and III, therefore, provide some support for the hypotheses outlined in Section II above. In all five industries, there is evidence that firms respond to either the grant of output autonomy or increases in the marginal profit-retention rate (or both) by strengthening worker incentives (either paying more in bonuses, or hiring more contract workers, or both). And in all five industries at least one of these incentive variables generates increased productivity.

We also looked at a reduced-form version of these questions, asking whether autonomy and profit retention affect productivity. The results of this regression, which includes time and firm fixed effects, are given in Table IV. The results are less clear-cut. In two industries (chemicals and building materials), productivity is significantly positively associated with autonomy; but for profit retention, there is only one significant interaction, and that is negative (in machinery). Our theory says that autonomy and profit retention do not affect productivity directly, but only indirectly, through their effects on worker incentives, and the results of Tables II and II are consistent with this; nevertheless, the relationship could be expected to carry over into the reduced form, and it is a puzzle why in most cases shown in Table IV it does not. Perhaps there is too much unmodeled variation across firms (picked up in the regressions by the firm and time fixed effects) for the reduced form to show much interaction.

Who benefited from the improvements in productivity that followed autonomy? Tables V and VI show the results of some regressions (based on equation (1)) that ask this question. The independent variables are the two autonomy measures: the output-autonomy

dummy X_1 and the profit-retention rate, X_2. Table V shows the effects on profits, remittances to the state, and investment from retained earnings. (In the following, the dependent variables are measured in per-employee terms to permit comparability across different firms.)

There is some weak evidence that output autonomy has increased enterprise pre-tax profits, but increasing the marginal-profit retention rate had mixed effects on pre-tax profits. Real profit per employee is significantly related to output autonomy in one industries (building materials), and is significantly positively related to the profit-retention rate in two industry (electronics, textiles), and significantly negatively related in one industry (building materials). The reforms, therefore, seem to have had a weakly positive effect on profits.

State-run industry has been the main source of the Chinese government's revenue, accounting for over 80 percent of budgetary revenues in the late 1970s [Naughton, 1992]. The government's budget does not seem to have benefited from the reforms. The government-approved subsidy for losses per employee rose in one industry (machinery) and fell with output autonomy in one industry (electronics); they did not significantly change with increases in marginal profit-retention rates. Thus there is little evidence that the government was able to reduce its subsidy burden by grants of output autonomy to enterprises. (The government subsidy for losses is simply the payments made by the government to cover losses on nonprofitable products. In the still partially planned economy, the government recognizes some of the responsibility for losses resulting from its role in setting prices.) Similarly, there is no evidence that the amount of profit remitted to the state increased with reform. Remitted profit per employee was positively associated with output autonomy in one of the industries (building materials), and it was significantly negatively associated with marginal profit-retention rates in two industries (building materials, electronics). No Laffer-curve effect occurred following the reduction in marginal

"corporate tax" rates, therefore, even though the "tax" rates initally were at or close to 100 percent.

Increased autonomy did, however, appear to increase the resources available to the enterprise. The production development fund, drawn from enterprise profit, showed no significant interaction with output autonomy; but it rose significantly with the profit-retention rate in three industries (textiles, machinery, electronics). (The production development fund is money retained by the enterprise, out of profits, that is used for fixed investment--construction and purchase of machinery--within the enterprise.) This increase in investment suggests that managers viewed the reforms as likely to be permanent rather than temporary.

Much of the benefits of autonomy seem to have gone to the enterprise's workers. Table VI shows the effects of autonomy on employees' earnings (inclusive of bonuses). The workforce as a whole seems to have benefited from output autonomy and increases in the marginal profit-retention rate. Real average employee wages (computed by dividing the total wage bill by the total number of employees and deflating with the urban consumer price index) rose significantly in one industry (machinery) with output autonomy and in three (textiles, machinery, and electronics) with the profit-retention rate. In the machinery industry, for example, the simple grant of output autonomy was associated with an increase in the average wage of 90 yuan, 8 percent of the mean industrial wage in the average year of output autonomy, 1986.

This increase in remuneration seems to have accrued mainly at the level of workers rather than managers. Average production-worker remuneration was not significantly associated with output autonomy, but rose with the profit-retention rate in three industries (textiles, building materials, and electronics). The evidence suggests that managerial personnel did not take advantage of the grant of autonomy to increase their incomes. Average management-personnel wages fell with output autonomy in one industry (textiles) and showed no significant interaction in the others; and there was no significant interaction

with the profit-retention rate in any industry. The finding that managerial wages do not rise with autonomy seems surprising. Managerial wages did, however, rise less than production-worker wages between 1980 and 1989. (Production-worker wages rose in real terms at 3.2 percent annually for the firms in the CASS sample, while managerial wages rose at 1.8 percent.) The 1980s saw the rise of a managerial labor market in China and considerable turnover in managers (Groves et. al. [1993a]); perhaps the slow rate of increase of managers' pay, and its lack of responsiveness to autonomy, reflects the increased competition for managerial jobs. Table VI leaves unexplained, therefore what it was that motivated the managers to introduce more efficient methods of production. The answer seems to be that, even if the level of manager pay did not rise much, the responsiveness of pay to performance did rise. The manager is an agent of governmental superiors, and his pay is determined by his contract with the industrial bureau. Managers' pay and promotion prospects through the 1980s became increasingly sensitive to the firms' profits and sales (as shown by Groves et. al. [1993a]).

Table VI gives some weak evidence that the nonpecuniary rents enjoyed by the enterprises' managers did, however, increase: enterprise management expenses per employee (which include office expenses, travel, etc.), although showing a significant negative association with output autonomy in one industry (textiles); showed a significant positive association with the profit-retention rate in two industries (textiles, electronics). The welfare fund, drawn out of retained profits and used to supply workers' housing and other benefits, fell with autonomy in one industry (electronics) and rose in per-employee terms in three industries (machinery, building materials, electronics) with the profit-retention rate: employees' welfare benefits seem therefore to have increased with the reforms.

So far we have been asking how the firms responded to given reforms. Another set of questions is: were there any systematic patterns in the industrial bureaus' decision-making over the imposition of the reforms? (This is a question both about the political

economy of reform and about potential selection bias in the econometrics.) According to the model of Laffont and Tirole [1986], if the government wanted to maximize the revenue it earned from the firms, but could not distinguish firms that have inherently high productivity from those with inherently low productivity, then it should offer a range of different contracts, with firms that claim to have high productivity being given high marginal-profit retention rates (together with high fixed-profit delivery obligations). Similarly, the government might have tried to achieve early reform success by giving autonomy first to the firms that were inherently the most productive. Did, in fact, good firms get high marginal-profit retention rates and/or early autonomy? We did some simple statistical analysis to look for such selection effects.[7] First, we ran panel-data regressions with, as the dependent variable, the marginal-profit retention rate and, as the independent variable, the production-function residual from the previous year (the residuals coming from panel estimates without firm fixed effects). No significant interaction was found, either for the pooled sample or industry by industry. Second, we computed, for all firms receiving autonomy in a given year, the average production-function residual in the previous year: if more productive firms received autonomy early, this average residual would fall over time. In the case of the machinery industry, but none of the others, there was an apparent tendency for more productive firms to receive autonomy early. With this one exception, output autonomy seems to have been imposed arbitrarily.

VI. CONCLUSION

Unlike in agriculture, where China's economic reforms have been spectacularly successful [McMillan, Whalley, and Zhu, 1989], progress in industry has been less clear. Some (Stepanek [1991] for example) go so far as to argue that the industrial reforms have been a failure. Industrial reforms, it is commonly argued, are more difficult than agricultural reforms, because of the greater complexity of the industrial management system

and the multiple contraints to which enterprise managers are subject. While there have been large-scale changes in ownership and use rights in agriculture, there has been virtually no change in ownership relations within state-run industry. Reforms in industry have been implemented in a gradual, piecemeal, but sustained fashion over more than a decade. A continuous series of measures, each slightly enhancing enterprise autonomy, has been enacted, but at different rates in different industries and regions. In many cases implementation was partial or inadequate; in other cases, individual changes seem trivial. It has been hard for outside observers to discern whether the cumulative impact of these changes has been meaningful.

Our analysis leads to the conclusion that the industrial reforms have in fact met with significant success. While enterprises remain subject to many of the problems associated with state ownership in Eastern Europe and elsewhere, increases in enterprise autonomy have induced measurable changes in behavior at the enterprise level. With autonomy in output decisions and with higher marginal profit-retention rates, enterprises increased their use of bonus payments and hired more fixed-term contract workers. This strengthening of workers' incentives was correlated with higher productivity. The improved productivity raised the workers' incomes (but not the managers' incomes), and resulted in more investment by the enterprises, but did not lower subsidies or increase profits.

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Notes

* We thank Julian Betts, Takeo Hoshi, Gary Jefferson, Alex Kane, Wei Li, James Rauch, Glenn Sueyoshi, as well as Lawrence Katz and three referees for comments, and the Ford Foundation for research support.

1. Production-function estimates from other data sets show similar increases in state firms' productivity. Gordon and Li [1989] estimated, using a sample of 400 state enterprises, that productivity rose by 4.6 percent annually over 1983-1987. Dollar [1990] estimated, using a sample of 20 state enterprises, that productivity rose by 4.7 percent annually over 1978-1982.

2. The McAfee-McMillan [1991] model works as follows. Consider a three-tier hierarchy: planner, manager, and worker. The worker's output depends both on his effort and on some productivity parameter that only he knows. The manager designs the contract for the worker; the planner for the manager. Having private information conveys bargaining power and therefore rents to the information-holder (as Myerson [1979] showed). The contract the manager optimally offers the worker gives less-than-full marginal incentives, because of the manager's need to induce the worker to reveal his information: there is a trade-off between inducing the worker to reveal his information and eliciting effort from him (as Laffont and Tirole [1986] showed). By the time the planner negotiates with the manager, the manager has acquired the worker's information; the manager can, like the worker in his negotiation with the manager, use this information to extract rents. Thus the cost of production as perceived by the planner incorporates two levels of informational cost, and, as a result, the planner orders an inefficiently low output. When the manager, rather than the planner, makes output decisions, this distortion is smaller, because now the production cost as perceived by the decision-maker (the manager) incorporates only one level of informational cost. As a result, the manager ties the

worker's pay more closely to his performance when the manager makes output decisions than when the planner makes output decisions.

3. Profit is defined according to Chinese accounting conventions, as sales revenue minus costs and turnover taxes (which are sales taxes that are collected at the factory gate; they differ by industry and product). Costs include material inputs, wages, depreciation, and interest charges on working capital loans. One portion of profit is retained by the firm, and a part of retained profit goes to worker bonuses: there is thus a part of profit that goes into the wage bill broadly defined. With this one exception, Chinese accounting for profit is similar to that in market economies. The major difference, of course, is that a large (though declining through the 1980s) share of transactions take place at state-set prices, and profitability is therefore improperly measured. In particular, interest and depreciation charges were set at low rates through most of the 1980s, artificially inflating profit levels. However, these low rates applied to all firms. Most of the bonus payments come out of profits, and are therefore not counted as costs in determining the profit variable (though a small fraction of the bonus is paid out as part of costs).

4. There are two kinds of nonpermanent workers: contract workers and temporary workers. Temporary workers, as the name implies, have few rights and can be fired at any time. Contract workers have some of the rights of permanent workers--it is difficult to fire them within the term of the contract--but the firm can choose not to renew their contracts after their expiry. For the regressions that follow, we sum these two classes of worker, so that "contract workers" should be taken to mean the total of contract workers and temporary workers.

5. Nominal values are deflated using the urban consumer price index, from State Statistical Bureau (1990b, p.250).

6. If bonuses are awarded equally to all, then in a large firm they will have no incentive effect. This regression, in showing that higher bonuses generate higher productivity in the electronics and machinery industries, suggests that bonuses are in fact

differentiated, being based on some kind of merit assessment of the individual workers, and so do induce workers to exert more effort. There is some anecdotal corroboration that the causality goes from bonuses to productivity. The CASS questionnaire asked the factory manager: "How effective do you think bonuses are in fulfiling the contract?" The answers were: unimportant: 14 percent; medium important: 35 percent; important: 41 percent. Based on interviews with managers of Chinese state-owned enterprise, Miljus and Moore [1990] report that bonuses "usually are tied to such criteria as output, cooperation, attitude, seniority and job responsibility" (p.52). Jefferson and Xu [1991] asked managers about the link between labor's performance and rewards: nine out of thirteen managers said they were very related, four said they were somewhat related, and none said they were unrelated (p.51). Wong [1989] reports that in a Shanghai electronics factory, "bonuses are not identical: they are dependent on such factors as attendance record, type of job, and production-group perfomance", although before 1985 "all workers in this factory received the same bonus, regardless of their job or performance" (p. 138). (Wong does not say when this factory was granted output autonomy, but most likely -- according to the data in footnote 4 above -- it was in 1985 or later.) A correlation between employee remuneration and labor's marginal product is reported by Jefferson and Xu [1991].

7. In the regression reported in Tables II, V, and VI, we sought to avoid the potential selection bias that this could have caused by, as discussed in Section IV, including dummy variables representing autonomy occurring two years in the future.

TABLE I

PROPORTION OF TRANSACTIONS VALUE AT PLAN PRICE, 1989

Industry	Inputs (percent)	Outputs (percent)
Textiles	53.0	73.0
Chemicals	32.0	62.0
Building Materials	19.0	43.0
Machinery	34.0	51.0
Electronics	23.0	58.0

TABLE II

EFFECTS OF AUTONOMY ON INCENTIVES

	Textiles	Chemicals	Building Materials	Machinery	Electronics	N	R^2
	Bonuses / Total Wage Bill					1630	0.62
X_1	-0.008	0.012	-0.006	0.020	0.038		
	[-0.72]	[0.83]	[-0.38]	[2.11]**	[2.36]**		
X_2	0.017	0.045	0.073	0.046	0.036		
	[1.35]	[1.76]*	[1.99]**	[2.83]***	[1.48]		
	Real Bonuses Per Employee					1464	0.64
X_1	-18.69	11.82	-15.01	34.66	60.22		
	[-1.26]	[0.63]	[-0.71]	[2.86]***	[2.93]***		
X_2	430.8	659.9	938.8	812.3	857.4		
	[2.61]***	[2.02]**	[2.02]**	[3.88]***	[2.77]***		
	Contract Workers / Permanent Workers					1446	0.85
X_1	0.052	0.143	0.031	0.002	0.002		
	[1.46]	[3.17]***	[0.60]	[0.06]	[0.04]		
X_2	0.305	-0.019	-0.001	-0.071	0.043		
	[7.54]***	[-0.24]	[-0.01]	[-1.41]	[0.57]		

Note: (1) X_1 = output autonomy, X_2 = marginal profit retention;
(2) *, ** and *** represent 10 percent, 5 percent, and 1 percent significance levels respectively;
(3) N = the total sample size.

TABLE III

EFFECTS OF INCENTIVES ON PRODUCTIVITY

	Textiles	Chemicals	Building Materials	Machinery	Electronics
	IV Estimation		N = 3047	R^2 = 0.97	
L	0.482	0.267	0.306	0.698	0.193
	[4.84]***	[2.54]**	[1.66]*	[2.31]**	[1.45]
K	0.143	0.232	0.214	-0.030	-0.018
	[2.46]**	[4.16]***	[3.27]***	[-0.71]	[-0.24]
M	0.459	0.455	0.256	0.606	0.431
	[10.86]***	[13.80]***	[6.42]***	[22.3]***	[9.69]***
X_1	1.860	0.926	1.358	1.324	1.967
	[1.72]*	[1.53]	[1.68]*	[2.11]**	[2.48]**
X_2	-0.037	0.332	0.343	-0.642	0.591
	[-0.35]	[3.96]**	[1.93]*	[-1.02]	[2.08]**

Note: (1) L, K, M = log-labor, log-capital, and log-material;
X_1 = bonuses/total wage bill, X_2 = contract/total workers;
(2) *, **, and *** represent 10 percent, 5 percent and 1 percent significance levels respectively;
(3) N = the total sample size.

TABLE IV

EFFECTS OF AUTONOMY ON PRODUCTIVITY

	Textiles	Chemicals	Building Materials	Machinery	Electronics
		N = 1402	R^2 = 0.97		
X_1	0.093	0.125	0.127	0.019	0.001
	[1.02]	[1.69]*	[1.68]*	[0.40]	[0.01]
X_2	-0.0003	-0.0004	0.0007	-0.0011	0.0013
	[-0.34]	[-0.41]	[0.75]	[-1.66]*	[0.90]

Note: (1) X_1 = output autonomy, X_2 = marginal profit retention;
(2) * represents the 10 percent significance level;
(3) N = the total sample size.

TABLE V

EFFECTS OF AUTONOMY ON PROFITS

	Textiles	Chemicals	Building Materials	Machinery	Electronics	N	R^2
	Real Profit Per Employee					1464	0.68
X_1	0.015	0.031	0.063	-0.001	0.025		
	[0.67]	[1.10]	[1.95]*	[-0.04]	[0.83]		
X_2	0.049	0.006	-0.158	-0.027	0.148		
	[1.99]**	[0.13]	[-2.26]**	[-0.85]	[3.16]***		
	Real Goverment Subsidy Per Worker					1216	0.51
X_1	-0.000	0.000	-0.001	0.006	-0.011		
	[-0.00]	[0.23]	[-0.25]	[2.26]**	[-2.83]***		
X_2	0.000	-0.007	-0.002	-0.008	0.007		
	[0.00]	[-0.92]	[-0.20]	[-1.55]	[1.23]		
	Real Profit Remitted to State					1374	0.62
X_1	0.003	-0.003	0.060	-0.011	0.015		
	[0.19]	[-0.11]	[2.39]**	[-0.76]	[0.61]		
X_2	0.020	-0.040	-0.179	0.032	-0.072		
	[0.99]	[-0.88]	[-3.30]***	[1.25]	[-2.01]**		
	Real Product Development Fund Per Worker					1415	0.51
X_1	-0.002	0.002	0.001	0.002	-0.002		
	[-0.35]	[0.36]	[0.06]	[0.40]	[-0.24]		
X_2	0.017	0.003	0.003	0.018	0.087		
	[2.97]***	[0.29]	[0.18]	[2.32]**	[8.02]***		

Note: (1) X_1 = output autonomy, X_2 = marginal profit retention;
(2) *, ** and *** represent 10 percent, 5 percent and 1 percent significance levels respectively;
(3) N = the total sample size.

TABLE VI

THE BENEFICIARIES OF AUTONOMY

	Textiles	Chemicals	Building Materials	Machinery	Electronics	N	R^2
	Real Wage Per Employee					1471	0.78
X_1	-67.93	45.23	-14.16	90.58	92.94		
	[-1.62]	[0.86]	[-0.24]	[2.64]***	[1.61]		
X_2	172.65	91.07	136.71	219.52	168.16		
	[3.71]***	[0.99]	[1.04]	[3.74]***	[1.92]*		
	Real Wage Per Production Worker					1110	0.76
X_1	-7.594	10.58	-10.25	21.22	-4.13		
	[0.13]	[0.14]	[-0.14]	[0.32]	[-0.25]		
X_2	346.53	169.00	12.76	137.26	362.80		
	[4.57]***	[1.18]	[0.08]	[1.79]*	[2.89]***		
	Real Average Management Wage					1164	0.74
X_1	-407.52	-25.51	-82.18	125.20	136.86		
	[-2.44]**	[-0.12]	[-0.37]	[0.93]	[0.59]		
X_2	-267.78	434.33	254.844	191.48	440.06		
	[-1.21]	[1.07	[0.52]	[0.91]	[1.22]		
	Real Welfare Fund Per Worker					1402	0.52
X_1	-0.001	0.002	0.002	0.002	-0.004		
	[-0.68]	[0.97]	[0.78]	[1.13]	[-1.73]*		
X_2	0.001	0.005	0.011	0.005	0.023		
	[0.58]	[1.11]	[2.01]**	[1.71]*	[6.14]***		
	Real Management Expenses Per Worker					1391	0.51
X_1	-0.041	0.004	-0.016	0.0105	-0.024		
	[-2.13]**	[0.18]	[-0.60]	[0.68]	[-0.93]		
X_2	0.055	-0.021	0.021	0.030	0.092		
	[2.62]***	[-0.46]	[0.34]	[1.17]	[2.39]**		

Note: (1) X_1 = output autonomy, X_2 = marginal profit retention;

(2) *, ** and *** represent 10 percent, 5 percent, and 1 percent significance levels respectively;

(3) N = the total sample size.

Figure I

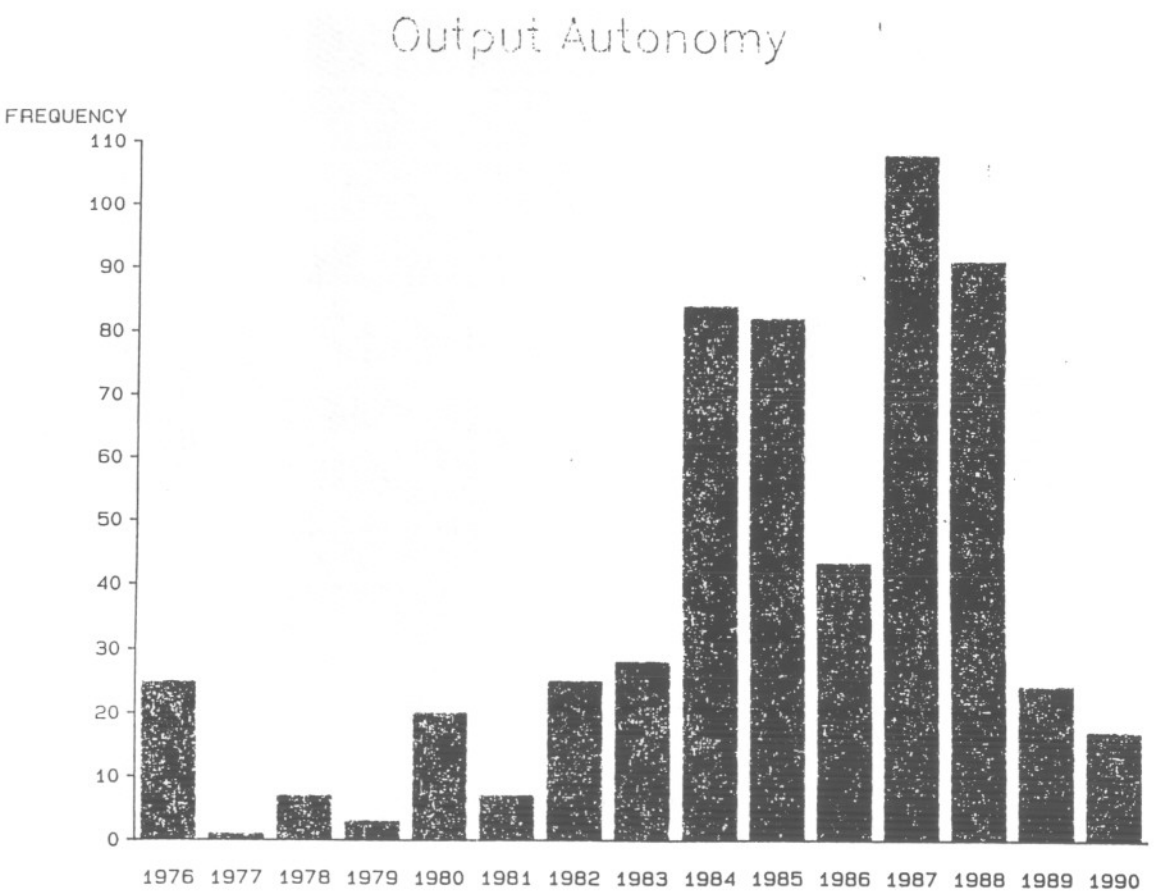

Output Autonomy
FREQUENCY
110
100
90
80
70
60
50
40
30
20
10
0
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990

Figure II

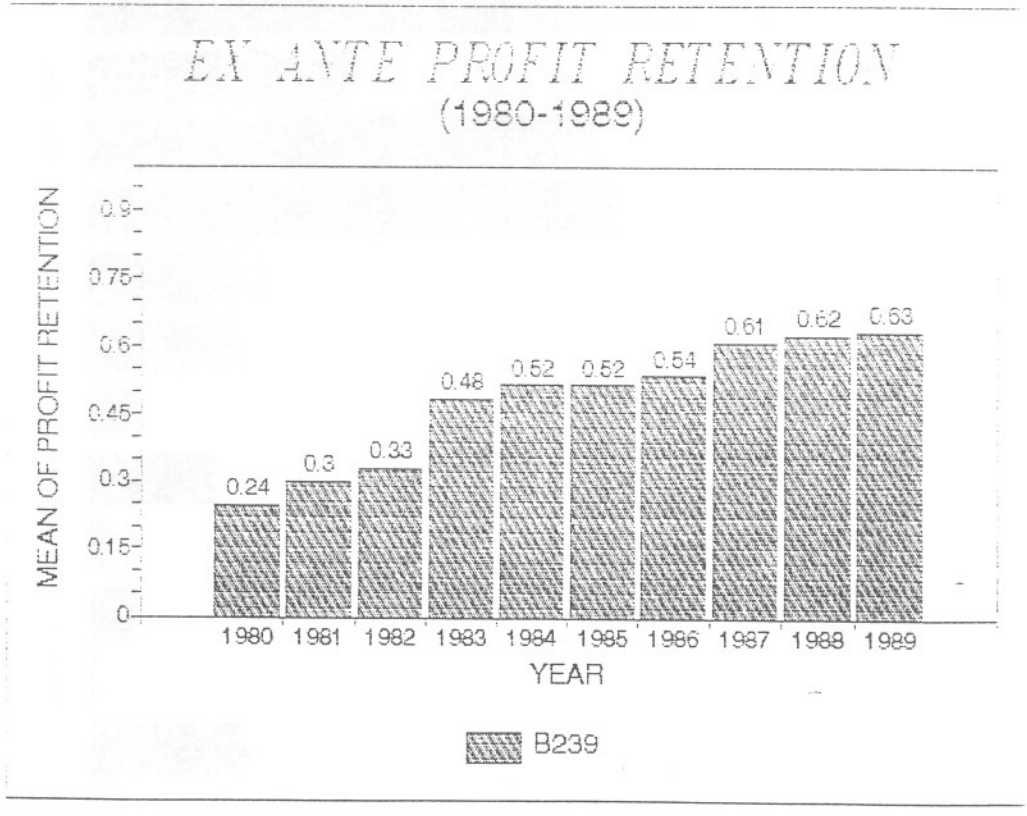

EX ANTE PROFIT RETENTION
(1980-1989)
MEAN OF PROFIT RETENTION
0.9
0.75
0.6
0.45
0.3
0.15
0
0.24
0.3
0.33
0.48
0.52
0.52
0.54
0.61
0.62
0.63
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
YEAR
B239

Figure III

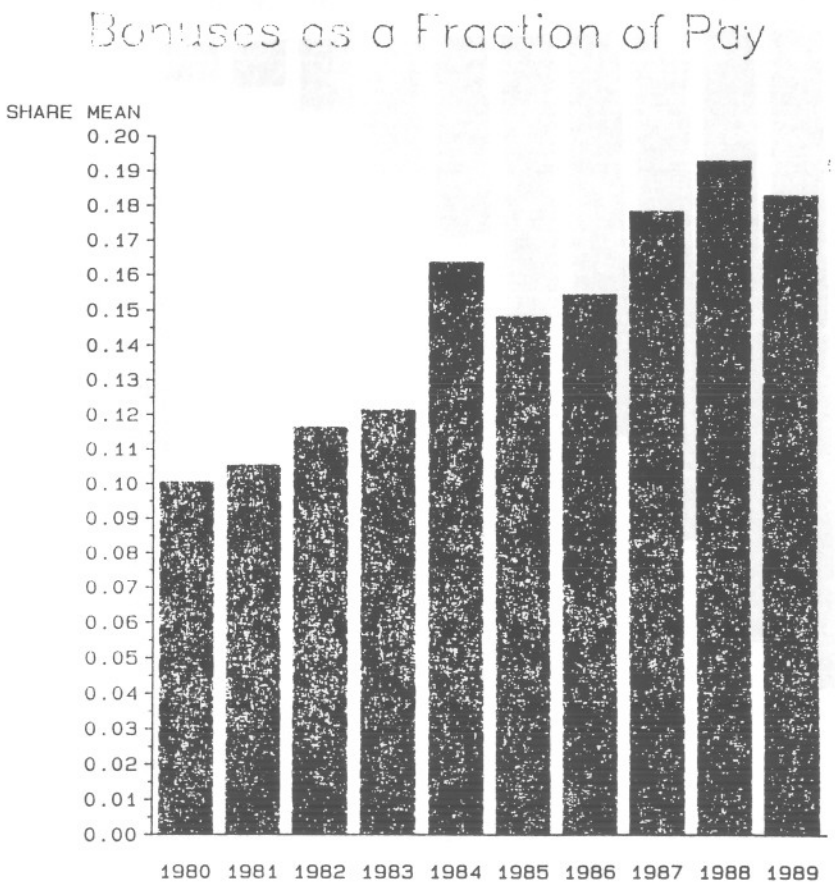
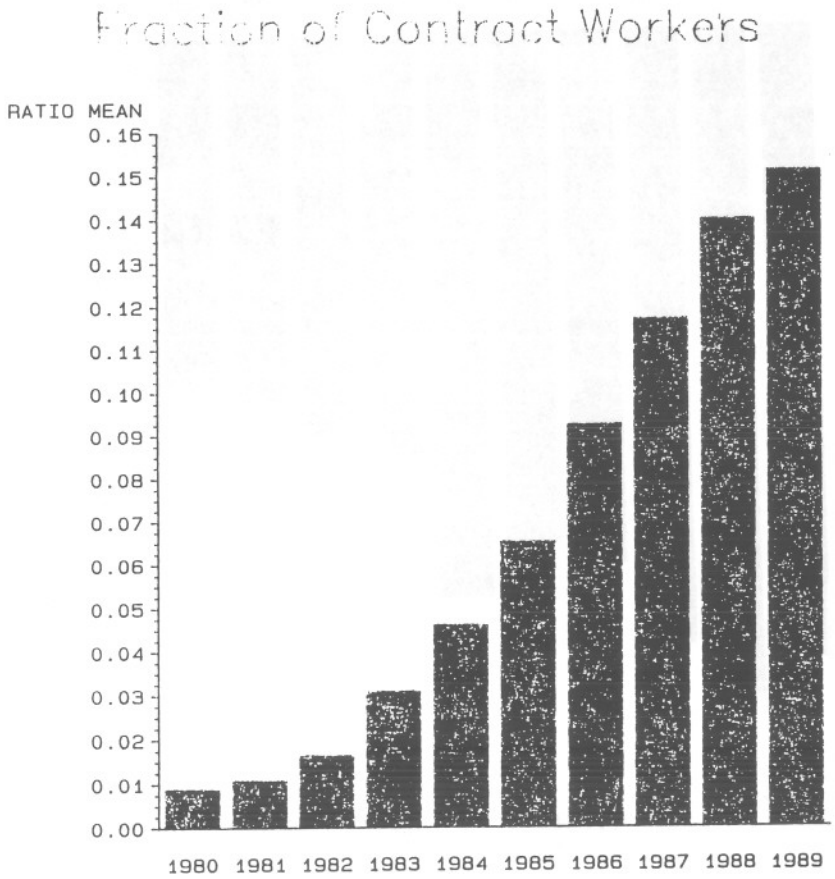

Bonuses as a Fraction of Pay
SHARE MEAN
0.20
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
1980 1981 1982 1983 1984 1985 1986 1987 1988 1989

Figure IV


Fraction of Contract Workers
RATIO MEAN
0.16
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989

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