

9. FACTORY DISCIPLINE

INTRODUCTION

Before the Industrial Revolution most European industrial workers controlled their work pace, timing, and conduct at work. Many workers worked when they wanted, drank beer while they worked, talked with each other, and supervised themselves. In the new factories of the Industrial Revolution - whether in England, France, Belgium, Switzerland, or Germany - factory discipline radically changed this. Employers now dictated how, when, and in what manner work was done. Much of the popular opposition to the Industrial Revolution stemmed from the dislike of workers for the new factory regime and its restrictions. This chapter examines why factory discipline triumphed only in the nineteenth century after the Industrial Revolution.

PRE-INDUSTRIAL WORK ORGANIZATION

Surprisingly most industrial workers before the mechanization of industry had a lot of freedom in their work lives. One large category of workers were those employed on what was called the “domestic” or “putting out” system. In this system manufacturers would give work to workers to do in their own homes or their own workshops. The workers would be paid per unit of work delivered. The manufacturer would maintain a warehouse where every Saturday (usually) the workers would turn in the work completed in the course of the week and collect their pay. There was thus no minute by minute supervision of workers. They were free to do the work as they wished.

This led to a natural rhythm of work. In order to get paid on Saturday afternoon the workers would labor long and hard on Saturday, and on the days before. But once they were paid they would take leisure on Saturday evening, and on Sunday, and gradually drift back to work on Monday, Tuesday or even Wednesday of the next week. If they had worked little at the beginning of the week, as was apparently common, they would put in intense efforts on Thursday and Friday. Some would work all night on Friday night if they had a specific task to complete such as to weave an entire warp of cloth. The intense efforts at the end of the

week would increase the desire for leisure at the beginning of the week. Not all workers would “honor St. Monday,” as the custom of taking a holiday on Monday was called, but enough that Monday in pre-industrial manufacturing areas was generally the equivalent of our Saturday. This was true of all the manufacturing areas of Europe.

Work hours within the week were completely flexible. If there was an event such as a hanging, a birthday, or a wedding, workers might down tools temporarily to join the fun. They could make up the time later. Just as workers varied their work pace over the course of the week, so they varied the pace over the course of the year. The weeks before the major feasts - Christmas and Easter for example - would be ones where workers put in extra efforts to earn more with which to properly celebrate the holidays. Records from workers employed in the nineteenth century under these conditions show that individual workers varied greatly in their weekly work patterns. Some would earn about the same week after week. Others would show great fluctuations in their weekly earnings.

Manufacturers of course preferred that the workers work as steadily as possible from week to week. Mainly they tried to ensure that if they gave out work then the product was returned within reasonable time. They did this by charging a weekly fee to workers who kept work longer than the allotted time for completion. Effectively they were charging the worker in part for the capital costs tied up in the inventory of work in progress. But a worker who did not take out any work for a week that they planned to take off would face no penalty.

Workers liked the “domestic” or “putting out system” for a variety of reasons. It gave the worker a great deal of freedom to control his or her own affairs. Workers could keep a small farm as well as engage in industrial production since their time was flexible. It also allowed workers to choose who they would work with. Generally also the worker was not tied to one employer. The domestic system also allowed great social mobility. If a worker was frugal they could increase the number of machines they owned and rent these out to other workers. They could also become a subcontractor giving out work to a whole group of workers for a distant manufacturer, and perhaps eventually setting up in business themselves as a “putter-outer.”

The pre-industrial putting out system could be quite elaborate. In Lancashire in England, for example, in the early eighteenth century there were a couple of manufacturers who were each employing more than 2,000 domestic workers spread across many

small villages. But there were people operating everywhere in the size spectrum from these huge manufacturers down to those who subcontracted work for 5 or 10 workers.

Gradually purely domestic production where the worker owned or rented his own workshop and equipment began to be displaced by a “workshop” system. Since many workers could not afford to buy the machines used in production they would rent these from machine owners at a certain amount per week. As the machines got bigger they would also rent “floor space” in the workshop again on a weekly basis. Some of these workshops became quite large with as many as 200 workers employed in them. But they were still quite distinct from modern factories. Workers were paid a piece rate for their output, but were required to pay a fixed sum per week for the rent of their machine, the floor space they used, and also sometimes explicitly for managerial overhead. Workshops opened longer than the 10 to 12 hours per day of factories - sometimes 16 or 17 hours per day - and workers worked when they wished within these hours.

Employers were largely indifferent to workers' performance and conduct within the workshop because their profit came mainly from the fixed rents, which were independent of output per worker. In framework knitting, for example, in the 1840s a machine worth 120 s. would be rented to the workman for 1 s. a week, a gross rate of return on capital of about 43% per annum. Slow workers were as valuable to the firm as fast ones. Thus there were few restrictions as to hours or even the amount of output required per week. Many establishments in the hand-powered industries called 'factories' by contemporaries were in fact such incentive-based workshops.

The workshop system was prevalent in hand framework knitting in England, for example, and by the 1840s probably more than 30,000 knitters were employed in this way. These shops often opened for 14-17 hours a day, and the workers remained free to come and go, and to converse with each other at work. One worker noted that "there is no regular superintendence whatever". Another reported that he began "in a general way about 6 o'clock" and continued till the shop master "locks up at 10; and I am in general there every day, for I have no money to go to a public house with. Employers expressed unhappiness at not being able to control workers more tightly, but they felt they had to offer freedom to attract workers.

There were also workshops in handloom weaving in the nineteenth century, but many employed the above 'rent and charges' system and exercised little discipline over workers. Bootmakers who rented space in cooperative workshops in London in the 1890s,

chain- and nail-makers who rented space at forges in 1906, wood sawyers and turners in East London sawmills, and Sheffield cutlery workers who rented a place at a grinding wheel from their employers or from 'public factories,' all had freedom about work pace, hours, and personal conduct. Even in some industries where there was a straight piece rate, such as metal manufacturing, potteries, hand brickmaking, and coal mining, workers had considerable control of work conditions. A large lock manufacturer, whose workshop of 200 employees was open 16 hours per day, reported that the workpeople

came when they had a mind - went when they had a mind: his workshops were always open. As they all worked by the piece, it was of no consequence to the employer when they did it, that was entirely their own affair.

Potteries were among the largest factories in Britain by the mid-nineteenth century, and employed an extensive division of labor in producing their ware. Yet they remained largely undisciplined. In 1908 it was reported by a factory inspector that,

The potteries are places by themselves with hardly any supervision... The trade was conducted in the old days independently by the men themselves, and the ordinary discipline of the factory or machine shop is not brought to bear upon them.

Even as late as 1931 a potter could report that, "we have no set time for stopping and starting here."

Up till at least 1914 miners were able to absent themselves from work when they wished in many areas. A Scottish pit owner noted in 1907 that, "There is no hard and fast rule that the miner must work so many days a week. A miner takes an idle day whenever he wishes, but, of course, if he persistently does that, the manager may dismiss him."

A popular view is that discipline was imposed in factories because many women and children were employed there, and they had less ability to object to discipline. It is thus important to note that many of the undisciplined workers in the nineteenth century were women and children. The Children's Employment Commission of the 1840s is replete with examples of women and children employed with incentives in conditions of relative freedom. Examples include pinmaking, file cutting, straw plaiting, rag cutting, and various workers in the potteries.

Workers in the workshop system used their freedom. They frequently worked irregularly within the week, and week to week, often taking Monday and even Tuesday off and working long hours on Thursday and Friday. The supervisor of over 50 workers in a knitting workshop stated that the men worked erratically, some working only 3 or 4 days in the week, some earning considerably different amounts from week to week. 24. A list of their weekly earnings over 15 weeks confirms their irregularity. The workshop was open from 6 am to 10 p.m. Table 1, showing the variability of weekly earnings of worker under incentive systems in the mid nineteenth century, illustrates this irregularity. The fact that the output of individual workers varied by much more than the output of the group of workers shows that the variations cannot be attributed to fluctuations in demand. At the same time many independent workers earned the same amount from week to week.¹

Workers who remained on incentive systems after the mid nineteenth century continued the tradition of irregular work. Potters as late as the 1890s, for example, were still practicing St. Monday, as were miners.

In the workshop system many workers did not have to produce any minimum output per week, and this as we shall consider below potentially implies certain coordination problems. Another method of organizing workers where coordination was more important was to pay a piece rate, with or without a rental charge for capital, but require either a weekly work quota, or require a minimum weekly output. Coventry ribbon weavers working for master weavers in workshops were employed in this way since it was reported that "The journeyhand weaver considers that so his work be done, he is at liberty to work what hours he pleases." In the Staffordshire coal mines in the nineteenth century many

¹ On colliery employer noted that, "The colliers, men, women, and children, go to their work at whatever hour of the night or day that they think proper, and work just as long as they choose." Another said, "It would be a capital thing to make the men more regular in their hours of work; but if we were to take a man and hang him every now and then, it would not make them regular." Great Britain, Payment of Wages, pp. 470, 289.

**TABLE 1: WORK IRREGULARITY UNDER
INCENTIVE SYSTEMS**

Group	Number Workers	of Weeks	Output Variation (workers)	Output Variation (group)
1845, domestic	120	16	53.7%	6.8%
1845, domestic	15	6	-	6.2
1845, workshop	20	14	-	10.0
1845, workshop	54	15	37.8	8.0
1854, workshop	38	14	24.4	4.9
1854, workshop	10	7	12.6	6.7
1854, workshop	20	8	9.4	2.8

Notes: Output variation is measured as the standard error of output divided by the mean output.

Sources: Great Britain, Framework Knitters, pp. 319-321; Great Britain, Stoppage of Wages (Hosiery), pp. 575-577.

miners were required to produce a weekly stint, which they could produce in whatever hours it took. In other cases if the worker did not return the work within a specified period a large payment was deducted from his or her earnings. The use of a quota of output per worker allows the worker freedom as to how they conduct themselves at work, and when they want to come to work, while protecting the employers' investment in machinery, and ensuring some coordination of the elements of the process.

Thus workers in these workshops controlled their own hours, work pace and conduct. They took breaks when they wanted, and socialized at work as they wished. They were not paid any more than equivalent domestic workers per unit of output, implying that they did not find the conditions of the workshop unpleasant.

THE FACTORY

The Industrial Revolution brought with it a new institution, “the factory.” What made factories distinct was not so much their size (there were already large workshops by the time of the Industrial Revolution) or the fact that most had steam engines or water wheels. Instead it was the way work was organized inside the factory. In the factory the employer dictated when workers worked, their conduct at work, and the steady attention of workers to their work. Under discipline workers were rewarded not only according to their output as in the workshop, but also or even exclusively based on their conduct. Workers were heavily penalized for small deviations from the approved conduct. Workers seem to have strongly resented factory discipline. The market evidence is that they had to be paid a substantial premium to work in these conditions.

When we look at the organization of work from the perspective of the twentieth century, the prevailing system, factory discipline, seems the natural and timeless way of organizing work. Under factory discipline the worker faces a very constrained choice. In return for their wage they surrender to the employer complete command of their labor for a fixed period each day. The employer sets the pace of work, and dictates also how the worker will conduct themselves at work. In some cases the worker will be offered a piece rate but even then the hours of work will be controlled, as will the conduct while at work, and a minimum pace of work will be expected.

In the nineteenth century workers under factory discipline, even when paid by the piece, were dismissed, fined heavily, or locked out for the day for a whole variety of infractions. These included arriving

a few minutes late in the morning, being absent from their machine, talking or eating at work, drinking beer, and whistling, singing, and other horseplay. Even workers on piece work were often subject to strict discipline. 21 of 32 linen mills in Belfast in the 1890s, for example, locked out piece workers who were a few minutes late, and 29 imposed fines for minor unpunctuality. Piece worker who were 5 minutes late were fined up to one hour's wages. In four of these mills the piece rate workers were already under a payment scheme which gave bonuses of 3 - 10% on earnings for achieving a minimum output level. In one mill workers who were not there by starting time on any day were locked out, had to pay a fine of about 2% of weekly wages in addition, and also lost any chance of the 8% bonus on earnings for the week. In a number of cotton weaving sheds in Lancashire, temporary weavers would come to the mills in the morning, and would be given the looms of any permanent weaver who was late, even though the weavers were employed under piece rates. In one case if the permanent weaver was 5 minutes late they lost their looms for the day in this way.²

A puzzling aspect of factory discipline was that instead of rewarding workers according to their output, it used the behavior of workers also as a measure of performance. Thus in one early cotton mill workers were already being fined in 1805-1813 for such infractions as "Idleness & looking thro' window," "Calling thro' window to some Soldiers," "Riotous behavior in room," "Riding on each other's back," "Dancing in Room," "Going out of the room in which she works to abuse the hands in another room," "Neglecting his work to talk to people," "Making a noise when order'd not," "Using ill language," "Terrifying S. Pearson with her ugly face," "Talking &c.," "Sewing in Mill time," "Sending for ale into the room &c."

The use of such discipline is puzzling because in industries such as cotton weaving where output is easily measurable discipline seems to give the employers no gain, but impose some costs. Discipline systems rewarded and penalized workers, even when they were on piecework, on the basis of their inputs to the production process rather than their outputs, even though inputs like hours of attendance, sobriety, and demeanor were rather loosely linked to outputs. In one cotton weaving shed in 1923 the outputs of 13 experienced weavers

² Marx notes the case of power weavers in 1863 who were fined 18 d. for being ten minutes late in the morning, the equivalent of 8 hours wages, as illustrative of the exploitative nature of capitalism (Marx, Capital, Vol. 1, p. 425).

each of whom operated 3 looms on the same type of cloth were averaged over one month of working. The best weaver got 93% of potential output from the looms, the worst 70%, even though they worked the same number of hours. Thus even with the imposition of discipline significant differences in output between workers remained. The best weaver above could start work 2.5 hours later each day than the worst and still produce as much. Why wasn't it easier to reward the workers just through a piece rate, rather than adding on other penalties that were loosely linked to performance? There might well be workers who would produce high output even though they were irregular, profane, or bibulous.

In the early textile factories there seems to have been a period of experimentation in which different methods of work organization were employed in different mills. In some there was the use of severe forms of factory discipline. But in others work was organization without the use of the new discipline. Thus in the hand spinning factory managed by Henry Houldsworth in Manchester in 1795 mule spinners were paid by the piece, and worked in the traditional pattern of small efforts on Monday and Tuesday, followed by extra long hours towards the end of the week. By 1816 Houldsworth enforced a strict 75 hour week in his mechanically powered Scottish cotton textile factories, though women cotton pickers who did not use machinery were allowed to come and go as they wished. Yet by the mid nineteenth century discipline had triumphed in the factory textile industry, with all workers having to attend at fixed hours and obey strict codes of conduct. In such a competitive industry as textiles, with hundreds of mills competing to sell largely undifferentiated output in a geographically compact area, there must have been some competitive advantage that discipline conferred. What was it?

Other industries also show signs of periods of experimentation with different types of work organization. In some such as handloom weaving of cottons or silk, or hand frame knitting the factory system is tried and fails before mechanically powered machines are introduced. In others such as power silk weaving in Coventry the workshop system is tried but is replaced by the factory. What was the competitive advantage of factory discipline, and why did that advantage appear only with some technologies?

THE ADVANTAGE OF FACTORY ORGANIZATION

There has been a long debate, starting with Marx in 1867 on why factory organization triumphed after the Industrial Revolution. The main views in this debate are portrayed below.

	Organization	Technology
	Williamson (1980)	Landes
Efficiency (1986)		
Exploitation	Marglin (1974)	Marx (1867)

The first major split in views is between those who think that factory organization triumphed because it was more efficient (it produced more output using the same amount of inputs), and those who think that the factory succeeded by exploiting the workers (that is the factory was profitable, but it made the profits by reducing the income of workers). The second split is between those who see factory discipline as simply an inevitable result of new technology, and those who regard it as an innovation in organization in its own right.

Critics of capitalism have argued that the imposition of discipline reflects a failure of capitalism to deliver appropriately humane work conditions. It had earlier been possible to organize production in a way that gave workers autonomy. That possibility remained even after the technological changes of the Industrial Revolution. While the advocates of capitalism celebrate its ability to give individuals "freedom to choose," factory discipline represented the end of freedom for workers. They now had one choice only - work under the stipulated set of conditions, or do not work.

One group of the defenders of capitalism have responded that while discipline is unattractive, it was a necessary cost of running modern power and capital intensive factories with an extensive division of labor. As long as labor markets are reasonably competitive, as they were in most industries in Britain in the Industrial Revolution period no employer can arbitrarily impose bad work conditions. If markets are reasonably competitive, what survives will be what is efficient. Workers chose discipline because manufacturers who organized labor in this way were able to reduce costs and offer higher wages. They preferred discipline and high wages to freedom and low wages. Their protection was and is the market. The critics are utopian dreamers.

This is a powerful line of reasoning familiar to all economists. The labor markets of the Industrial Revolution industries imposing

discipline were perhaps the closest we shall see to perfect labor markets. In 1838 in the parish of Manchester alone there were 182 working cotton mills employing 39,000 workers. 14 other parishes in Lancashire had more than 10 working cotton mills, including Oldham with 200, Bury with 114, and Whalley (adjacent to Manchester parish) with 113. A cotton worker in Manchester in 1838 would have been within walking distance of at least 100 potential employers vying for his or her services. In the town of Nottingham in 1844 just before the factory was introduced into the framework knitting industry there were 56 employers holding 3,490 knitting frames between them.

But this reasoning does not establish why discipline succeeded in manufacturing only after the Industrial Revolution. What advantage did it confer, given that workers disliked it? To use an example from evolutionary biology, we know that the tail of the peacock must confer some advantage in the struggle for survival, but it is still an enduring mystery what the advantage is. So with the triumph of factory discipline. Discipline must have been efficient. But what was its advantage? What were the cost savings that allowed employers to pay about 20% more per unit of output to workers employed under conditions of discipline?

DISCIPLINE AS COORDINATION

Most economists and historians, and indeed anyone who first considers the subject, think they know why discipline emerged in the Industrial Revolution period. The prevailing wisdom is that new production techniques were developed in this period that involved mechanical power, more machinery per worker, and an extensive division of labor. Without the imposition of discipline the whole production process would grind to a halt because one worker was absent, drunk, or conversing with his fellows. Thus Marx quotes Ashworth, a large cotton manufacturer, as noting that

"When a labourer lays down his spade, he renders useless, for that period, a capital worth eighteen pence. When one of our people leaves the mill he renders useless a capital that has cost £100,000"

This is the coordination theory.³

There are four tests of the coordination theory:

(1) Suppose workers care about two things: the wage they receive w , and the amount of effort they put in, e . Their satisfaction can be indexed by $U(w,e)$ where U increases with w and declines with e . Figure 1 shows a typical indifference curve. Now if the labor market is competitive so that workers are paid their marginal product, then w and e will be connected as follows:

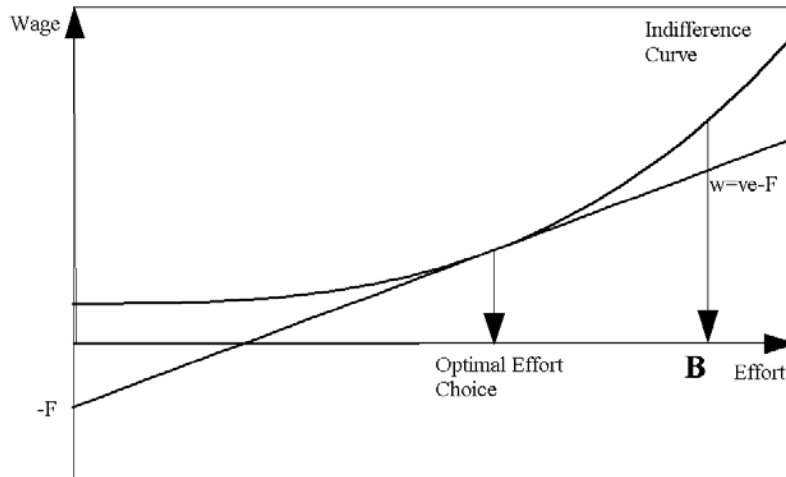
$$MP_L = w = v \cdot e - F$$

where F is the rental cost of the fixed capital, and v is the value of each unit of effort to the firm. If there is no consideration of coordination with other workers the optimal choice of effort and wage will be on the highest indifference curve as is shown in the figure. Formally the worker will choose e to:

$$\max U(w,e) \text{ subject to } w = v \cdot e - F$$

³ Thus Usher argues that the division of labor could only be effectively carried out with "the subjection of the whole body of workmen to a systematic schedule" so that "no group of workers need be obliged to wait for the group engaged on the earlier stages of the work" (Usher, Industrial History of England, p. 347).

Figure 1: The Choice of Effort Level



Note that the capitalist does not need to specify the amount of effort the worker puts in. Merely by paying according to the marginal product, which the employer will be forced to do in a competitive market, the worker will make the optimal choice. If there is an increase in the amount of fixed capital per worker where the worker is kept on the same indifference curve, then the worker will choose more effort and a higher wage. But again the capitalist simply needs to set the payment schedule and let the worker choose.

If there is more than one worker and each needs to do the same amount of work per week or per year, because there is a division of labor, then the capitalist may have to announce work targets. He or she might find it too costly to allow complete freedom of effort choice. But when he or she chooses these targets they will be chosen to be the amounts the average worker would have freely chosen anyway. Suppose that a capitalist tries to impose a higher effort level than workers would freely choose, say at point B in Figure 1. Now the worker, even though they could be paid a higher wage, is on a lower indifference curve, and must be paid more to get them back to their old utility level. Thus in a competitive market with rational workers there is no profit to the capitalist in trying to destroy workers' effort choices away from what they would have chosen outside the factory using the same technology.

This is an important prediction of the coordination theory of discipline. Discipline will not distort the average choice of work intensity away from what independent workers choose using the same technology.

(2) The alternative to coordinating workers through discipline is to hold inventories between each stage in production so that the whole process does not have to close down because one worker is absent. If discipline was imposed because of the need to coordinate the workers better then we should be able to identify savings in the form of:

- (a) Reduced inventory costs.
- (b) Reduced operating costs from shorter opening hours for the factory (since all the workers are there at the same time) that equal at least 20% of the wages of workers.

(3) The third prediction of the coordination theory is that in a competitive labor market the penalties for deviating from the set production schedule or the approved behavior will be related to the

costs to the employer. In a competitive labor market the penalty for being a few minutes late, for example, times the probability of detection will equal the cost to the employer. That is,

$$\textit{Probability of detection} \times \textit{penalty} = \textit{Cost to employer}$$

This is another application of the principle that the wage equals the marginal product of labor in a competitive market. If the penalty is too high then it will be bid down since firms will earn more by having irregular workers.

(4) A fourth prediction we can make with the coordination theory of discipline is that discipline will be imposed where the costs of not coordinating are high. One of the major costs of not coordinating workers schedules tightly is that the firm has to keep inventories of work in progress between each stage of the production process to ensure that work does not halt because one worker is absent from the production process. The cost of the inventory in any production process, as a fraction of the wage bill, will depend on the number of stages in the division of labor, N , and on the value of output relative to the wage bill, b , (which in turn will depend on the capital per worker, and on the value of raw materials). The more stages in the division of labor the more piles of inventory there have to be kept per worker. The higher the value of the output relative to wages, the greater the capital cost of storing this inventory relative to wages. The reason for this is that if Q is the value of output of the firm per week, and wL is the wage bill, then the value of inventory that would have to be kept to keep the factory working for a week in case any worker was absent would be

$$QN$$

Relative to the wage costs of the factory the inventory required to ensure a week of operation without coordination of workers is

$$\frac{QN}{wL} = N/b$$

where $b = (wL/Q)$ is the share of wages in the value of output. If discipline is for coordination discipline should be chosen in industries where N/b is large.

DISCIPLINE AS COERCION

The coercion theory of factory discipline argues that discipline succeeded not primarily by saving costs from coordinating workers, but by forcing them to increase their efforts. Suppose that while workers can freely choose some things, such as whether they work in a factory for not, but other choices they do not have complete control over, such as the amount of effort they put in over the course of a week when given the freedom to choose. The coercion theory says that with a free choice of effort the worker ends up with a sub-optimal level of effort at the week's end, and hence a low wage w_0 as in Figure 2. But when they enter the factory with its enforced higher effort norms they get the higher wage w_1 , though there is some unpleasantness in having to submit to discipline, which we can denote by d . Discipline is then preferred if,

$$U(w_0, e_0) < U(w_1, e_1) - d$$

Note that the greater the amount of fixed capital per worker is, the greater the chance is that the factory will be preferred since the wage is given by

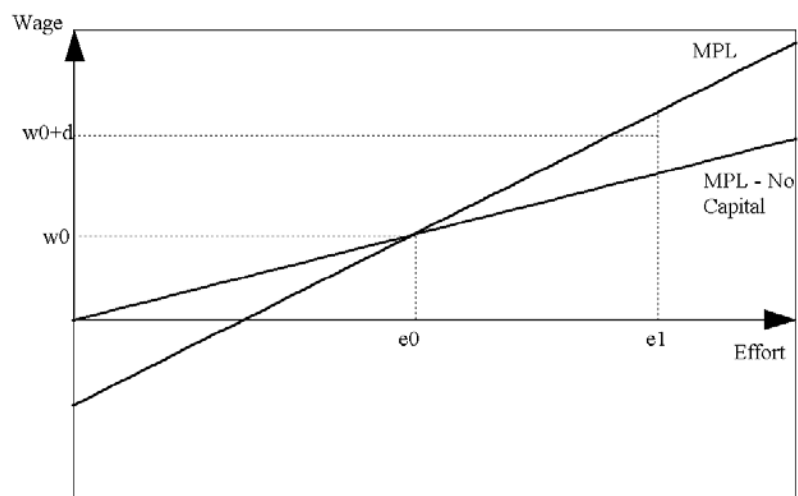
$$w = v \cdot e - F$$

so that the greater F is, the greater the wage premium is that is paid in conditions of discipline.

The coercion theory also implies that there is no need for penalties on workers to be related to costs even in a competitive labor market. For if the reason discipline succeeds is that workers find they cannot discipline themselves appropriately with the normal costs of starting late to work, or talking at work, then the discipline regime deliberately imposes artificially high costs for deviation from the approved production schedule. It does this to force workers to keep to the approved schedule.

Finally the coercion theory would argue that discipline will be imposed not where there is a greater premium to coordinating work schedules but where the marginal value of efforts is

Figure 2: The Coercion Account of Discipline



higher. That will be where there is more capital per worker. With no fixed capital, so that F is zero, if discipline increases output per worker by 33%, the wage would rise by precisely this amount. With greater amounts of fixed capital the wage increase from harder work will be more than proportionate to any increase in the amount of work. Coordination costs can be high, but there will be no discipline unless there is substantial fixed capital per worker.

Table 2 summarizes the different predictions of the two theories I have laid out here. Which one fits the data better?

Table 2: The Predictions of Each Theory

	<i>Coordination</i>	<i>Coercion</i>
Effects of discipline on worker effort	No effect	Increased effort
Source of cost of savings from discipline worker	Lower inventories, and overhead costs	Reduced cost capital per
Relation between Costs penalties and costs	Penalties = Costs	Penalties >
Technologies where discipline is found	N/b is high	Large fixed capital costs

DID DISCIPLINE INCREASE WORK EFFORTS?

What happened to work efforts where discipline was imposed compared to the same technology employed under conditions of incentives? The coordination theory implies no change in work efforts with discipline. The coercion theory argues the success of discipline lay in increasing work efforts.

We can estimate the relative amount of work done per week by people on the same techniques inside and outside the factory from information on their weekly wages and their payments per

unit of output. Suppose that w is the weekly wage, and θ the piece rate payment. Then the amount completed per worker per week will on average be

$$h = w/\theta$$

Let the subscripts f and i indicate factory independent (domestic or workshop) workers. Then in the early nineteenth century we find that

$$w_f = 1.6w_i$$

$$\theta_f = 1.17\theta_i$$

That is, factories paid workers for the same techniques wages which were 17% higher per unit of output, but paid wages per week which were on average about 60% higher than for domestic workers. This implies that the amount of work completed per worker in the factory per week was about one-third greater than for independent workers. This is not consistent with the idea that factory discipline was adopted only to coordinate workers.

There is also plenty of direct testimony that disciplined workers produced more. The quoted rates of increase of work intensity with discipline vary widely but all suggest a substantial increase. In the Derby silk weaving industry, for example, the workers reckoned that if a worker worked continuously for factory hours they would produce 48% more than the average undisciplined hard worker. These results show that had workers in factories continued to work the traditional hours of the hand industries they would have worked only 45 to 53 hours per week instead of the 60 to 70 demanded by the disciplined factories.

The reason for the greater factory efforts may have been that the domestic or workshop workers combined their work with small scale agriculture or other by-employments. But if it was economically desirable that with more capital intensive techniques workers concentrated on one occupation, the market system will lead to that outcome without any need for the factory discipline to achieve it. For independent workers faced with higher rental fees for more expensive capital would themselves choose to concentrate on one occupation. There is no need for factory discipline to impose this choice.

Another source of evidence that discipline increases labor intensity comes from experiments in Britain in the early twentieth

century which show that with a given set of workers the imposition of tighter discipline will increase weekly production, even for workers on piece rates. Eight workers working fixed hours on piece rates were subject on alternate days to a regime of imposed silence. On the days of silence they produced 7.6% more, though they greatly disliked these days. Ten workers on piecework had one worker isolated from the others on a rotating schedule. The isolated workers produced 36.4% more on the same task than when with the group, but again they disliked the periods of isolation. In another study workers increased their output by 6.7% when silence was imposed. This suggests that discipline would indeed have a causal role in driving up labor effort.

WHY WAS THE DISCIPLINED FACTORY MORE PROFITABLE?

We saw above that factory workers were typically paid a higher piece rate per unit of output. If the coordination theory of the factory is correct it should be because discipline allowed sufficient savings in inventory to pay workers this larger amount.

Let there be two weaving mills competing in the same labor and output markets. The first, ARKWRIGHT MILLS, is organized with strict factory discipline. Workers work a given schedule of 6 days of 11 hours per day, with no socializing at work, and a constant work pace. They are fined or dismissed if they turn up even five minutes late for work. The second, FREEDOM MILLS, allows workers as much freedom as possible consistent with producing the same 66 hours of output per week. It uses the workshop type of organization. Workers can come and go when they want, they can behave as they want, and they can vary the intensity of labor they wish. To give the workers this freedom the mill opens for 79.2 hours per week (13.2 hours per day instead of 11), and simply requires that by the end of the week each worker turns in a given stint of work. With this arrangement even though each worker is required to turn in 66 hours of work they can take all of any day off in the week, or they can begin up to 2.2 hours late each morning. They can come and go from the mill as they wish. The only difference between ARKWRIGHT MILLS and FREEDOM MILLS is the tighter coordination of workers in the disciplined mill.

There are three costs from the looser coordination in FREEDOM MILLS. Since the factory opens longer there has to be more supervisory input per worker. Since the factory opens

longer steam power and heating has to be provided for a longer period each day – more has to be paid for the engineman, and for coal. Finally if there is a division of labor larger inventories of work in progress have to be kept so that workers are not prevented from working by a lack of materials when workers earlier in the process are not present. Unlike the forebodings of Ashworth quoted above, even with a complex division of labor the mill will not grind to a halt when one worker is absent as long as sufficient inventory of work in progress is kept at each stage of the production process.

In FREEDOM MILLS 13.2 hours of extra inventory will be the maximum required at each stage of the production process as a result of the looser discipline. If the worker has to meet a target at the end of each week of 66 hours output and the workshop opens for 13.2 hours each day, no worker can get more than 13.2 hours ahead in their work than any other. Thus to ensure that each worker was not held up because the worker before him in the production process was working more slowly there would have to be no more than 13.2 hours of inventory at each stage of the process.

What is the sum total of these extra costs? The answer for a typical nineteenth century weaving mill is that it was about 3% of the wage bill. Thus the gain from coordination alone cannot explain why discipline made the factory profitable. But the coercion theory is able to explain this. For if it was the case that discipline made workers produce more output per machine per week then now there would be an additional gain from discipline in the form of lower capital costs per unit of output. This gain is much greater than any of the inventory savings and would imply that mill owners who imposed discipline could pay a wage up to 25% higher per unit of output to workers working in a disciplined weaving mill.

Suppose that cotton weaving involved no fixed capital. Then most of the cost savings from increased efforts under discipline would be lost, and ARKWRIGHT MILLS would not survive in a competitive labor market. The condition for discipline to succeed is that there exist significant fixed capital costs per worker. Houldsworth, mentioned above as having employed hand mule skimmers with incentives and power mule spinners with discipline noted that,

“it must always be of importance that work-people should be steady and attentive to

their work, but as the capital occupied by a hand-spinner was so much less than that which is now occupied by a power-spinner, it of course was not of the same importance.”

PENALTIES AND COSTS WITH DISCIPLINE

In a competitive labor market no employer will be able to impose penalties for deviation from approved conduct that exceed the cost to the firm of these deviations. Otherwise they will lose profitably employed workers to other enterprises. Consider the fines or lockouts that were imposed in industries such as cotton weaving when workers are a few minutes late to work. A typical fine would be two hours wages for 5 minutes lateness, about 3.6% of weekly wages. Or, because of fear of prosecution under the Truck Acts, employers would simply prefer to lock the workers out for a couple of hours. Did a worker who came five minutes late conceivably impose such costs on the firm?

Suppose we offered workers who were often penalized for being late the following contract. They would be allowed to be up to one hour late without any penalty, because the factory would be kept open an hour longer. But they would have to pay the costs of keeping the factory open for the longer period each day. That is they would have to pay the costs their irregularity imposed on the firm. The cost that would have to be imposed on the firm if all workers used this option would be 0.023% of the weekly wage for each day that they wanted the option of coming later. Even if only 10% of the workers were irregular the cost would be a penalty equal to nine minutes of work time for each hour a worker came late. With this arrangement the workers who could commit to regularity would get paid a slightly higher wage than those who chose the option of irregularity. But the difference would be negligible.

Disciplined factories thus consistently fined workers more for being late than would be expected in a competitive market.

The coercion theory can explain these heavy penalties as being necessary to coerce workers to do more work than they would otherwise choose.

TECHNOLOGY AND DISCIPLINE

What happened in the industrial revolution period to techniques which had high inventory costs of not coordinating but small amounts of fixed capital per worker? The coordination theory suggests that discipline would be used with these techniques also. But the coercion theory argues that these techniques would remain undisciplined, since there would be small gains from better coordination alone.

The pottery industry in the nineteenth century is exactly the kind of industry which falls in this category. The manufacture of pottery required an extensive division of labor in the nineteenth century, but with very little fixed capital per worker. Figure 11.3 shows the flow of work through the pottery making process. As can be seen the typical article would start with preparing the clay and grinding flint and the preparation of a paste of clay and flint, which took six steps. Then the paste would be stored to mature. Before being formed it would be wedged and beaten to smooth it further and remove air bubbles. Then a baler would weigh out the correct amount, a thrower would form the rough shape, and a runner would take the piece to a drying oven. When sufficiently dry it would be given its final shape by the turner, then a handler would apply handles and other non-circular elements. Then it would be dried, and placed in clay vessels called saguaro for the biscuit firing. After being removed from the biscuit oven the piece would be inspected by sorters to remove defective ware, before being scoured by fettles or towers to remove imperfections picked up in the firing. Then the piece would be placed in the biscuit warehouse. It could be decorated in several ways. One was by printing a pattern from a paper transfer, where the paper was removed by washing the piece in water, before dipping the piece in an alkaline solution. The glaze was applied in the glost oven after the piece was placed in another sagger. On removal from the oven the piece was inspected again, polished, and finally crated for transport. One ceramic item could easily pass through 29 different hands in this process.

The extreme division of labor in pottery is reflected in a statement by a manufacturer in 1908 that,

Figure 3: The Division of Labor in Earthenware Manufacture

1. wash flint
2. clean clay of stones heating flint
3. granulating clay granulating flint
4. forming clay liquor forming flint liquor
5. sifting sifting
6. mixing flint and clay liquors
7. evaporating water to form paste
8. storing paste to let it mature
9. beating paste
10. balling paste (weighing it)
11. throwing
12. drying
13. turning
14. attaching handles, etc.
15. drying
16. placing in saggars
17. biscuit firing
18. sorting
19. scouring
20. transferring print
21. washing off paper
22. dipping in alkaline solution
23. dipping in glaze
24. brushing
25. drying
26. gloss firing
27. sorting
28. polishing
29. packing

Source: Ure, Dictionary of Arts, Manufactures, and Mines, pp. 1015-1036.

“there would be fifty, sixty, or a hundred different departments, and work passes from one department to the other. In many of those departments the thing is simple, the person works alone.”

In confirmation of the extreme division of labor, a 1913 survey of a group of factories found 87 occupational groups in the production of earthenware. The extensive division of labor meant that the value of work flowing past each worker would be high in relation to the wage of the worker. “In many cases the value of the finished article is 100 times the individual wage for doing a portion of it.”

The fixed capital per worker was very small because apart from the steam powered grinding machinery and a few steam powered potters wheels most of the work was done by hand or with simple hand-powered machinery.

Above we noted that a measure of the inventory cost of not coordinating across industries relative to wages would be N/b where N is the number of stages in the division of labor and b is wage share in total costs. For cotton weaving $N = 3.5$ and $b = 0.112$, so that $N/B = 31$.

In the mid-nineteenth century the value of output was about double the wage bill, so that $b = 0.5$ in pottery. Though there were at least 29 steps in the division of labor, some of the work would be done by coordinated work teams such as the thrower and the runner who took the ware to the drying oven. But there were still at least 20 independent sets of workers involved in the production of simple earthenware at a large factory. Thus $N/b = 40$, which is higher than in power cotton weaving. The cost of the FREEDOM mill arrangement in the potteries would be 1.6% of wages from extra inventory alone, compared to 1.2% in power weaving. There were some extra fuel costs from keeping the factories open longer than necessary in the potteries also (since there was some steam power, and fuel was used to run drying ovens and heat workshops). The total coordination cost of indiscipline in the potteries cannot have been any less than the 3% of wages calculated in the cotton weaving mill.

Yet, as noted above, the potters were allowed their traditional freedoms well into the twentieth century. In the 1840s some pottery factories opened for 84 hours per week, even though the

amount of work done probably did not exceed 60-63 hours, since the workers were undisciplined and some other factories opened for only 10 or 10.5 hours per day on stricter schedules. This implies that they kept large stocks of inventory to accommodate the uncoordinated workers. The coordination theory again fails. But the indiscipline of the potters is consistent with the coercion theory given the very small amounts of fixed capital per worker in the industry.

Pin making had an extensive division of labor in the nineteenth century but very little capital per worker, since the machinery was simple and hand-powered. Pin making in the mid-nineteenth century involved 14 distinct steps. The value of the output was again about double the wage bill, which implies that $N/b = 28$, nearly as high as in power weaving. Yet the pin factories of Warrington in 1843 were open for 13 or 13.5 hours daily, and within these limits the workers had “no restrictions as to time... they come and go just when they please.” On Mondays less than half the workers were at work.

The indiscipline of miners is consistent with the coercion theory. Mining up until 1914 was largely a hand industry, with a surprisingly small amount of fixed capital per worker. Thus in the late nineteenth century fixed capital costs per ton of coal at the pithead were only about 20-25% of wage costs. Compare this to capital costs of 35% of wages in power cotton weaving by 1840, and even more in power spinning. Increasing output per miner through strict discipline would not save enough in capital costs to pay the discipline premium that we see being paid in the nineteenth century. Also the fixed capital in the mines was largely embodied in the shafts, the winding machinery and the underground roads. 60% of the workforce in the mine in the late nineteenth century were the faceworkers, who worked by hand to hew the coal. The hewers were undisciplined and so produced less per week than if they had been forced to attend at regular hours and closely supervised within those hours. But this could be compensated by giving each miner a smaller part of the coal face to work. In effect the fixed cost per coal hewer was still quite small despite the use of much steam power in the industry to wind up the coal. Had all coal hewers decided to work 33% more it would not have been possible to get more output out of a given pit, since the limitation was the winding capacity of the shaft. There were coordination costs from the indiscipline of coal hewers, but few capital costs. Consequently miners were undisciplined.

DISCIPLINE AND WORKER RATIONALITY

The fact that saving on capital costs through increases in labor intensity seem to have been crucial to the success of factory discipline is very puzzling, however. For if workers are rational there is no reason for the disciplined factory to gain an advantage from its ability to increase labor intensity. Undisciplined workers controlled by incentives who were fully rational would always be able to reproduce the work pace of disciplined workers, if this was what they desired, without having to suffer the unpleasant aspects of discipline.

FREEDOM MILLS can always achieve the same work intensity as ARKWRIGHT MILLS with rational workers simply by setting a minimum quota on work performed per week which is the same as the disciplined factory achieves. Simply by raising the stints of undisciplined workers most of the wage gains of the disciplined factory were attainable.

Alternatively factories could have employed one of the compensation systems employed in practice which encouraged workers to economize on the use of capital. One of these was charging a lump sum “machine and power” rent each week, as was done with many hand powered machines, and paying a higher piece rate. With the increase in capital intensity the fixed charge per worker would be increased, encouraging the worker to utilize the capital more intensively. There were certainly a few cases where powered machinery was accommodated by simply increasing the ‘rent and charges,’ while leaving workers their traditional freedoms. Such a rental system continued for at least 40 years in cutlery grinding in Sheffield until at least the 1890s, the fixed charge for power and factory space then averaging almost 33% of the net wage. Some clothing workers in 1907 paid weekly rent and power charges for sewing machines used in factories. Hairdressers (and taxi drivers) now sometimes pay a flat fee for their chair (or taxi), and collect all the customer’s payment, leaving employers indifferent to how much they work.

If workers were minimally rational both these schemes, stints and fixed rental charges for capital, should have allowed FREEDOM MILLS to offer workers most of the traditional freedoms of the workshop, without reducing the wage the factory could offer by a significant amount. Thus the success of the factory through increasing the amount of output delivered per

worker is a puzzle, in that it is not consistent with workers being completely rational.

It implies that discipline was needed because workers under incentive schemes were not able to match the efforts of their colleagues under discipline, no matter how much at the end of the week they might wish they had done so. Discipline increased the work effort simply by locking the worker into working for a set number of hours without distraction each week. The key was that it temporarily removed from workers control over how hard they worked – the factory worker voluntarily entered into a temporary condition of slavery.

One hypothesis about why the workers had to hire discipline from the employer would be the following. Almost all production activities yield not current satisfactions, but some future reward to which this moment's effort contributes some small element. In a world of perfectly rational actors this presents no difficulty. The individual simply decides whether the disutility of each current effort is greater than the resulting addition to utility at some later date, discounting future pleasures by some factor if necessary. A problem arises, however, if the utility of the future outcome resulting from the current small effort is indistinguishable from the outcome without the current effort because the difference is small and human perception and calculation limited. This is the limitation on rationality. If the current moment's sacrifice makes no appreciable difference to the future, why make the effort? What is true of this moment's sacrifice is true seriatim of each moment. Delaying the start of work in the morning by five minutes on a particular morning will not have any discernible effect on your earnings at week's end, nor will delaying another five minutes once you are already five minutes late. Consequently workers face the analog of the classic free rider problem for public goods within their own person. Future benefits are the consequence of the collectivity of current sacrifices, but each momentary sacrifice in itself makes an insignificant contribution to the future benefits. Why undertake any current sacrifices?

This problem has been noted in the context of savings behavior, and is the class one of dieters. Dieters are asked to forego a current satisfaction for the sake of some small future weight reduction, a difference which on its own will be imperceptible. Each bit is inconsequential, and consequently almost all diets are unsuccessful. But if each bite were to produce some discernible outcome, the appearance of a corresponding small lump of flesh, dieting would be much easier. A solution to

this problem of self control is to arrange to raise the costs of avoiding each momentary sacrifice. This is exactly what factory discipline does for the workers. By locking them in the factory and banning most social intercourse the possibility of seeking a few moments pleasure rather than working is eliminated. The cost of pleasure is not now some imperceptible future loss of income, but a heavy fine or the loss of one's livelihood. The workers dislike discipline but they stay in the factory because at the end of the week their wage is 60% greater than they can achieve without discipline.

This, of course, is all speculation. What we can say for sure, however, is that the triumph of the factory was by a means that is entirely unexpected to economists, though not perhaps to some historians. It was not a triumph driven purely by technology, but relied on subtleties of human nature that are not normally explored in economics.

CONCLUSION

I argue that the competitive advantage of factory discipline on the new machine powered technologies of the nineteenth century was its ability to make a given set of workers work harder than they would under incentive systems. I estimate that discipline pushed up the work rate by about 33% in the nineteenth century. The workers disliked the imposition of discipline, and to get workers to work in these conditions capitalists had to pay a substantial premium on weekly wages which I estimate to be about 56-66%. With the hand technologies of the eighteenth centuries and earlier discipline could not succeed because the gains to the employer from increased output per worker were less than the wage premium. But when new techniques appeared where there were substantial amounts of fixed capital per worker, more work per worker produced substantial savings through more intensive use of capital. Thus disciplined displaced incentives, but only on the appropriate technologies. Where the technical conditions were right incentive systems survived into the twentieth century.

Though factory discipline was coercive, forcing the worker to do what he or she would otherwise not have done, the worker was in no sense exploited by the introduction of discipline. The workers voluntarily entered into the temporary servitude of the factory, and were appropriately rewarded for its disamenities with higher wages. Had they been able to exercise more self-control factory discipline could have been avoided for most technologies in the nineteenth century.

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