"A Theory of Bailouts of Firms and Enterprises, With Evidence from Polish Industry"

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Abstract

This thesis examines a number of aspects of a government policy of rescuing firms or enterprises that are in difficulties, with particular attention to the East European context.

The first part of Chapter 2 examines a concept introduced by Janos Kornai, the "soft budget constraint", and argues that it should be interpreted as a state policy of bailouts of enterprises in financial difficulties. The second part of the chapter examines the effect on incentives of a state policy of bailouts, arguing that in principle a bailout policy has an ambiguous effect on enterprise performance.

Chapter 3 looks at the causes behind a government policy of bailouts. A game-theoretic model is presented in support of the argument that a cause of a bailout policy may be that the government is unable to make a credible commitment not to bail out an enterprise. The model also shows that if the government can acquire a "reputation for toughness", its threat of "no bailouts" may be credible. The phenomenon of "storming" or rush-work to meet a deadline is also analysed.

In Chapter 4 a model of economic natural selection is developed. The model demonstrates that profit-maximisation does not "summarise appropriately" the conditions for firm survival. If firms have market power, profit-maximisers are not necessarily the best survivors. The economic model presented derives from the biologists' "evolutionarily stable strategy" (ESS) model. An appendix presents a version of the ESS model for finite populations.

Finally, the thesis looks at empirical evidence on financial bailouts using data from the 500 largest enterprises in Polish industry, 1983-88. Chapter 5 discusses the data and the tax/subsidy system. Chapter 6 looks at how these enterprises were subsidised, and presents evidence, based on econometric estimates of government subsidy policy, that subsidies were used to rescue loss-making enterprises.

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Chapter 1: Introduction

This thesis examines a number of aspects of a government policy of rescuing firms or enterprises that are in difficulties, with particular attention to the East European context. Other subjects discussed in the thesis are Janos Kornai's concepts of the "soft budget constraint" and "paternalism"; "storming" or rush-work to meet a deadline, a typical feature of socialist economies; and "economic natural selection" and evolutionary game theory. The last part of the thesis is an empirical investigation of bailouts of Polish enterprises in the 1980s.

Chapter 2 serves as an extended introduction to the subject. In it I make two separate points. The first concerns a concept introduced by the Hungarian economist Janos Kornai, the "soft budget constraint". The "soft budget constraint" has sometimes been interpreted by other economists in different ways; I argue that the interpretation most consistent with Kornai's writings is that socialist enterprises are bailed out by the state if they run into financial difficulties. The second part of the chapter examines the effect on incentives of a state policy of bailouts. I argue, in contrast to a number of writers on this subject, that in principle a bailout policy has an ambiguous effect on enterprise performance. The formal models used to demonstrate this point also show that empirical studies of bailout policies will face an observation problem: if firms do not run into difficulties then state subsidies to rescue firms will not actually be paid out, but a bailout policy may still exist and have real effects on firm behaviour.

Chapter 3 looks at the causes behind a government policy of bailouts. A game-theoretic model is presented in support of the argument that a cause of a bailout policy may be a government credibility problem: the government may be unable to make a credible commitment not to bail out an enterprise. The model also shows that if the government can acquire a "reputation for toughness", its threat of "no bailouts" may be credible. An interesting feature of this model is that the enterprise exhibits a "storming" work pattern, i.e. the work tempo speeds up as the production deadline approaches. Existing explanations of the storming phenomenon have not always been convincing. I explore this point briefly in the main text of the chapter, and then in more depth in the second of two appendices to the chapter (the first appendix presents the complete list of equilibria for the main model of the chapter).

Since under a government policy of bailouts no firms go bankrupt, such a policy means "economic natural selection" does not operate: all firms survive, the "fit" as well as the "unfit". A natural subject to investigate is the effects of suspending the process of economic natural selection in this way. Evolutionary economic modelling is not very well developed, however, and in particular the logically prior subject of the effects of allowing economic natural selection to operate has not yet been fully investigated. It is this latter subject that I turn to in Chapter 4. A model of economic natural selection is developed, drawing on theoretical work by evolutionary biologists. The model demonstrates that the well-known conjecture of Milton Friedman and others that profit-maximisation "summarises appropriately" the conditions for firm survival is not generally true. If firms have market power, profit-maximisers are not necessarily the best survivors. The economic model presented derives from a now-standard model in evolutionary biology, the "evolutionarily stable strategy" (ESS) model of John Maynard Smith. This latter model was originally developed for studying infinite populations; in the appendix to this chapter, I present a version of the ESS model for finite populations. The economic model presented in the chapter is essentially a modified version of the ESS model for finite populations.

Finally, the thesis looks at empirical evidence on financial bailouts in Poland. The source of the evidence is data from the 500 largest enterprises in Polish industry, 1983-88. Chapter 5 is essentially an introduction both to the data and to the tax/subsidy system in place in Poland during this period. Chapter 6 then looks at how these enterprises were subsidied. In particular, I present evidence, based on econometric estimates of government subsidy policy, that subsidies were used to rescue loss-making enterprises.

The main results and arguments presented in the thesis are summarised in the concluding Chapter 7.

Chapter 2: Budget Softness and Enterprise Efficiency[1]

Introduction

The purpose of this chapter is two-fold. First, I will briefly examine the concept of the "soft budget constraint", introduced by the Hungarian economist Janos Kornai. I will argue that the soft budget constraint amounts to a policy by the state to "bail out" or rescue enterprises that are in difficulties. Second, I will present two simple formal models which will explore the relationship between budget softness and enterprise efficiency. The point of these models is simply to show that this relationship may be more complex than is typically assumed in the literature on this subject. In the first model, budget softness can lead to improved efficiency; in the second model it leads to lower efficiency. The models also demonstrate that empirical studies of budget softness may face an observation problem: if enterprises do not run into difficulties then state subsidies to rescue enterprises will not actually be paid out, but budget softness may still exist and have real effects on enterprise behaviour.

Kornai's "Soft Budget Constraint"

In his Economics of Shortage (1980, chapter 13), Janos Kornai introduced the concept of the "soft budget constraint". Enterprises in a socialist economy, he argues, do not go bankrupt if they overrun their budgets. Rather, the survival of the enterprise is ensured by a variety of instruments available to the state which are employed on the enterprise's behalf: free state grants, tax breaks, price changes, and so forth. In his book Kornai applies the "soft budget constraint" notion to enterprises in centrally planned and Hungarian-type economies, but he points out that firms in Western market economies may also have soft budget constraints.

Kornai's main concern in his 1980 book is shortage, and "budget softness" plays a crucial role in his explanation of persistent shortage in socialist economies. In brief, he argues that the natural drive of enterprises to expand leads to an insatiable demand for investment and thus shortage of investment goods, which in turn generates shortage of goods generally. This insatiable demand of enterprises for inputs is possible only because the enterprise faces a soft budget constraint - its demand is not tempered by the possibility of bankruptcy.

Kornai's argument is criticised by Stanislaw Gomulka (1985b), who stresses the importance of the price system in determining the extent of shortage. Gomulka argues that in a hypothetical socialist economy where enterprises have soft budget constraints but where prices are more flexible than budget constraints and are set by enterprises in the market place, we would not observe conditions of chronic shortage. Rather, the main consequence of budget softness in this economy would be inefficiency in enterprises. I will return to this latter point later in this paper.

In an article published in 1986 which is in part a response to Gomulka's paper, Kornai (1986a) presents a reformulation of the soft budget constraint concept. Kornai redefines budget softness as follows:

> The "softening" of the budget constraint appears when the strict relationship between expenditure and earnings has been relaxed, because excess expenditure over earnings will be paid by some other institution, typically by the State. A further condition of "softening" is that the decision-maker expects such external financial assistance with high probability and this probability is firmly built into his behavior. (Kornai 1986a, p. 4)

It is important to note here the conditionality of the means by which budget constraints are softened. A enterprise with a soft budget constraint receives "external financial assistance" only if it incurs "excess expenditure over earnings". The subsidy paid by the state is conditional on the enterprise making losses; if the enterprise did not make losses, the subsidy would not be paid. In contrast, an unconditional subsidy does not soften the enterprise's budget constraint; if the enterprise went into the red despite the subsidy, it would still go bankrupt. In other words, a enterprise with a soft budget constraint will be "bailed out" or rescued by the state if it makes losses. This means, by the way, that the mere existence of enterprise subsidies is not proof that budget constraints are soft, since the subsidies may not be conditional on loss-making.

The importance of the conditionality of measures to rescue enterprises is implicit in Kornai's 1980 formulation and explicit in his 1986 paper. In the latter, Kornai sets out four means by which a enterprise's budget constraint may be softened.

1. Soft subsidies by the state. "The subsidy is soft if it is negotiable ... and is adjusted to past, present or future cost overruns." (Kornai 1986a, p. 5)

2. Soft taxation. This does not mean a low rate of taxation. Rather, "[tax] rules are negotiable" and "the fulfillment of tax obligations is not strictly enforced: there are leaks, ad hoc exemptions, postponements, etc." (p. 6)

3. Soft credit. This refers not to the magnitude of the interest rate but to the repayment terms: "the fulfillment of a credit contract is not enforced ... and postponement and rescheduling are in order." (p. 6)

4. Soft administrative prices exist if they are "set [bureaucratically] according to some permissive 'cost plus' principle that almost automatically adjusts the price to costs." (p. 6)[2]

Since Kornai's initial presentation, a second definition of the soft budget constraint has been used in the literature. This definition identifies budget softness with the existence of bargaining between the state and the enterprise over financial resources. For example, this is the definition that Marrese and Mitchell (1984) use when they write that "firm management in the [Hungarian] postreform environment bargains with superior authorities about financial regulation (certainly this is the true essence of soft budget constraints)" (p. 77). This is also the definition used by Gomulka in his critique of Kornai.

This confusion in the literature over exactly what is the definition of the "soft budget constraint" is probably mostly a result of Kornai's exposition. His 1980 book concentrates on the means by which budgets are "softened" (the means by which enterprises are rescued), and not on the conditions under which aid is granted (the enterprise must be in financial difficulties). Indeed, Kornai himself has sometimes suggested this as the correct interpretation of "budget softness". For example, in Kornai (1987, p. 325) he writes that in Hungary

> ... fiscal redistribution is, to some extent, subject to bargaining. If a firm enjoys high profits, it keeps silent so that a supervising agency will be less likely to skim away the extra earnings. On the other hand, if a firm has financial troubles, laments will be heard by the authorities. ... I call this situation the "softening of the budget constraint .... [a firm's] budget may expand or contract at the will of the authorities, who can add or subtract from the pretax, presubsidy profit as much as they want. ... An important characteristic of the soft budget

> constraint is leveling, which depresses the profitability of the successful firms, at the same time helping out the losers.

In this particular paper, Kornai not only identifies bargaining as the central feature of the budget softness phenomenon, but also states that the concept covers the treatment of both loss-makers <u>and</u> profitable enterprises.

In his 1986 <u>Journal of Economic Literature</u> paper, Kornai (1986b) appears to use <u>both</u> definitions of budget softness. First he states (p. 1697)

> Loss, even if long lasting, can be compensated for by different means; ad hoc or permanently favorable tax conditions or bail-out credits. The author ... coined the term <u>soft budget constraint</u> to describe this phenomenon.

This appears unambiguous: budget softness is identified with bailouts/rescues. But then on the next page (p. 1698) he writes

> On the other end of the spectrum are the firms making large profits. ... [T]here is a peculiar egalitarian tendency operating to reduce the larger profits. The budget constraint is not only soft, but also perverse.

Nevertheless, in most of his writings Kornai uses the first definition - budget softness as rescue in the case of financial difficulties. Significantly, when he presented a formal model of the soft budget constraint, this was the definition used (Kornai and Weibull 1983). This is now the usual interpretation used by other writers (for a formal model using this definition, see Goldfeld and Quandt 1988), and is the interpretation I will use in the remainder of this chapter.

It is worth noting at this point that, although it has been Kornai who has recently focused attention on the importance of bailouts/rescues in socialist economies, the idea itself is not new. Ludwig von Mises wrote in 1920,

> in practice the propertyless [i.e. socialist] manager can only be held morally responsible for losses incurred. And so ethical losses are juxtaposed with opportunities for material gain. The property owner on the other hand himself bears responsibility, as he himself must primarily feel the loss arising from unwisely conducted business. (von Mises 1920, p. 122)

In other words, von Mises is arguing that socialist enterprises/managers have soft budget constraints, and capitalist firms/managers do not.[3] And identifying the soft budget constraint with bailouts/rescues makes the connection to the existing literatures on bailouts/rescues in Western/capitalist economies. (A recent example of this literature is Hillman et al. 1987.)

Budget Softness and Enterprise Efficiency

Kornai does not discuss the relationship of budget softness and enterprise efficiency in his 1980 book. This theme is taken up briefly by Levine (1983, pp. 254-5), who states that the soft budget constraint slows the diffusion of new technology by allowing inefficient enterprises to survive instead of being replaced in a process of "creative destruction" (Schumpeter's term), and by reducing the incentive to innovate provided by the threat of bankruptcy. In his 1985 critique of Kornai, Gomulka argues that efficiency and budget softness are directly connected:

> Budget constraints are softer when and where tolerated economic inefficiency is greater, and it is relatively high efficiency losses, not chronic shortages, that are probably an unavoidable characteristic .... (Gomulka 1985b, p. 74)

Gomulka goes on to suggest that, at the enterprise level, the degree of budget softness is "the unit resource loss that is tolerated by markets and/or planners, taking the unit resource cost that would obtain under a perfectly competitive market structure as the standard against which to compare the performance of firms" (Gomulka 1985b, p. 77). Total budget softness is "the total resource loss that a firm incurs in the course of its economic activity within the budget period" (ibid.).

In his 1986 paper, Kornai argues that budget softness reduces innovation and efficiency:

> If the budget constraint is hard, the firm has no other option but to adjust to unfavorable external circumstances by improving quality, cutting costs, introducing new products or new processes, i.e. it must behave in an entrepreneurial manner. If, however, the budget constraint is soft such productive efforts are no longer imperative. Instead, the firm is likely to seek external assistance asking compensation for unfavorable external circumstances. ... The soft budget constraint protects the old production line, the inefficient firm against constructive destruction and thus impedes innovation and development. (Kornai 1986a, pp. 10-11)

Kornai is thus in substantial agreement with Gomulka and Levine.

In this chapter I shall argue that the effect of budget softness on efficiency may actually be more complex. My main point is that under certain circumstances a soft budget constraint may promote efficiency gains. A second point is that empirical studies of budget softness may face an observation problem: budget softness may affect the level of efficiency of enterprises without any subsidies actually being paid.

Before proceeding, I should note that my main concern in this chapter is with the direct consequences of budget softness for enterprise efficiency. For example, Kornai has argued that the soft budget constraint leads to shortage and a sellers' market, and incentives to improve efficiency in a sellers' market are weakened because enterprises do not find it difficult to sell their products. I will not discuss such indirect effects in what follows.

Budget Softness and Enterprise Efficiency: Another Look

We can distinguish between two direct consequences of budget softness on enterprise efficiency. First, unprofitable enterprises, obsolete or inefficient capital stock and techniques, etc., survive longer or more frequently, and their more efficient replacements thus diffuse less rapidly. This direct effect of budget softness is thus to slow the process of creative destruction. The effect of this on aggregate productive efficiency is unambiguously negative. (It is not necessarily the case, though, that budget softness will mean profit-maximising behaviour is observed less frequently, because "economic natural selection" does not necessarily lead to the success of profit-maximisers, as we shall see in Chapter 4.)

Second, budget softness may affect enterprise efficiency via incentives at the enterprise level. However, the direction of this second effect is *a priori* ambiguous. This can be seen if we distinguish between "positive" and "negative" incentives for enterprises to improve their productive efficiency. Positive incentives are rewards for raising efficiency; they promote what might be called "greed-driven" improvements. Negative incentives are penalties for not raising efficiency; they promote "fear-driven" improvements. Budget softness can in principle increase positive incentives and decrease negative incentives.

Take the specific example of enterprise R&D, though the argument applies to any risky activity which can improve enterprise efficiency. Suppose that, since budget softness ensures the survival of the enterprise, the negative incentive of penalties for non-innovators is decreased. On the other hand, riskiness of R&D may deter enterprises from innovating; in this case, budget softness, by guaranteeing the survival of the enterprise, effectively increases the reward to innovating (the lower tail of the probability distribution of the returns to innovating is cut off). Thus the net result may be more, or less, innovation.

The ambiguous effect of budget softness on enterprise productivity has important implications for how we measure budget softness; it means that measuring the degree of budget softness by its ex post efficiency effects on enterprise performance (as suggested by Gomulka) may be inappropriate. Rather, I suggest we define the degree of budget softness by reference to the ex ante probability distribution of state aid conditional upon the size of the actual loss experienced by the enterprise.[4] In this framework, "complete budget softness" means that a loss of any size will always cause the state to rescue the enterprise with a 100% matching subsidy.

Several points about this definition are worth noting. First, by the enterprise's "loss" I mean the excess of actual, ex post "profit" over planned, ex ante "profit". A enterprise may be subsidised in order to ensure that its planned revenue matches its planned costs; but if this enterprise experiences a cost overrun which is not met by a further subsidy, then its budget constraint is not "soft" (though the existing subsidy may be evidence of bargaining between the state and the enterprise, i.e. definition 2 of "budget softness").

Second, this definition of budget softness contains the notion of "conditionality" mentioned above; the state aids the enterprise only if the enterprise experiences cost overruns. The definition excludes state aid granted to the enterprise for reasons other than losses.

Third, the definition can accommodate Gomulka's notion of "marginal budget softness" (Gomulka 1985b, p. 78). For simplicity, let us define the degree of budget softness as the difference between the expected value of the state subsidy and the actual loss experienced by the enterprise, divided by that loss. In other words, the degree of budget softness is the fraction of the losses experienced by the enterprise which the state is expected to cover. We can then write the degree of budget softness as a function of the size of the loss experienced by the enterprise. This would, for example, allow us to formulate situations in which the degree of budget softness declines with the size of the enterprise's losses - the larger the losses, the smaller the percentage covered by the state. In such cases we could say that the enterprise's budget constraint becomes increasingly "hard" at the margin.

Finally, this definition and the models I present later in the chapter implicitly link the fate of managers and enterprises. In other words, I do not allow for the case where the enterprise makes losses and is rescued by the state, but the manager is penalised as well. I would argue that this managerial incentive structure contains a hard budget constraint; I will return to this point in the next chapter.

Kornai, in arguing that budget softness decreases enterprise efficiency, has only "fear-driven" efficiency improvements in mind. This is clear from the quote on innovation cited above, and from his statement that

> A hard budget constraint means that even if the firm tries hard to cut its losses, the environment will not tolerate a protracted deficit. The emphasis is on punishment. The budget constraint is hard, if persistent loss is a matter of life and death; the more the loss-maker is spared from the tragic consequences, the softer is the constraint. (Kornai 1986a, p. 8)

Several recent essays (Levine 1983, p. 255, Gomulka 1985a, p. 25, McAuley 1985) have argued that the poor innovation performance of enterprises in centrally planned economies is due primarily to the absence of competition and of penalties for non-innovators. Thus McAuley (1985, p. 37) writes that "it is not the absence of the promise of substantial financial rewards that discourage rapid innovation. ... [S]luggishness in the diffusion of new products and processes is to be attributed to the absence of substantial penalties for laggards." The importance of budget softness in explaining the innovation performance of the socialist economies may therefore be considerable.

In the next two sections I will present two simple models budget softness and enterprise-level incentives. In the first model, efficiency improvements are "greed-driven" and budget softness leads to more a higher level of enterprise productivity. In the second model, efficiency improvements are both "fear-driven" and "greed-driven" and budget softness leads to a lower level of enterprise productivity.

Budget Softness and "Greed-Driven" Efficiency: A Model

The utility-maximising manager of an enterprise is faced with the decision of whether or not to enter into an investment project with an uncertain return (or indeed to engage in any single risky activity). Only one project is available for consideration. The outcome of the activities of the enterprise which are not concerned with the project are known in advance with certainty; only the outcome of the investment project is uncertain. In other words, the enterprise earns a basic level of profit which is certain and known in advance to the manager; and the investment project yields an incremental profit which may be positive or negative and is uncertain.

Part of the manager's income is positively related to the performance of the enterprise. Thus the uncertainty of the investment project translates directly into uncertainty in the manager's income. More specifically, the manager receives, in addition to his/her basic salary, a bonus or penalty which is a fixed percentage of the *ex post* final profit (including subsidies) of the enterprise;

i.e. the bonus or penalty is proportional to the sum of the certain basic profit of the enterprise, the actual incremental profit which the investment project has generated, and any state subsidy given to the enterprise.

To make things simpler, we assume that the size of the manager's bonus is insignificant compared to the enterprise's profits. In other words, we will ignore the component of the enterprise's expenses which is the manager's bonus.

To begin, assume the manager is risk-neutral, i.e. his/her utility function is linear. Utility maximisation by the manager implies the manager will approve investment projects which mean to him/her a positive increment to his/her expected utility (i.e. an uncertain increment to utility whose *ex ante* mean is positive). The manager's risk-neutral utility function combined with the linear (fixed percentage) bonus scheme in turn imply that any investment project with a positive expected return has for the manager a positive expected increment to utility, and an investment project with a negative expected return has for the manager a negative expected utility increment. The component of the manager's income which is determined by the enterprise's unrisky non-investment activities does not affect the manager's decision, since it has no effect on whether the marginal expected bonus resulting from the project is positive or negative. In short, the manager will approve projects which have positive expected profits. The manager will not approve dubious, "uneconomic" projects with negative expected profits.

Now add budget softness. By this I mean that if the investment project's profits are so negative that the enterprise's ex post total profit is negative, the state will with some positive probability subsidise the enterprise; i.e. state aid is conditional on the failure of the enterprise to make positive profits. The effect is identical to stating that, beyond a particular level of losses incurred by an investment project, state subsidies may be forthcoming.

Now, if there is no chance that the investment project will fail so miserably as to drag the enterprise's entire profits below zero, then the manager's investment decision is unaffected because the enterprise will never need to be rescued.

But if there is some positive probability that the state will need to rescue the enterprise if the project fails, then the introduction of budget softness has an effect on managerial behaviour. The manager is now willing to go ahead with some projects which he/she was unwilling to approve without budget softness - namely, those dubious "uneconomic" projects whose expected profit is negative but which now have for the manager a positive marginal bonus. Budget softness has led to more investment in the sense that the set of investment projects which the manager finds acceptable has been enlarged.

This is because the introduction of budget softness shrinks part of the lower tail of the distribution of the returns to the enterprise (including subsidies) which result from the project. The effect is as if disastrous projects were less likely. The managerial income scheme means that budget softness also shrinks part of the lower tail of the distribution of the marginal bonus which the project yields to the manager. The manager is thus now willing to approve those projects which, in the absence of budget softness, had a negative expected profit, but which, in the presence of budget softness, now have a positive expected profit. And if the enterprise's budget constraint is <u>completely</u> soft, meaning that losses of any size by the enterprise will always be rescued completely by the state, the manager will be willing to begin <u>any</u> project. Thus in this very simple model of the investment decision, if we measure investment by the number of projects a manager is willing to start, at the enterprise level budget softness and investment are positively related.

Several points should be noted at this stage. First, if a dubious project (one with a negative expected profit) does not by some chance lead to losses large enough to drive the enterprise's <u>ex post</u> profits below zero, rescue by the state will not actually take place - but budget softness has still affected the behaviour of the enterprise by causing it to begin the dubious project. Here is the observation problem mentioned earlier - we observe no subsidy, but budget softness has affected enterprise behaviour. However, if we look at many enterprises at once or at one enterprise over time, we will expect to see some projects fail so badly that state subsidies are forthcoming.

Second, note we have assumed that the set of potential investment projects is independent of the degree of budget softness. This excludes the possibility that an economy with soft budget constraints will have available a smaller (or greater) number of potentially successful investment projects.

So far we have considered the effects of budget softness on the investment decision of a single enterprise. Turning now to the industry level, say that budget softness is introduced to all the enterprises in an industry. We will see more investment projects entered, but against this we must count the cost of rescuing failed projects. In fact, under the assumptions we've been using, these costs will be greater than the larger enterprise profits from the increased number of successful projects. This is because prior to the introduction of budget softness, managers approved all projects with an expected profit greater than zero. Budget softness causes uneconomic projects to be started, which in aggregate will yield more losses than profits. Thus while budget softness increases the number of investment projects started, it causes efficiency losses through dubious uneconomic projects.

Now, return to the case of the individual enterprise with no budget softness. If we now assume that managers are (identically) risk-averse, and that they cannot entirely avoid bearing the risk of an individual investment project, the picture changes considerably. Managers will not now approve investment projects which are too risky - they will not approve projects with a positive expected profit and corresponding positive expected marginal managerial bonus if this expected marginal bonus is not great enough to compensate the manager for bearing the risk. However, if budget softness is introduced, managers will now be willing to approve some of these risky but profitable projects. And if the degree of budget softness is not so excessive as to cause too many uneconomic projects to be started, then we will see an aggregate efficiency gain over the situation with no budget softness. The profits of the investment projects which the managers were not previously willing to start will now, in aggregate, be positive - the profits of the successful projects should exceed the subsidies to the failed projects. In effect, a policy of budget softness leads to efficiency gains through the state spreading risk and thus providing a form of insurance.[5]

It is important to note here that the <u>conditional</u> nature of the budget softness is crucial to the results of the model. An <u>unconditional</u> subsidy to the enterprise - a subsidy paid by the state to the enterprise even if the project isn't started, or regardless of the outcome of the investment project - would have very different effects on the manager's investment decision. Thus, if the manager is risk-neutral, an unconditional subsidy would have no effect at all on the investment decision. This is because an unconditional subsidy would leave the expected profits of investment projects unchanged, and since risk neutrality implies a linear utility function, the manager's expected utility increment resulting from an investment project would also be unchanged.

The problem of how to get managers in a socialist economy to engage in risky innovation is not new. Hayek wrote in 1935,

> If the penalty for loss is the surrender of the position of the "entrepreneur" will it not be almost inevitable that the possible chance of making a loss will operate as so strong a deterrent that it will outbalance the chance of the greatest profit? ... [Without the incentive of possible gains there would be] a sacrifice of all experimentation with new and untried methods. Even if progress is inevitably connected with what is commonly called waste, is it not worth having if on the whole gains exceed losses? (Hayek, 1935, p. 235)

Bergson (1978) has a good discussion of the problem of getting risk-averse managers to engage in risky but socially beneficial projects.

The soft budget constraint, it can be argued, may be an answer to this problem. The point is that by protecting managers from some of the penalties of failure, a soft budget constraint can remove some of the risk faced by managers and cause them to engage in risky but profitable innovation activity which they would otherwise avoid. We would then see an aggregate efficiency gain over the situation with no budget softness.[6] Of course, introducing budget softness may well have negative consequences for incentives which outweigh the positive effects just described. I now turn to a small model which attempts to formalise some of these negative effects.

Budget Softness and "Fear-Driven" and "Greed-Driven" Efficiency: A Model

We have a simple two-enterprise, one-period, game-theoretic duopoly model. The enterprises initially have identical production costs and sell identical products. The managers of both enterprises must decide on whether to engage in a costly activity which will lower production costs. This activity could be, say, an investment or innovation project, or even just the application of extra managerial effort; for illustrative purposes I will use this last interpretation in the presentation below. Both the costs of extra managerial effort and the exact size of the cost reduction are known with certainty to the managers. There is only one possible level of extra managerial effort. The incomes of the managers are linear functions of the profits of their enterprises, and so managerial payoffs can be written in terms of managerial effort and shares of enterprise profits.

Notation is:

E Managerial effort

M Manager's share of the (monopoly) profit to the enterprise with the hard-working manager if the other enterprise's manager doesn't work hard

X Manager's share of the (exit) penalty to the enterprise with the lazy manager if the other enterprise's manager works hard

p Probability that a manager will choose to work hard

S An unconditional subsidy

If both managers do not work hard, both enterprises earn zero profits in the market place - but since both managers have avoided expending managerial effort E, each manager has a final payoff of 0 (the lower right hand corner of Figure 2.1 below). If both work hard, their enterprises still earn zero profits in the market place, but since they have both expended effort, each has a final payoff of -E (the upper left hand corner of Figure 2.1). In other words, as long as the enterprises have identical production costs, the profit they earn in the market place is zero and independent of the production cost, but managerial payoffs depend on whether or not managers expended extra effort. This exact payoff structure is not crucial to the model, but it makes things much simpler. It is also not as bad as it first sounds. For example, in a simple symmetric Bertrand pricing duopoly model with no fixed costs and constant marginal costs, both enterprises engage in a price competition which results in both setting price equal to marginal cost, whatever that marginal cost is; in other words, profit is zero for any marginal cost.

Returning to the present model, say the manager of enterprise 1 works hard and the manager of enterprise 2 doesn't (the upper right hand corner of Figure 2.1). Manager 1 does very well - say his enterprise monopolises the market and he earns a "monopoly bonus" M - but the manager gives up E for the privilege, so his payoff is M-E. Manager 2 does very poorly - say his enterprise must leave the market and he suffers a large exit penalty X - but he didn't give up E since he didn't work hard. So the manager's payoff is -X. Since the model is symmetric, the outcome is simply reversed if the manager of enterprise 2 expends extra managerial effort and the manager of enterprise 1 doesn't.

Figure 2.1: Payoffs

		Manager 2: Work Hard	Manager 2: Don't Work Hard
Manager 1	Work Hard	(-E, -E)	(M-E, -X)
	Don't Work Hard	(-X, M-E)	(0, 0)

Notation: (manager 1's payoff, manager 2's payoff)

The equilibrium of this game depends on the relative size of monopoly profits M, exit costs X and effort costs E. If X > E > M, we have two pure strategy Nash equilibria and one mixed strategy Nash equilibrium, none of which is a dominant strategy equilibrium. In this situation the comparative statics exercises below using the mixed strategy equilibrium are not meaningful, and so I exclude this case.[7] For the remaining possibilities, it can be shown that, if $M \neq E$ and $X \neq E$, there is a unique Nash equilibrium which is an equilibrium in mixed strategies. If M=E <u>or</u> X=R, but not both, then there are multiple pure strategy Nash equilibria, but one of these equilibria will be a dominant strategy equilibria. It is natural, therefore, to take as the solution to the game these dominant pure strategy equilibria and the unique symmetric Nash mixed strategy equilibria (and to exclude the possibilities that M=X=E or that X>E>M). This choice of solution may be justified by reference to Selten's concept of "perfect equilibrium". It has been shown that for all games with two players, an equilibrium is undominated if and only if it is perfect (see e.g. Van Damme 1987, Corollary 2.2.6 and Theorem 3.2.2).

Specifically, the solution of the game is for both managers to expend extra effort with probability

$$p = 1 \qquad \text{for } M,X \geq E \text{ but not } M=X=E \qquad (1)$$

$$p = \frac{M - E}{M - X} \qquad \text{for } M > E > X \qquad (2)$$

$$p = 0 \qquad \text{for } M,X \leq E \text{ but not } M=X=E \qquad (3)$$

By varying M and X, we can engage in comparative statics exercises with p. Such exercises are meaningful for this specification of an equilibrium and these restrictions on the parameter values.[8]

When exit penalties exceed the costs of extra effort ($X > E$), both managers always work hard and this gain in enterprise efficiency is purely "fear-driven"; managers work hard entirely out of fear of the consequences of being left behind by their competition. Even if $M = E$, i.e. the potential monopoly gains from working hard are matched entirely by effort costs, the managers will still always choose to work hard.

When $M > E > X$ and the managers work hard only sometimes, they have both positive and negative incentives for doing so; in this case enterprise efficiency is both "greed-driven" and "fear-driven". This is reflected in comparative statics exercises with the equilibrium p.

Taking the total differential of p, we have

$$dp = \frac{M-E}{(M-X)^2}dX + \frac{E-X}{(M-X)^2}dM \tag{4}$$

Both the right hand side coefficients are positive. That is, an increase in penalties X increases the probability of working harder, as does an increase in the monopoly rewards M.

Now introduce budget softness into the model. We might regard this as a case of "market socialism" - the enterprises compete with each other to sell their products, but the state will, if necessary, aid the enterprise that would otherwise have to leave the industry or go bankrupt. In this model, budget softness means a subsidy which reduces the exit penalty X suffered by the manager. (Note the conditionality of the subsidy - it is paid to the enterprise only if the enterprise is facing the hardship of leaving the market.)

Budget softness affects payoffs and thus enterprise productivity in two ways. First, the exit penalty X is now reduced; the state eases the burden of leaving the market. If $M < 0$, both managers never work hard regardless of the value of X, so we consider only the case where $M \geq E$. If $X > E$ both before and after the introduction of budget softness, we will still see both managers always working hard: $p = 1$, from equation (1). But if $X > E$ before budget softness is introduced and

$X < E$ after budget constraints become soft, then from equation (2) we can see that the probability p of working hard drops so that $p < 1$. In other words, if exit penalties become less than effort costs, budget softness causes a drop in "fear-driven" efficiency. The same is true if $X < E$ before and after the introduction of budget softness. We can see this from (4) in which $dX < 0$, $dM = 0$, and, by assumption, $M \geq E$, so that $dp < 0$.

Second, a large enough degree of budget softness will enable the enterprise with the lazy manager to stay in the market. The effect of this is to lower the monopoly reward M - the enterprise with the hard-working manager will no longer reap such large profits by driving its competitor out of the market. Consider the case where initially $M > E$. Again assuming $X < E$, the result is a further decrease in p, the frequency of working hard. For the case of the decreased M still greater than E, this can be seen from the coefficient of dM in equation (4). And if M becomes less than or equal to E, from equation (3) we see the result is $p = 0$; no extra managerial effort work is ever observed. In short, budget softness causes in this model a decrease in "greed-driven" efficiency as well.

It is worth noting the special situation in which $M = E$ and budget softness causes X to drop below E (i.e. the potential rewards to working hard do not change and are equal to effort costs E, and budget softness causes the large exit penalty X to drop below E). Without budget softness, we saw that if exit costs X exceeded effort costs E, both managers always worked hard even if the monopoly reward M was so low as to equal effort costs E. With $X < E$ because of budget softness, however, the situation is exactly the opposite: if $M = E$, both managers <u>never</u> work hard. But in that case we will never see any rescues by the state. No subsidies will ever be paid out; but budget constraints will still be soft and still decrease enterprise efficiency. Here again we have the observation problem mentioned above: budget constraints are soft, affect enterprise-level incentives and decrease enterprise efficiency, but no subsidies will ever be observed.

Now consider, on the other hand, an unconditional subsidy paid to both enterprises, regardless of their actions. Managers are rewarded with a fraction of enterprise profits, so we say that the fraction of the subsidy which goes to the managers is S. I will consider two possible forms for the unconditional subsidy. First, the subsidy may be similar to managerial effort E in the sense that it isn't fungible, i.e. it cannot be spent in market competition. In other words, we add S to all the payoffs in Figure 2.1. It is easy to see that (with risk-neutral players) the equilibrium is completely unaffected by this unconditional subsidy, and so equations (1)-(3) are unchanged. Thus in this model, an unconditional subsidy of this form has no effect on enterprise efficiency.

The second possibility is that the subsidy may be spent by enterprises in competitive activity (say they can wage an advertising war). Let's say that if the enterprises have the same production costs (i.e. both managers work hard or both don't work hard), enterprises spend the subsidy on such competitive activity and managers do not receive S. On the other hand, if one manager works hard and the other one doesn't, both enterprises retain the subsidy and do not spend it on market competition, and both managers receive S. This is not unreasonable if we assume the subsidy is not so large as to be able to keep the enterprise with the lazy manager in the market. Since this enterprise must exit the industry, there is no reason for it to spend the subsidy on a hopeless competition; and in this circumstance there is no reason for the other enterprise to spend the subsidy in a competition it will win anyway.

The payoffs of the game are now as in Figure 2.2:

Figure 2.2: Payoffs

		Manager 2: Work Hard	Manager 2: Don't Work Hard
Manager 1	Work Hard	(0, 0)	(M+S, E-X+S)
	Don't Work Hard	(E-X+S, M+S)	(E, E)

I will consider only the case where $M > E > X$, i.e. $0 < p < 1$ both before and after the introduction of the subsidy. In this case the mixed strategy game is for each manager to work hard with p

$$p = \frac{M-E+S}{M-X+2S} \tag{5}$$

What will be the effect of introducing an unconditional subsidy of this form on the probability of working hard? Subtracting (2) from (5), we get

$$p_{S>0} - p_{S=0} = S * \frac{(E-X) - (M-E)}{(M-X)(M-X+2S)} \tag{6}$$

The effect on p is ambiguous, because we know only that $(E-X) > 0$ and $(M-E) > 0$; we do not know their relative magnitudes. The numerator of (6) may be positive or negative depending on the size of exit penalties relative to effort costs (the "fear-driven" incentive to work hard) and on the size of monopoly profits relative to effort costs (the "greed-driven" incentive to work hard). Thus an unconditional subsidy of this form, unlike budget softness, has in this model an ambiguous effect on enterprise efficiency.

Notes to Chapter 2

1. This is a revised version of a paper presented to the SSRC Summer Workshop on Soviet and East European Economics, held at the University of Illinois, Urbana in July 1986. It is based upon work supported under a National Science Foundation Graduate Fellowship. I would like to thank the National Science Foundation for their generous financial support, and Abram Bergson, Stanislaw Gomulka, Janos Kornai, Fyodor Kushnirsky, Mike Spagat, Peter Wiles, and the participants of the SSRC Summer Workshop for their many helpful comments and suggestions on an earlier version of this paper.

2. In his 1980 book, Kornai states that price-making behavior by a capitalist firm constitutes budget softness, because "by its price-making power it can almost 'automatically' guarantee its survival" (Kornai 1980, p. 312). However, Kornai's 1986 formulation mentions only bureaucratic price-making.

3. But see below in section III the problem of the distinction between the fates of firms and the fates of their managers.

4. A similar formal definition was independently proposed by Goldfeld and Quandt (1988).

5. If managers are risk-averse but not identically so, the analysis is more complicated but the basic point is unchanged - budget softness can lead to efficiency gains. The complication is that the same degree of budget softness may not be sufficient to cause a very risk-averse manager to engage in a profitable project, but may also cause a different, mildly risk-averse manager to approve uneconomic projects.

6. Of course, the degree of budget softness should not be too great; otherwise, considering all the investment projects caused by the introduction of budget softness, the losses from uneconomic investment projects would in aggregate exceed the gains from the risky but profitable ones.

7. Why $X < E < M$ is excluded is best seen from an example. Say these inequalities hold, and the mixed strategy equilibrium is given by equation 2 below, and the total differential of p is given by equation 4 below. Then if, say, the exit penalty X rises, p paradoxically falls. This is because, for p to be a self-sustaining mixed strategy equilibrium, players must be indifferent between the expected payoffs of the two pure strategies. If X rises, player 1 must believe player 2 will work hard with a <u>lower</u> probability if player 1 is to be indifferent between his expected payoff if he works hard and his expected payoff if he doesn't. See below and also the following note.

8. More specifically, the mixed strategy p (equation 2) gives the same solutions as equations 1 and 3 in the limiting cases. Consider the situation where M>E>X and equation 2 holds. As X->E from below, p->1; and if X=E, p=1 from equation 1; so p is continuous here. Similarly, as M->E from above, p->0; and if M=E, p=0 from equation 3.

Chapter 3: The "Credible-Commitment Problem" in the Centre-Enterprise Relationship[1]

Introduction

In the previous chapter, as in the existing literature on the bailout ("soft budget constraint") problem in socialist economies, I simply took as given the existence of a state policy of bailouts; I did not try to explain why the state might follow such a policy. In this chapter I offer one explanation of why the centre rescues ailing enterprises. The core of the explanation is that the centre may be unable to make credible commitments about its future behavior toward an enterprise.

In perfect information versions of the simple model presented below, the centre is unable to prevent itself from rescuing the enterprise with additional resources, i.e. it is unable to commit itself to a policy of "no bailouts". In one of these versions, the centre is also unable to prevent itself from making the enterprise's output target easier to fulfil. In the imperfect information version of the model, on the other hand, by acquiring a "reputation for toughness" the centre is able to credibly threaten a policy of "no bailouts". In the model, the "credible-commitment problem" can lead to the deliberate withholding by the enterprise of resources which the centre wants devoted to production. Perhaps surprisingly for such a simple set-up, the model also illustrates a rich variety of empirical phenomena and theoretical concepts regarding enterprises or firms in centrally-planned economies (CPEs), market socialist economies (MSEs), and capitalist economies (CEs): bailouts and rescues, plan revisions, storming, plan tautness, plan discipline, the role of reputations, the role of the planning horizon, Kornai's "soft budget constraint" and paternalism, and Gomulka's "budget flexibility". (NB: in this chapter, and in the rest of the thesis, I largely abandon the "soft budget constraint" terminology and refer simply to bailouts/rescues. This is mostly for clarity's sake.)

The model presented is a game between the centre and an enterprise. The basic model is as follows. Production by the enterprise takes place over two periods. The enterprise's personnel can influence the level of production by expending a variable amount of "effort" in each period. These personnel face a disutility of effort and all other things equal would prefer not to work hard. At the end of the second period, the personnel receive a reward or "bonus" only if enterprise production meets a certain target. The size of this reward is determined exogenously, outside the model. We can interpret the "enterprise's personnel" as either its manager(s) or its workers. In between the two production periods the centre may, if it chooses, give the enterprise additional resources to be devoted to production; i.e. it may "rescue" the enterprise. These additional resources can be material inputs, extra funds to buy inputs, tax breaks, etc. The centre's utility increases with increases in the output of the enterprise and falls with its expenditure of these additional resources.

Three perfect information versions and one imperfect information version of the model are presented. In version I, the target level of output is set exogenously, outside the model. In version II, the centre chooses the target before the first production period; it is unable to revise the target after period one. In version III, the centre chooses the target in between the two production periods. Version IV is obtained by repeating version I over time and allowing for some uncertainty on the part of the enterprise as to whether the centre will rescue the enterprise. That is, the enterprise is unsure of whether the centre is "weak" or "tough".

The model has two natural interpretations. The first is that of the centre-firm relationship in an MSE or CE in which the centre or the state has the ability to rescue enterprises or firms. Here the state would rather not have to expend resources in order to rescue a firm that is in difficulties, but it also does not want the firm to "fail" by going out of business, or by having to lay off large numbers of employees in order to avoid bankruptcy. The firm's "personnel" may refer either to the manager or to the workers. The target level of output is the level below which the firm the firm would fail, and the reward or bonus received by the personnel is the reward of avoiding such a failure. The state does not set this target output level and so this MSE/CE interpretation corresponds to version I of the model. An alternative MSE/CE version I interpretation is also available. The level of effort is chosen by the manager, and the target level of output is the minimum output the firm must achieve for the manager to keep his job and not be fired by the owners of the firm (CE) or by the workers (labour-managed firm). In these MSE/CE interpretations of version I, we might argue that the target level of output is set by market competition; the greater the degree of competition, the higher is the target.

The second interpretation is that of the centre-enterprise relationship in a classical Stalinist-type CPE. Here too the enterprise's "personnel" may refer either to the manager or to the workers. The centre is a ministry, say, which desires high output levels from its enterprises, but which would rather not bail out enterprises and would prefer to conserve productive resources and force the enterprise personnel to exert the maximum possible amount of effort. The ministry can set the output target which an enterprise must meet before its personnel can receive their bonuses. This CPE interpretation corresponds to versions II and III of the model.

The requirement that equilibria be credible is met by invoking the criterion of sequential rationality (Kreps and Wilson 1982a). Recall that a player's strategy is a plan of action for every decision point in the game. Sequential rationality means that a player's strategy must prescribe behavior that is optimising at every decision point. By requiring sequential rationality, we exclude strategies that are not credible in the sense that if some decision point were reached, the player whose decision it is might not make his best move. That is, players are not allowed to threaten behavior in some situation where, if that situation were actually reached, it may not be in the player's interest to carry out the threat.

In versions I-III of the model, the sequential rationality criterion is met by restricting attention to subgame perfect equilibria (Selten 1975), the natural sequential rationality equilibrium concept for games of perfect information: an equilibrium is subgame perfect if the equilibrium strategies of the players form Nash equilibria in all the subgames of the game. In version IV, which is an imperfect information game, subgame perfection is not adequate and we look instead at a subset of subgame perfect equilibria, sequential equilibria (Kreps and Wilson 1982a). In this formulation, players have beliefs regarding the uncertainty they face, i.e. regarding where in the game tree they really are. In a sequential equilibrium, each player's strategy prescribes behavior which at every decision point is optimal with respect both to these beliefs and to the strategies of the other players.[2]

The assumption that the centre is unable to precommit is crucial to the results of the model. It is also fairly realistic. It is reasonable to argue that the centre will often be unable to tie its own hands and prevent itself from taking a specific action in the future.[3] Formal or legal mechanisms through which such precommitment could take place are not obvious; the centre, meaning the state or a branch of it, is often in a position to change laws or bend rules. Furthermore, the importance of informal, and thus to some extent extra-legal, mechanisms in limiting these precommitment possibilities should not be underestimated, particularly in socialist countries where Party connections, influence, the second economy, etc., can and do play a large role in resource allocation.

Several recent studies of the ratchet effect (Freixas, Guesnerie and Tirole 1985; Litwack 1987; Ickes and Samuelson 1987; Laffont and Tirole 1987, 1988), where the enterprise conceals its productive capacity from the centre in order to get a less demanding incentive scheme, have also used the sequential equilibrium concept. The equilibria in these models therefore also require that players' strategies be credible; but these models and the credibility problems that arise within them differ from those in this chapter. The credibility problem in these studies takes the form of the centre's inability to commit itself to using a particular incentive scheme in the future. A very productive enterprise is reluctant to produce at full capacity this period, because by doing so it reveals its capacity to the centre and will face a tougher incentive scheme next period. The centre would like to be able to commit itself to avoid taking advantage of the enterprise in this way, but such a commitment is not credible. Here imperfect information is the source of the centre's problems; in its absence, it would have no difficulty choosing the optimal incentive scheme for the enterprise.

In versions I-III of the model in this chapter, we have perfect information and the centre's credibility problem is acute. In version IV we have imperfect information, but here it is the enterprise which faces the uncertainty; it is unsure of the toughness of the centre, and this uncertainty is a solution to the centre's problems. The model in this chapter is therefore in a sense a natural complement to the ratchet effect models. Another important difference between the ratchet models mentioned above and the model in this chapter is that here the centre's problem is not to choose the "optimal incentive scheme" for the enterprise, but rather to choose an optimal course of action given the assumed form of incentive scheme. We will return in the conclusion to the possible political, practical and institutional constraints on the centre's choice of scheme, but for now we note only that the incentive scheme assumed here does have the virtues of simplicity and of capturing important features of real world incentive schemes.[4]

The Model

In what follows I use "the enterprise" as a shorthand for "the enterprise's personnel".

Action Spaces: In production periods 1 and 2 the enterprise chooses its level of effort. It can, in either period, choose E (work hard) or e (take it easy). In between production periods 1 and 2 the centre can either devote resources R to a rescue of the enterprise, or devote 0 resources to a rescue, i.e. not rescue. In versions I and IV of the game, the output target Y^T is exogenously given. In version II, the centre can also precommit before production period 1 to some output target Y^T. In version III, the centre can only precommit to this output target in between periods 1 and 2, i.e. at that time it chooses Y^T and simultaneously decides whether or not to rescue. Without loss of generality, Y^T is restricted to outputs that are technically feasible.

Production Technology: Output Y is a function of the enterprise's effort in production period 1, the resources supplied by the centre for a rescue, and the enterprise's effort in period 2. For simplicity, there are only four technically feasible levels of output. We write

$$Y_1 \equiv Y(E,R,E) \tag{1}$$
$$Y_2 \equiv Y(E,0,E) = Y(e,R,E) = Y(E,R,e) \tag{2}$$
$$Y_3 \equiv Y(e,0,E) = Y(E,0,e) = Y(e,R,e) \tag{3}$$
$$Y_4 \equiv Y(e,0,e) \tag{4}$$

According to (2) and (3), the rescue resources should be interpreted as an injection of resources that compensates for a low level of effort in one period. A natural restriction on the technology is that the marginal products of inputs are positive, implying that

$$Y_1 > Y_2 > Y_3 > Y_4 \tag{5}$$

We also require

$$Y_1 - R > Y_3 \tag{6}$$
$$Y_2 - R > Y_4 \tag{7}$$

so that a rescue will make economic sense for the centre in some circumstances. For most situations, (6) and (7) together are stronger than necessary; they are both assumed to hold throughout only for expositional simplicity.[5]

Enterprise's Preferences: The enterprise suffers disutility of effort. It does not discount effort in period 2 vis à vis effort in period 1. If, after period 2, actual output equals or exceeds target output Y^T, the enterprise also receives a reward or "bonus" B. Enterprise preferences over outcomes, best to worst, are assumed to be as follows:

1. Bee - bonus received, expended little effort in both periods
2. BeE and BEe - bonus received, expended little effort only in period 1 or period 2, respectively
3. BEE - bonus received, worked hard in both periods
4. 0ee - no bonus, expended little effort in both periods
5. 0eE and 0Ee - no bonus, expended little effort only in period 1 or period 2, respectively
6. 0EE - no bonus, worked hard in both periods

The bonus is therefore the top priority of the enterprise and the level of effort the second priority. The implicit assumption here is that the reward for achieving Y^T is "large".

<u>Centre's Preferences:</u> The centre's goal is to maximise "net output", that is, total output Y minus any rescue costs. The reward B either is not paid by the centre, or, if paid, is small compared to Y and R and can be ignored.[6] The centre may value output for its own sake, or because output is correlated with something else the centre does value (e.g. the enterprise's level of employment). Whatever the case, we interpret output Y as a measure representing also the value of the enterprise's production for the centre.

Figure 3.1: Extensive Form of Version I

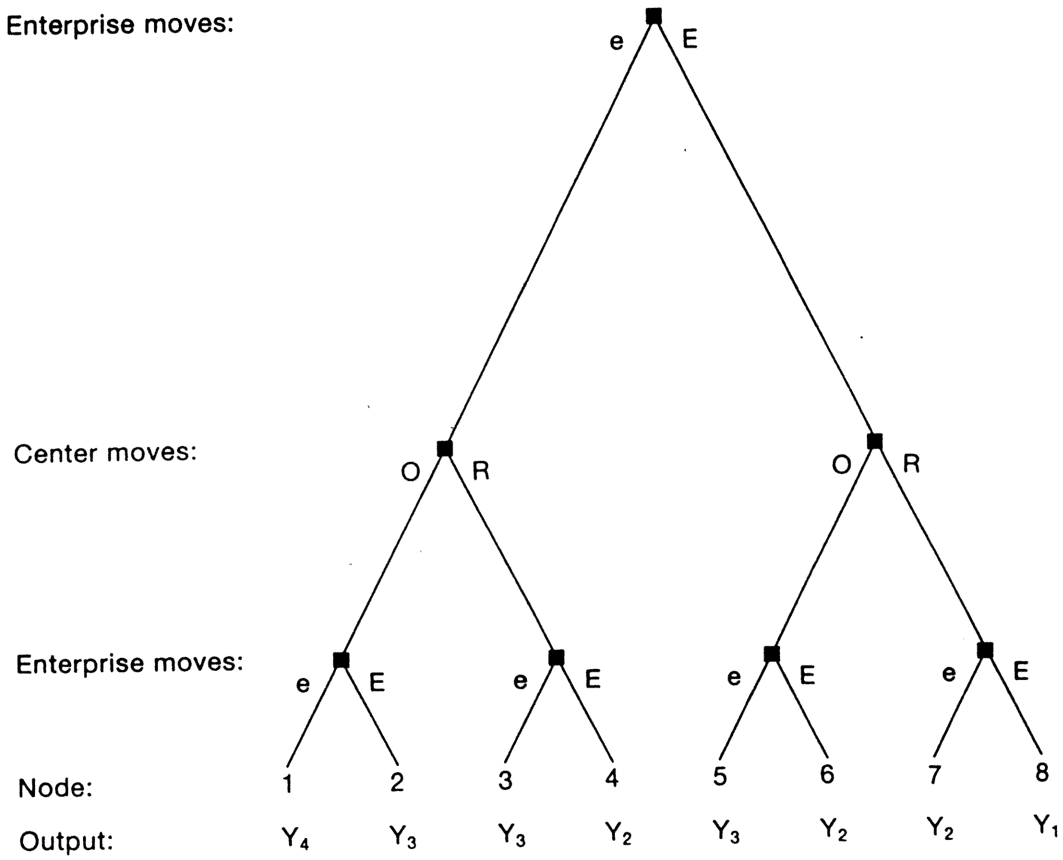


Figure 3.2: Subgame Perfect Equilibrium of Version Ib

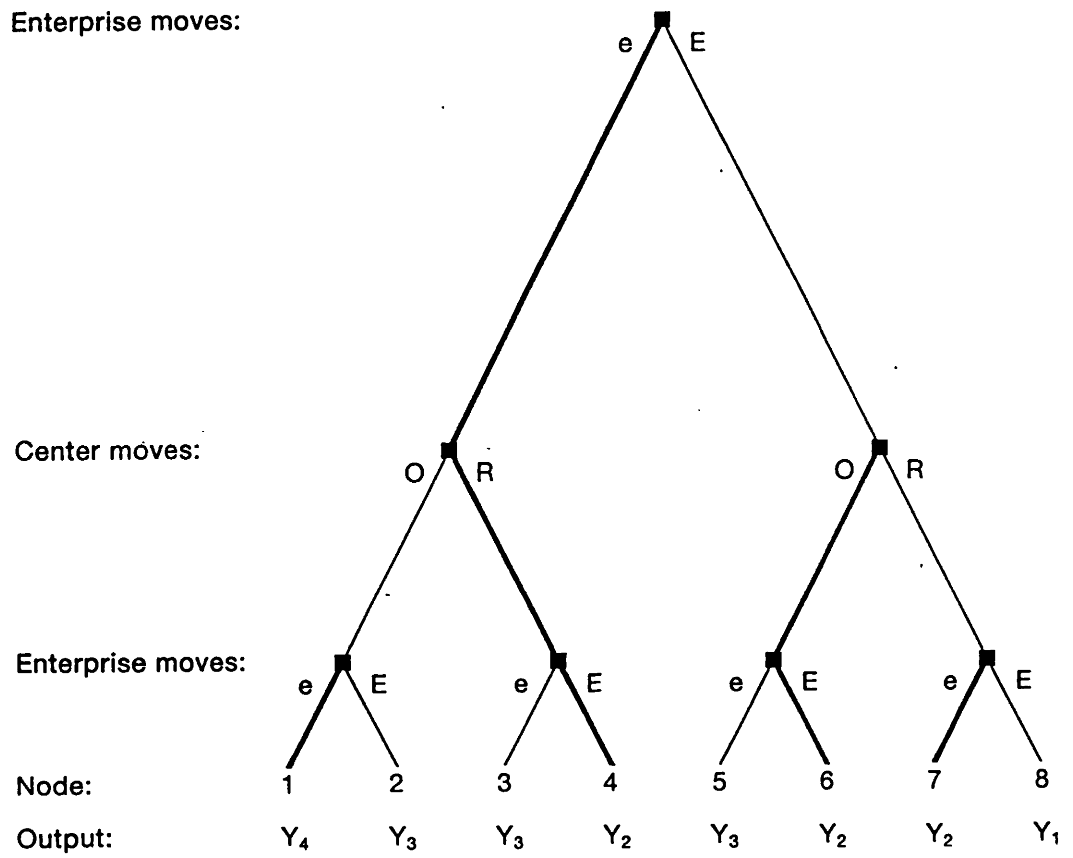


Figure 3.3: A Non-Subgame Perfect Nash Equilibrium of Version Ib

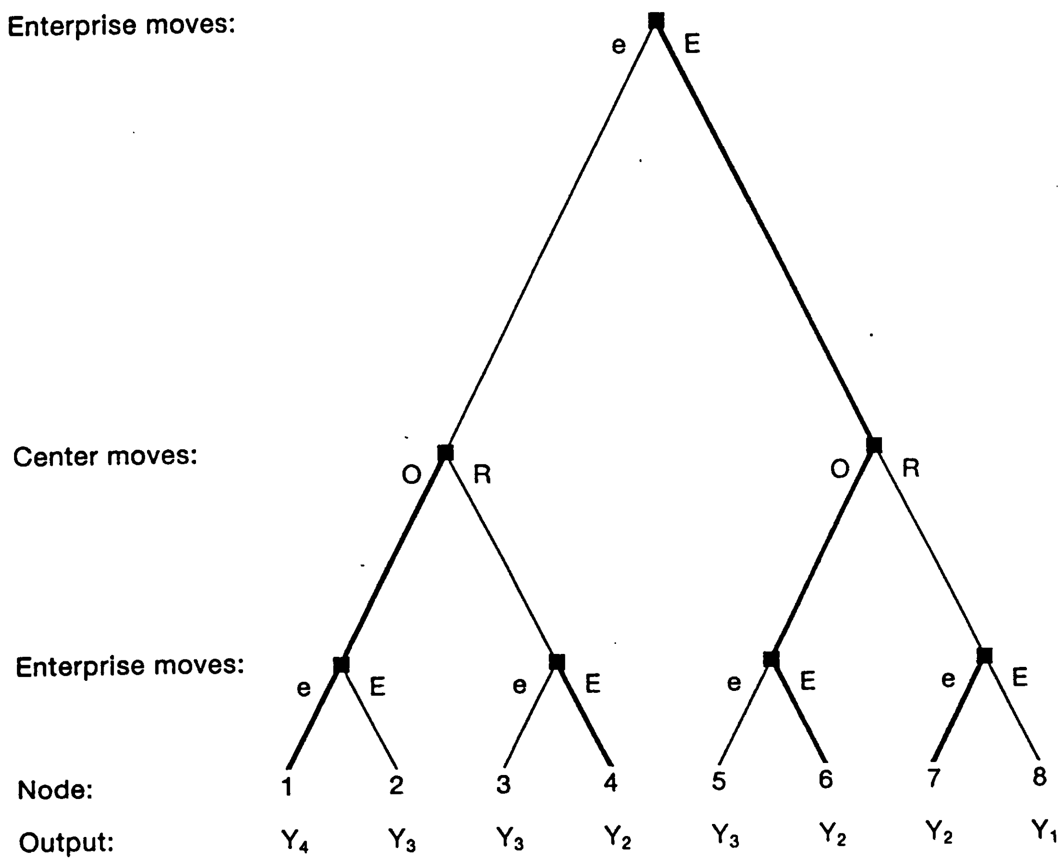


Table 3.1: Payoffs

Node:	1	2	3	4	5	6	7	8
Output:	Y_4	Y_3	Y_3	Y_2	Y_3	Y_2	Y_2	Y_1

Target	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent
$Y^T=Y_1$	Oee Y_4	OeE Y_3	Oee Y_3-R	OeE Y_2-R	OEe Y_3	OEE Y_2	OEe Y_2-R	BEE Y_1-R
$Y^T=Y_2$	Oee Y_4	OeE Y_3	Oee Y_3-R	BeE Y_2-R	OEe Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R
$Y^T=Y_3$	Oee Y_4	BeE Y_3	Bee Y_3-R	BeE Y_2-R	BEe Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R
$Y^T=Y_4$	Bee Y_4	BeE Y_3	Bee Y_3-R	BeE Y_2-R	BEe Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R

Enterprise "effort" level E = work hard, e = take it easy
Centre's move R = rescue, 0 = don't rescue

Enterprise's payoff is bonus received (if any) and effort made e.g. OeE = no bonus, was lazy in per. 1, worked hard in per. 2

Centre's payoff is "net output" ≡ output level - rescue costs e.g. Y_2-R = output of Y_2 - rescue costs R

Model Results

Figure 3.1 gives the extensive form of version I of the game, where Y^T is given exogenously. The extensive form of version II, where the centre precommits to a Y^T before production period 1, is obtained by making this decision by the centre the first move of the game. The extensive form of version III is similarly obtained by having the centre choose Y^T when it chooses R. Table 3.2 summarises the subgame perfect equilibrium outcomes for versions I-

III.[7] The equilibria are fully described in Appendix 3.1.

Subgame perfect equilibria are calculated through backwards induction. This can be seen in Figure 3.2, which gives the subgame perfect equilibrium for version Ib; the equilibrium strategy choices are indicated with bold lines. We begin with the enterprise's decision in period 2. It may find itself at any one of four decision nodes. Moving from left to right, at the first of the four, the enterprise has a choice of either playing e and ending up at node 1, or playing E and ending up at node 2. The former gives the enterprise the larger payoff, and so playing e at this node becomes part of the enterprise's equilibrium subgame perfect strategy. Similarly, at the second decision point from the left the enterprise has a choice of either playing e and ending up at node 3 or playing E and ending up at node 4. The latter gives the larger payoff, and so playing E at this node is part of the enterprise's strategy. The procedure is the same for the remaining two nodes.

We can now calculate the centre's subgame perfect equilibrium strategy. The centre may find itself at either one of two nodes. Moving from left to right, the centre has a choice of playing R or O. Taking as given the enterprise's choices for period 2 as calculated in previous paragraph, we find that if the centre rescues it will end up at node 4 and if it does not rescue it will end up at node 1. The former gives the larger payoff, and so R is the centre's equilibrium choice for this node. Again, the procedure is the same for the second of the centre's two decision points.

The last step is to calculate the enterprise's equilibrium choice of effort in period 1. Taking as given the enterprise's choices for period 2 and the centre's choices as calculated as above, we see that if the enterprise chooses e in period 1 it will end up at node 4, and if it chooses E in period 1 it will end up at node 6. Node 4 gives the larger payoff, and so playing e at the period 1 decision point is part of the enterprise's strategy. This completes the calculation of the subgame perfect equilibrium of version Ib.

Table 3.2: Subgame Perfect Equilibrium Outcomes, Versions I-III

I. Y^T set outside the model, before the game begins

a. $Y^T=Y_1$
Play is E,R,E; outcome is node 8
Output is Y_1, target is achieved
Enterprise's payoff is BEE
Centre's payoff is Y_1-R

b. $Y^T=Y_2$
Play is e,R,E; outcome is node 4
Output is Y_2, target is achieved
Enterprise's payoff is BeE
Centre's payoff is Y_2-R

c. $Y^T=Y_3$

(i) $Y_2-R > Y_3$ Two equilibrium outcomes

(1) Play is e,0,E; outcome is node 2
Output is Y_3, target is achieved
Enterprise's payoff is BeE
Centre's payoff is Y_3

(2) Play is E,R,e; outcome is node 7
Output is Y_2, target is exceeded
Enterprise's payoff is BEe
Centre's payoff is Y_2-R

(ii) $Y_2-R < Y_3$ Two equilibrium outcomes

(1) Play is e,0,E; outcome is node 2
Output is Y_3, target is achieved
Enterprise's payoff is BeE
Centre's payoff is Y_3

(2) Play is E,0,e; outcome is node 5
Output is Y_3, target is achieved
Enterprise's payoff is BEe
Centre's payoff is Y_3

d. $Y^T=Y_4$

(i) $Y_3-R > Y_4$
Play is e,R,e; outcome is node 3
Output is Y_3, target is exceeded
Enterprise's payoff is Bee
Centre's payoff is Y_3-R

(ii) $Y_3-R < Y_4$
Play is e,0,e; outcome is node 1
Output is Y_4, target is achieved
Enterprise's payoff is Bee
Centre's payoff is Y_4

Table 3.2 (continued)

II. Centre has the first move and can precommit to a choice of Y^T before period 1

Centre chooses $Y^T=Y_1$
Play is $Y^T=Y_1$,E,R,E; outcome is node 8
Output is Y_1, target is achieved
Enterprise's payoff is BEE
Centre's payoff is Y_1-R

III. Centre can precommit to a choice of Y^T only before period 2 and after period 1; chooses Y^T and makes rescue decision simultaneously

(i)	$Y_2-R > Y_3$	Centre chooses $Y^T=Y_2$ Play is e,R and $Y^T=Y_2$,E; outcome is node 4 Output is Y_2, target is achieved Enterprise's payoff is BeE Centre's payoff is Y_2-R
(ii)	$Y_2-R < Y_3$	Centre chooses $Y^T=Y_3$ Play is e,0 and $Y^T=Y_3$,E; outcome is node 2 Output is Y_3, target is achieved Enterprise's payoff is 0eE Centre's payoff is Y_3

Note: Nodes in the Table refer to terminal nodes in the Figures and Table 3.1.

Version I (MSE/CE)

The version which illustrates the main point of this chapter is $Y^T=Y_2$ (version Ib in Table 3.2, and Figure 3.2). The enterprise takes it easy in the first period; it is able in this way to commit to some extent and so substitute rescue resources for effort. The centre is forced to rescue the enterprise, for only with this help will the enterprise be able to achieve the target output. If the centre did not rescue, the enterprise would not find it worthwhile to work hard in period 2, and final production would be very low at Y_4. After obtaining the rescue resources the enterprise works hard in the second period, achieves the target Y_2, and receives the bonus.

Note that there are Nash equilibria that are not subgame perfect and that the centre would prefer: in these equilibria the centre has a strategy of "no rescue", and the enterprise a strategy of "work hard in period 1; if not rescued, work hard in period 2 and if rescued, take it easy in period 2". One such equilibrium is given in Figure 3.3.[8] The equilibrium outcome in these equilibria is node 6; play is "work hard in period 1", "do not rescue", "work hard in period 2", and output is Y_2 i.e. the target is achieved. Why these equilibria are not credible is clear from Figure 3.3. Here the centre's threat of no rescue is not credible; were the enterprise to actually take it easy in period 1, it would not be optimal for the centre to carry out this threat.

The subgame perfect equilibrium of version Ib may be interpreted as featuring what Kornai (1980, 1986a) has dubbed the "soft budget constraint"; firms that are in difficulties are helped by the centre. Kornai has argued that the source of budget softness is paternalism on the part of the state. As noted above, others who have analysed budget softness (Gomulka 1985b, Goldfeld and Quandt 1988) have typically assumed its existence and not explained why it may exist. The above model provides one possible explanation; the centre cannot credibly threaten not to rescue enterprises because of the costs of allowing firms to fail to meet targets or go bankrupt, and the enterprises realise this and take advantage of it.[9] Indeed, the preferences of the centre given above are paternalistic; the centre would prefer that the enterprise do well and not fail, and a "soft budget constraint" is a consequence.[10] It is also worth pointing out that although budget softness is a financial notion, in Kornai's analysis both financial assistance and grants in kind of inputs to production are the results of paternalism (Kornai 1980, pp. 561-5). Similarly, in the above model rescue resources R may be additional resources of any kind devoted to production.[11]

We also have here an illustration of Gomulka's (1985b) notion of "budget flexibility", as well as a generalisation to the non-financial case. Flexibility may be limited because it takes time for the centre to make a rescue decision and carry it out; or because it takes time for the enterprise to make use of the rescue resources. The model in this chapter is an example of the former; the centre has a limited flexibility in that it can decide to rescue the enterprise after period 1 but not after period 2. Complete flexibility would occur if the centre could rescue the firm even after period 2, at the last minute. Similarly, complete inflexibility would be the case where the centre is only able to decide to rescue before the enterprise begins production; although after that point the centre has both the resources and the desire for a rescue, and thus there is "softness", it lacks the flexibility to implement a bailout in time.

The case of complete inflexibility on the part of the centre is in fact the case of precommitment; the threat of no rescue is now credible because the centre lacks the ability to rescue. The Nash equilibrium in Figure 3.3, in which the centre's strategy is "no rescue", is now subgame perfect and credible.[12] If the centre were able, it would prefer to tie its own hands and be inflexible, and so achieve this equilibrium.

Note the work pattern of the enterprise in the model: first take it easy, then work hard to make the target. This is the familiar phenomenon of "storming" or rush-work to meet a deadline. Recent empirical studies have argued that storming exists not only in CPEs but also in Hungary (Rostowski and Auerbach 1986, 1988; Laki 1980).

Interestingly, it is the centre's limited flexibility, rather than "softness" or paternalism per se, which causes storming in this model.[13] By way of contrast, take for example version Ib but with the modification that the centre has complete flexibility and can rescue at the end of period 2. The calculation of the equilibria is left to the reader, but it is easy to see that with the centre having the last move, any time "take it easy in period 1, work hard in period 2", is an equilibrium work pattern for the enterprise, "work hard in period 1, take it easy in period 2" will be as well. The point is that, without further assumptions (for example, about the enterprise's time preferences), the enterprise is indifferent to the choice of which period in which to exert more effort.

Connections between bailouts and "budget softness", "budget flexibility", and "storming" have not been noted previously. While our model is not primarily a model of storming behavior, it suggests that the credibility problem may also contribute to storming in actual socialist enterprises. Indeed, theoretical explanations of storming have not always been convincing. Typically storming is blamed simply on the presence of a deadline by which time work must be finished.[14] However, this is not sufficient to explain storming. Indeed, the following is a very simplified argument that, contrary to all empirical evidence, such deadlines should lead rational managers to storm at the beginning of the month; we could call this "anti-storming". Say that managers can devote a variable amount of effort to production, and output is subject to a stochastic shock which becomes known halfway through the production period, e.g. the actual level of material supplies becomes known. The shock has a large variance, so it is possible that, depending on the level of effort in the first half, a very negative shock might make the target unachievable for any feasible level of managerial effort in the second half of the period. Managers have the preferences described in this paper; they suffer disutility of effort, but receive a very valuable bonus if the production target is achieved or exceeded, and, for clarity, have a zero rate of time discount. In this example, managers on average will work harder in the first half of the period than in the second, because their primary goal is to achieve the target and get the bonus; the stochastic shock means that if they take it easy in the first half, this goal may be unachievable.

In Appendix 3.2, I explore further the relationship between plan targets and storming. There I present two simple models where the stochastic shock to production is small (rather than large, as in the above example); and again, the presence of a production target does not necessarily lead to a storming pattern of production.

Version II (CPE)

In this CPE version of the model the centre, as the first move in the game, chooses the target Y^T. That is, the centre can precommit to a target; it lacks the "flexibility" to revise it. However, it still has limited flexibility with respect to the rescue decision, i.e. it can still rescue between the first and second periods. We could motivate these assumptions by arguing that co-ordination requirements of the system of material balances limit the centre's ability to adjust output targets, but reserves of materials or funds can be directed to enterprises fairly quickly.

The subgame perfect equilibrium outcome for this case is given in Table 3.2, part II: the centre chooses $Y^T=Y_1$, the firm works hard in the first period, the centre rescues with R, the firm works hard in the second period, and the target is achieved.[15] The equilibrium is calculated simply by noting that of versions Ia-d, version Ia with its target of $Y^T=Y_1$ gives the centre the largest payoff.

In this version the output target gives the degree of tautness of the plan. Note that the centre here chooses the most taut plan possible. This is true even if $Y_2 > Y_1-R$, i.e. even if the centre would prefer a less taut plan with no rescue. As pointed out earlier, the model with a less taut target of $Y^T=Y_2$ has Nash equilibria but these equilibria are not credible i.e. not subgame perfect.

It should be noted that the production technology assumption $Y(E,0,E) = Y(E,R,e)$ in equation (2) plays a large role in the equilibrium for this version (and thus for version Ia as well). If $Y(E,0,E)$ is slightly less than $Y(E,R,e)$, the model results above do not change, but consider what happens if we assume both that $Y(E,0,E)$ slightly exceeds $Y(E,R,e)$, and also that $Y(E,0,E) > Y_1-R$.[16] The centre can now achieve its most favoured result by precommitting to a target of $Y^T=Y(E,0,E)$. This target is achievable if and only if the enterprise works hard both periods, and because the target is credible this is the enterprise's subgame perfect equilibrium strategy. Since $Y(E,0,E) > Y_1-R$, the centre prefers not to rescue, and final output is $Y(E,0,E)$.

Version III (CPE)

In this CPE version the centre chooses Y^T after period 1 and before period 2; it is able to commit to a target only then. The subgame perfect equilibrium outcomes are given in Table 3.2, part III. There are two possible equilibrium outcomes, depending on whether $Y_2-R \gtrless Y_3$.

If $Y_2-R > Y_3$, the firm takes it easy in period 1, the centre chooses $Y^T=Y_2$ and simultaneously rescues with R, the firm works hard in period 2, and the target is achieved. The same equilibrium outcome was covered at length in the discussion of version Ib with $Y^T=Y_2$, but some additional points are worth noting.

First, the centre now has not only a rescue decision credibility problem but also a target decision credibility problem. Both problems can be interpreted as plan implementation or plan discipline problems. Say the centre announces a plan that specifies no additional material inputs, i.e. no rescue. This plan is not credible; violation of plan discipline by the enterprise forces a plan revision of additional deliveries of materials to the enterprise.[17] Similarly, say the centre announces a plan that specifies very taut targets. Again, this plan is not credible; the enterprise violates plan discipline and takes it easy the first period, making the plan target infeasible and forcing a plan revision of a lower target.[18] Note also the target actually chosen before period 2 can still be interpreted as "taut", since it forces the enterprise to work hard in the second period in order to achieve the target and receive the bonus.

The second possible equilibrium outcome arises when $Y_2 - R < Y_3$. In this case the firm takes it easy in period 1, the centre chooses a target of $Y^T = Y_3$ and does not rescue, the firm works hard in period 2, and the target is achieved. The intuition behind this is straightforward. The marginal increase in production from a taut plan, a plan which sets $Y^T = Y_2$ and gives the firm additional resources R to make this target feasible, is $Y_2 - Y_3$. This is less than the marginal cost of a taut plan, namely R.

The centre therefore chooses a less taut target, but one taut enough to ensure the enterprise will work hard in period 2, and does not rescue.

In neither of these possibilities does the production technology assumption Y(E,0,E) = Y(E,R,e) in equation (2) have an important role, as it did in version II. This is because in version III the enterprise plays e in the first period, thus making impossible an output of Y(E,0,E) (or of Y(E,R,e)). In the subgame which follows the enterprise's choice of e in period 1, the centre can always elicit E from the enterprise in period 2 through an appropriate choice of Y^T.

Version IV (MSE/CE): Repetition with Imperfect Information[19]

Since the centre-enterprise relationship typically persists over time, there are large gains to be reaped by the centre if it can find a way to make its threats of "no bailout" credible. Intuition suggests that the centre should try to acquire a reputation for "toughness". Not rescuing the enterprise is costly, but if the centre refuses to rescue and lets the enterprise fail now, it may deter the enterprise from taking it easy in the future.[20]

If we repeat, say, version Ib any finite number of times, it turns out that such reputation-seeking is still not credible: the unique subgame perfect equilibrium outcome for the repeated game is simply the subgame perfect outcome for each of the repetitions. This peculiar result has been dubbed the "chain store paradox" (Selten 1978), and follows from backwards induction and the perfect information assumption. In the last period, subgame perfection implies the centre will rescue. In the next to last period, it is common knowledge that the centre cannot succeed in building a reputation for being tough in the last period, so again the centre will rescue. Continuing in this way, the game unravels to the beginning, with the centre rescuing every period.[21]

The perfect information assumption is crucial to this result; because both players are fully informed from the beginning of the game, there is no opportunity for learning to take place. If we relax this assumption, then the reputation effect comes to life. Say that the centre is either "weak" or "tough", and while the centre knows what type it is, the enterprise does not. If weak, the centre's preferences are those described above; but if tough, it will never rescue. A tough centre can be interpreted in a number of ways; for example, the centre may actually prefer to punish the enterprise if it violates the discipline of the plan; or the central planner may be penalised by his superiors if he allows a rescue; or the centre may actually lack the resources to rescue.

If the probability that the centre is tough is large, then the enterprise will fear that a rescue is unlikely and therefore work hard. But even if it is unlikely that the centre is tough, the enterprise may still figure that no bailout is forthcoming and therefore work hard. Since a tough centre never rescues, once a weak centre does so it reveals itself as weak and the no rescue threat is no longer credible. This gives a weak centre an incentive to mimic a tough centre and not rescue. While not rescuing a failing enterprise is costly to the weak centre in the short run, it causes the enterprise to revise upwards the probability that the centre is actually tough; the enterprise then works hard in the future, and the weak centre recoups its losses.

We can formalise this argument by using Kreps and Wilson's (1982b) model of Selten's "chain store" game. The model was devised to study a problem in industrial organisation theory, predation by a monopolist, but is easily adapted to our centre-enterprise framework.[22]

Version IV of the model is as follows. We repeat version Ib N times. In the terminology of game theory, version Ib is the stage game, and the N repetitions of version Ib make up the repeated game, version IV. Recall that in version Ib the enterprise chooses levels of effort for production periods 1 and 2. A natural interpretation is thus that there are N planning periods, and each planning period is divided into two "production periods", for example as annual plans are broken down into quarterly plans. The duration of the repeated game, i.e. the value of N, can be be interpreted as the duration of a particular centre-enterprise relationship. At the end of the game, say, the planner and/or manager move to completely new jobs. Alternatively, we can think of the end of the game as the extent of the players' subjective time horizons. For example, the game lasts one year; there are 4 quarterly planning periods (N=4) each of which is divided into monthly production periods; and the players discount the events of future years highly or entirely.

For convenience we index time backwards: the repetitions of the stage game are numbered N...n...1, and repetition n is the nth repetition from the end. Within each repetition of the stage game we index the production periods by i = 1,2; thus n,2 denotes the second production period in the (N-n)th planning period. Payoffs are received at the finish of each repetition of the stage game. There is no discounting of payoffs. With some small positive probability δ, the centre is tough: its only feasible action is "no rescue". With probability (1-δ), the centre is weak, with a choice of whether or not to rescue and with preferences as in the previous versions of the model.

To apply the Kreps-Wilson results we need to redefine the version Ib payoffs for the enterprise and the centre, both of which we assume to be risk-neutral utility maximisers. For the enterprise, let $U_E(X)$ be its original utility as a function of payoffs X. A linear transformation of $U_E(X)$ is also a legitimate utility function. Let the enterprise's new utility function be

$$V_E(X) \equiv \frac{U_E(X) - U_E(BEE)}{U_E(BeE) - U_E(0ee)}$$

where $U_E(BEE)$, $U_E(BeE)$ and $U_E(0ee)$ are fixed numbers. The centre's new utility function is

$$V_C(\pi) \equiv \frac{\pi - (Y_2-R)}{(Y_2-R) - Y_4}$$

where π denotes net output, meaning output minus rescue costs if any, and was the centre's original utility. We can now adopt the following notation:

$$V_C(Y_2) \equiv a \tag{8}$$

$$V_E(BeE) \equiv b \tag{9}$$

The point of the transformations above is to ensure that $a > 0$ and $0 < b < 1$, as required by the Kreps-Wilson model.[23] Kreps and Wilson consider in their paper the case where $a > 1$, and so we also require this, i.e. we assume

$$\frac{R}{(Y_2-R) - Y_4} > 1$$

As explained in the Introduction, we impose the requirement of credibility by calculating a sequential equilibrium for the model. In this game a sequential equilibrium consists of a strategy for each player and a function $p_{n,i}$ for each choice of effort by the enterprise. The latter are the beliefs of the enterprise regarding the centre's type, i.e. in production period i of planning period n the enterprise believes the centre is actually tough with probability $p_{n,i}$. These beliefs plus the players' strategies constitute a sequential equilibrium if

1. Starting from any point where it is the centre's move, the centre's strategy is a best response to the enterprise's strategy.
2. For each choice of effort by the enterprise, the enterprise's strategy is a best response to the centre's strategy, given that the centre is strong with probability $p_{n,i}$.
3. The game begins with $p_{N,1} = \delta$.
4. Each $p_{n,i}$ is computed from the previous p and also from Bayes' rule whenever possible.

Kreps and Wilson (1982b) show that the following constitute a sequential equilibrium:[24]

Beliefs of the enterprise: (a) For n < N, set $p_{n,1} = p_{n+1,2}$. That is, the enterprise's beliefs at n,1, the first production period of planning period n, are set to the beliefs at n+1,2, the second production period of the previous planning period. (b) If the enterprise worked hard at n,1 and this was followed by no rescue, then $p_{n,2} = p_{n,1}$. (c) If the enterprise took it easy at n,1, this was followed by no rescue, and $p_{n,1} > 0$, then $p_{n,2} = \max(b^n, p_{n,1})$, where b is given by equation (9). (d) If there is ever rescue in planning period n, or if $p_{n,1} = 0$, then $p_{n,2} = 0$.

Strategy of a strong centre: By assumption a strong centre never rescues.

Strategy of a weak centre: (a) If the enterprise worked hard at n,1, then do not rescue. (b) If the enterprise took it easy at n,1 and $p_{n,1} > b^{n-1}$, then do not rescue. (c) If the enterprise took it easy at n,1 and $p_{n,1} \leq b^{n-1}$, then rescue with probability $p_{n,1}(1-b^{n-1})/b^{n-1}(1-p_{n,1})$. Note that the probability of rescue is zero when $p_{n,1} = 0$, and one when either $p_{n,1} = b^{n-1}$ or n=1.

Strategy of the enterprise: (a) If $p_{n+1,2} > b^n$, then work hard at n,1. (b) If $p_{n+1,2} < b^n$, then take it easy at n,1. (c) If $p_{n+1,2} = b^n$, then randomise at n,1, working hard with probability 1/a. (d) The effort levels in every production period 2 are as in the second production period in Figure 3.2 (version Ib).

As the game is set up here, the outcome this equilibrium induces is in fact the unique sequential equilibrium outcome.[25] Equilibrium play for the initial repetitions of the stage game consists of the enterprise always working hard, and a weak centre never rescuing and indeed never willing to rescue; only near the end of the game, when a weak centre's future benefits of a tough reputation are small, will the enterprise take it easy and a weak centre rescue. Note that as soon as a weak centre rescues, it reveals itself as weak, p is set to zero, and from that point onward we get the perfect information, subgame perfect result in each planning period; the enterprise takes it easy, the centre rescues, and then the enterprise works hard and gets its bonus.

The surprising fact about this equilibrium is the power of the reputation effect: even if δ is very small, the fear that a weak centre will try to acquire a tough reputation is incentive enough for the enterprise to work hard for most of the game. In other words, a weak centre is initially able to achieve the credible-commitment outcome, despite the lack of formal commitment mechanisms. Furthermore, the point at which this no rescue phase ends is determined only by b and δ and not by N. Thus for large N, the centre's overall average payoff per repetition is close to the credible-commitment payoff. For example, if b=0.5 and δ=0.1, a weak centre will rescue with positive probability only within the last 4 planning periods, and the enterprise will only try taking it easy during the last 3 periods from the end, regardless of how many planning periods came earlier.

The results of this equilibrium are robust to a variety of changes in formulation (see Kreps and Wilson 1982b). In particular: (a) If $0 < a \leq 1$, where a is given by equation (8), the character of the equilibrium is the same (until near the end of the game the enterprise works hard and the centre is unwilling to rescue) but the play at the end of the game is more complicated. (b) Say the centre discounts its payoffs by a factor r per planning period. If $r > 1/(a+1)$, then again until near the end of the game the enterprise will work hard because the centre will not rescue. But if $r \leq 1/(a+1)$, the equilibrium is quite different: a weak centre will rescue the first time the enterprise takes it easy in a first production period, and the enterprise will do so if $p_{n,1} < b$.

We see therefore that a weak centre can reap large benefits if it can build a reputation for toughness. Nevertheless, there are a number of reasons why this may be difficult to accomplish and why the perfect information / subgame perfect / rescue outcome may be more plausible.

An important feature of the Kreps-Wilson model is that the enterprise's only source of information about whether the centre is tough or weak is the centre's rescue decision. In the chain store application of the model, it is reasonable to assume that the players observe only each others' actions; the market is impersonal. In the planning context, this assumption is less reasonable. The centre and the enterprise are typically in regular communication with each other over a wide range of matters: the enterprise's targets, material supplies, bonuses, etc. The planner and the manager are likely to know each other personally; their relationship is an ongoing one; they may well both be members of the Party; and so on. In such circumstances it may be difficult for a weak planner to sustain a tough reputation. As time goes on, the manager may be able to gather information and eventually conclude that the planner is weak, even if the planner has not previously rescued the enterprise. This is not to say that reputation effects will never occur, only that in some plausible circumstances they may not occur; an enterprise may well often be confident that the centre is "weak".

Worth mentioning here again are Kornai's concepts of the "soft budget constraint" and paternalism. Kornai explains why budget constraints are soft, that is, why the centre rescues enterprises, by arguing that the centre is paternalistic. Paternalism fits nicely into the Kreps-Wilson weak-tough framework; a paternalistic centre is weak. Kornai's analysis, however, does not make use of imperfect information; rather, the enterprise knows the centre is paternalistic. The assumption of perfect information, and thus versions I-III, therefore seem more appropriate for a formalisation of these ideas of Kornai's.

Two more reasons why the perfect information / rescue outcome may often occur have to do with the planners' time horizon. First, while it is true that the centre-enterprise relationship is long-term, possibly lasting many years, this is less true of the planner-manager relationship. Personnel turnover in the planning apparatus means that a planner's time horizon may actually be fairly short in a significant number of cases. Recall that in the sequential equilibrium above a weak centre will rescue and thus reveal itself to be weak in the late rounds of the game. If planners have short time horizons, late rounds, and therefore rescues, may predominate. Second, we saw above that if the centre discounts the future at a high enough rate, the equilibrium is very different; the enterprise will take it easy, and a weak centre will rescue it, if the probability that the centre is tough is small relative to the benefits to the enterprise of taking it easy and being rescued. Again, once the enterprise takes it easy, we have the perfect information outcome. It has been argued that in practice, planners tend to discount the future highly, being under pressure to come up with results today. This is another reason why the perfect information / rescue outcome may be relevant in some important circumstances.

Finally, the planned economies of Eastern Europe and the Soviet Union have by most accounts become less Stalinist, less disciplinarian, over time. In earlier days it was certainly sensible for enterprises to figure that the centre might well be "tough"; but now we often observe the pattern of frequent threats of bankruptcy and severe discipline which are not followed by actual implementation of these measures. This suggests that the imperfect information version of the model helps us understand the classical Stalinist system, and the perfect information versions the classical Brezhnevian system. A caveat is in order here, though. The rotation of managerial personnel under Stalin was fairly frequent (about three years), but this practice was abandoned. Thus under Stalin the "game" ended quickly. The time horizon argument above means that, other things held constant, frequent managerial turnover would have lead to more rescues and less plan discipline.[26] For rescues to have been less frequent under Stalin one would have to argue that other features of the model differed under the Stalinist and Brezhnevian regimes. For example, it is reasonable to suggest that δ, the initial probability that the centre is tough, was larger under Stalin.

Indeed, one could possibly interpret the history of central plan discipline in these economies in terms of the model in this paper. First, as Stalinist excesses moved further into the past, new centre-enterprise relationships would begin with a lower a priori probability that the centre was tough. Second, as the Party bureaucracy developed, personnel moved about and accumulated experience, personal connections grew, etc., the opportunities for an enterprise manager to discover what type of planner he faced also increased. Both these changes would make it harder for a weak central planner to build and maintain a reputation for toughness.

Concluding Comments

The root of the credibility problem in this model is the fact that centre can take actions after the beginning of the game. A strategy of no rescue or very taut target may not be credible in the sense that the firm may take it easy the first period and make threats subobtimal for the centre to carry out. One way the centre might overcome this problem is to try to build a reputation for toughness, but as we have seen this may not be feasible. What other options does the centre have?

One possibility suggested by the model is for the centre to take measures to decrease its flexibility. For example, the centre could pass a law against rescues and rely on the fact that repealing or evading the law would take time. Alternatively, it could set up a lengthy bureaucratic procedure through which all requests for bailouts must pass. Just how practical these measures might be is unclear. Such measures require the rule of law; the state must be unable to repeal or violate laws and rules quickly and at will. Implementing such measures also imply for the state a surrender of power, something which states generally do not like to do. And although decreased flexibility might help with the credibility problem, it could entail economic costs through a slower rate of adjustment to changing circumstances.

A simpler and more direct step would be for the centre to modify the enterprise's incentive structure, i.e. change the bonus function. The centre could, for example, simply pay a separate bonus for each production period based either on output or on effort. This was in fact tried in the Soviet Union in the early 1940s; Berliner reports that in order to reduce storming, enterprise directors in some ministries were required to report daily on the preceding day's output (Berliner 1956, pp. 97-8). This scheme ran into predictable monitoring problems; for example, enterprises would deceive the centre by "prolonging the work day" and including some of tomorrow's production in today's output. Such imperfect information problems, akin to the informational problems in ratchet-effect models, are outside the scope of the model in this paper, and are a possible subject for future research. Berliner notes as well the additional burden of the scheme on the administrative and planning apparatuses.

The bonus function does not, however, have to be modified in such a disaggregated way, because in general the centre-enterprise relationship is long-term. We saw in version IV above that the centre could take as given the enterprise's payoff structure and instead try to use this long-term relationship to build a reputation for toughness. In fact, more direct options may be available. For example, the centre could threaten to punish the manager if it ever saw the manager take it easy. Since in reality the centre is likely to face monitoring problems, one possibility for future research would again be to incorporate imperfect information into the model; in such a model, the centre could threaten to fire the manager, or withhold his bonus, or delay his promotion, if the manager seemed to come asking for help too often. This threat by the centre could often be credible in a classical CPE, although the administrative and informational requirements for such a scheme may be high. However, the nomenklatura system and widespread Party membership of managers may limit the centre's ability or desire to punish laggard managers. A similar constraint on the centre's choice of incentive scheme operates if the workers rather than the manager choose the level of effort. It is not easy to fire and replace a workforce, especially in an economic system based on socialist principles.[27]

It is important to note that these direct measures require the centre to have the power to manipulate directly the enterprise's bonus for meeting the target. This could be the case in a CPE, though the centre's freedom in choosing an incentive scheme for the enterprise will still be limited by political, social, institutional, and practical factors. The nature of the constraints to solutions to the credible-commitment problem, and how or even whether they can be overcome, are possible questions for future research. The centre's choices will be even more restricted in a decentralised MSE or CE where enterprises are autonomous and the bonus is interpreted as the reward of staying in business. In such decentralised economies the fates of enterprises and managers, and of enterprises and workers, are linked; it may not be easy for the centre to rescue the enterprise without rescuing the manager and the workforce as well. A decentralising reform that removes from the centre this power to determine the pay and bonuses of the manager or the workforce, without also limiting the power to rescue, will tend to make the credibility problem worse rather than better.

Notes to Chapter 3

1. This paper was written while the author was supported by an IREX Developmental Fellowship, and appeared (in modified form) in the Journal of Comparative Economics (Vol. 13, No. 3, September 1989). The comments and suggestions of Stanislaw Gomulka, Richard E. Ericson, Joseph Berliner, Janet Mitchell, Josef C. Brada, the participants of the LSE Comparative Economics Seminar, and two referees, are gratefully acknowledged.

2. There are also some other conditions a sequential equilibrium must meet. For a very clear exposition of these and related game-theoretic concepts, see van Damme (1987).

3. Litwack (1988) makes the important point that in a CPE the need to monitor economic activity in order to co-ordinate it rules out one practical possibility, commitment via a limited information structure.

4. If in the model below we allowed the centre complete freedom in choosing the incentive scheme, the model immediately becomes uninteresting. The centre has perfect information about the actions of the enterprise and so can simply dictate required levels of effort to the enterprise personnel, period by period.

5. It is worth noting, though, that if we subtract (7) from (6) and substitute using (1)-(4) we get

$$Y(E,R,E) - Y(E,0,E) > Y(e,R,e) - Y(e,0,e)$$

In other words, (6) and (7) together imply effort and rescue resources are cooperant factors of production.

6. This is the case in the MSE/CE interpretation above, where the reward B is the reward to the enterprise of staying in business. It also applies to the CPE interpretation if ministries do not keep unpaid bonus funds. This has been the case in the Soviet Union, for example, where unpaid bonus funds revert to the state bank (I am grateful to Rick Ericson for making this example known to me).

7. Table 3.2 gives equilibrium outcomes, and not the strategies which support these outcomes. This is because in versions Ia, Id, II and III the strategy choices off the equilibrium path, i.e. the strategy choices for situations which do not arise in the equilibrium outcome, are sensitive to the values of the parameters Y^T and R. This does not affect the interpretation of the equilibrium outcomes.

Version Ic has multiple equilibrium outcomes because the enterprise can be indifferent between possible outcomes. If, say, the enterprise preferred BeE to BEe because it discounted the future disutility of effort, this multiplicity disappears.

8. There are actually four Nash equilibria of this form.

The reason is basically technical. A complete description of a player's strategy must include planned decisions at nodes which will never be reached no matter what the other player does. Thus even though the enterprise chooses to work hard in period 1, its strategy must still include plans for what it would do if it took it easy in period 1. There are four possibilities: (1) if no R then e; if R then e; (2) if no R then E; if R then e; (3) if no R then e; if R then E; (4) if no R then E; if R then E. The third is the example given in Figure 3; it is chosen as an example because, roughly speaking, it is subgame perfect if the centre is able to precommit to a "no rescue" strategy.

9. The use of the subgame perfect equilibrium concept to model the "soft budget constraint" seems particularly appropriate given Kornai's statement that a condition for further softening of the budget constraint is that the enterprise "expects ... external financial assistance with high probability and this probability is firmly built into [its] behaviour" (Kornai 1986a, p. 4).

10. The broader interpretation of Y as the centre's valuation of the enterprise's production, representing the importance to the centre of the enterprise's output, employment levels, etc., is probably closer to the spirit of Kornai's analysis.

11. If the rescue resources are either additional material inputs or are used to obtain such, we see that the enterprise has succeeded in substituting materials for effort. A high material intensity has been observed in socialist economies (Gomulka and Rostowski 1988). One referee made an interesting comparison here: the credible-commitment problem in Western public utility regulation is usually viewed as inhibiting investment in fixed capital and thereby probably lowering the materials-to-labour ratio. The reason is that public utilities commissions cannot credibly guarantee a utility a fair rate of return on sunk investment.

12. Though strictly speaking we should draw a new game tree in which the rescue/no rescue decision is the first move of the game.

13. I am grateful to Janet Mitchell for stressing this point to me.

14. In Peter Wiles' terminology, this is the "hard time constraint".

15. Again we can interpret the rescue in terms of additional deliveries of material inputs and a consequent high level of material intensity.

16. This could be the case, say, in a more realistic model where the centre is not limited to only two possible levels of rescue resources.

17. The model may help explain the practice of allocating materials to the reserves of the centre; in this view the centre anticipates the need for materials with which to "rescue". However, the initial allocation of materials to reserves takes place during the planning process, before production begins. This raises the possibility that the centre can successfully precommit to a low number of rescues by not allocating much to reserves.

18. On revisions of output targets in the USSR see Khaikin (1980).

19. I would like to thank one of the referees of the JCE for stimulating comments which led to the writing of this section.

20. For more detailed presentations of the reputation model in this section and the intuition behind it, see Kreps and Wilson (1982b) and van Damme (1987, Chapter 10, Section 7).

21. By contrast, if the game is repeated an infinite number of times, we have a different problem, namely that we have a multiplicity of subgame perfect equilibria. Here subgame perfection has no bite: "rescue every period" is a subgame perfect equilibrium, but so is "no rescues ever" and indeed even "rescue some periods and not others". Since everything is now "credible", it is difficult to get any insight into the credibility problem in the infinitely-repeated version of the game, and so we concentrate on the finitely-repeated version in the text instead. See e.g. Milgrom and Roberts (1982, Appendix 1) who present an infinitely-repeated version of the chain store game and reject it for these reasons.

22. The centre corresponds to the chain store in the Kreps-Wilson-Selten model; the enterprise in each period corresponds to a potential entrant who will compete with the chain store in a market; the effort level chosen by the enterprise corresponds to the entrant's decision of whether or not to enter; and the centre's choice of rescue vs. letting the enterprise fail corresponds to the chain store's choice of sharing the market with the entrant vs. engaging in cut-throat competition.

23. Note also that $V_C(Y_2-R) \equiv 0$, $V_C(Y_4) \equiv -1$, $V_E(BEE) \equiv 0$, and $V_E(0ee) \equiv b-1$.

24. Actually, the proof is slightly different because the game here differs from the Kreps-Wilson game in that here (a) the enterprise has a second production production, and (b) if the enterprise works hard in the first production period, the centre can still decide to rescue. These additional moves do not change the nature of the game. The proof of equilibrium follows Kreps and Wilson, with additions along the following lines. (a) In the equilibrium described the enterprise has no incentive to deviate from its strategy for effort levels in the second

production periods. The centre's strategy for later planning periods does not depend on the enterprise's strategy for these effort levels, and so the enterprise should simply choose the effort levels which give it the largest stage game payoffs. These are given in Figure 3.2.
(b) Using (a), backwards induction tells us that in any repetition of the stage game, if the enterprise works hard the first period, the centre has a choice between no rescue with payoff Y_2 and rescue with payoff Y_2-R. If it doesn't rescue, it has a higher stage game payoff; moreover, the beliefs of the enterprise do not change (intuitively, by not rescuing a weak centre reveals nothing about its type). Thus a weak centre has no incentive to deviate from the strategy of "no rescue" if the enterprise works hard in some first production period.

25. This is because we have assumed that a strong centre cannot rescue. In the original Kreps-Wilson formulation, a strong centre prefers not to rescue. This leads to the existence of other sequential equilibrium outcomes. These other outcomes are are not, however, very plausible, and can be ruled out by using a variety of criteria: see Kreps and Wilson (1982b) and van Damme (1987).

26. I am grateful to Joe Brada for making this point to me.

27. On the role of this constraint in bank and government bailouts of illiquid enterprises in Yugoslavia, see Tyson (1977).

Appendix 3.1: Description of Subgame Perfect Equilibria

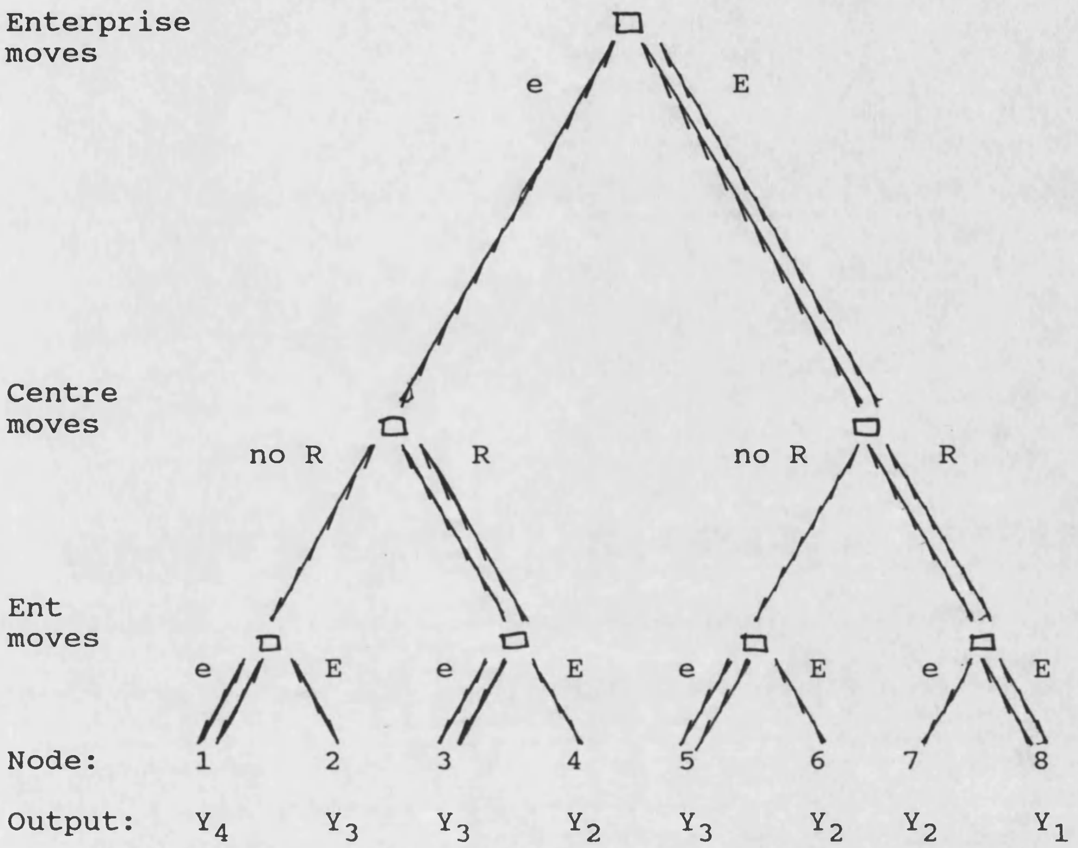
Contents

For Figures A3.1-A3.11, subgame perfect equilibrium strategies are denoted by doubled lines.

For Figures A3.12-A3.15 a special notation is used. The enterprise's move in the second period takes as given its move in the first period and the centre's choice of both target and R/no R. This is denoted by underlining the payoff the enterprise receives given all possible combinations of enterprise first moves and centre choices of target and R/no R. For example, in Figure A3.12, given a choice of e in the first period, and a choice of $Y^T=Y_1$ and no R by the centre, in period 2 the enterprise can either choose e, in which case it arrives at node 1 and receives 0ee as its payoff, or it can choose E, in which case it arrives at node 2 and receives 0eE. The former is preferred by the enterprise, so its strategy at that decision node is e. This is indicated by underlining the payoff 0ee in the $Y^T=Y_1$ row and the node 1 column. The centre's strategy is denoted similarly: the underlining of the payoff in the $Y^T=Y_2$ row and node 4 column indicates that if the enterprise chooses e in period 1 the centre's strategy is to choose R and $Y^T=Y_2$ (the R choice is doubled as well for clarity). Finally, the enterprise's strategy for period 1 is indicated by a doubled line.

Figure A3.1: Subgame Perfect Equilibrium of Version Ia

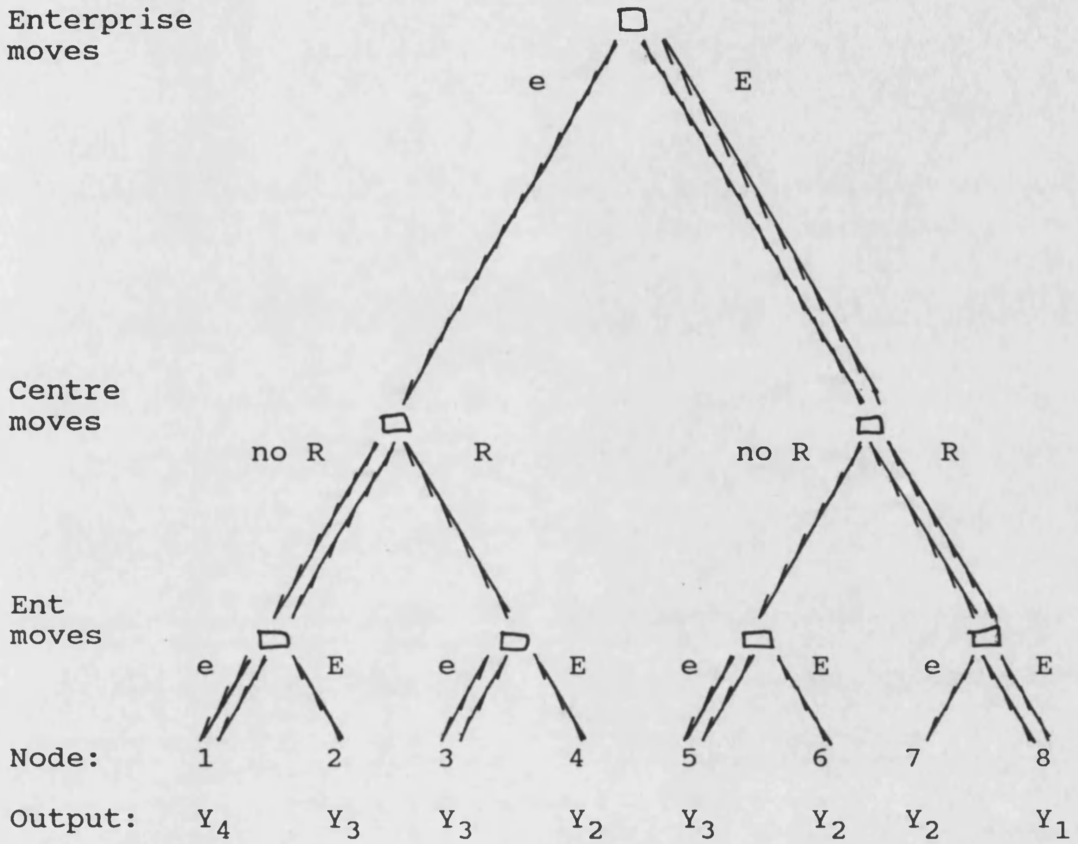
Case A: $Y_3 - R > Y_4$



Target	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent
$Y^T=Y_1$	0ee Y_4	0eE Y_3	0ee Y_3-R	0eE Y_2-R	0Ee Y_3	0EE Y_2	0Ee Y_2-R	BEE Y_1-R

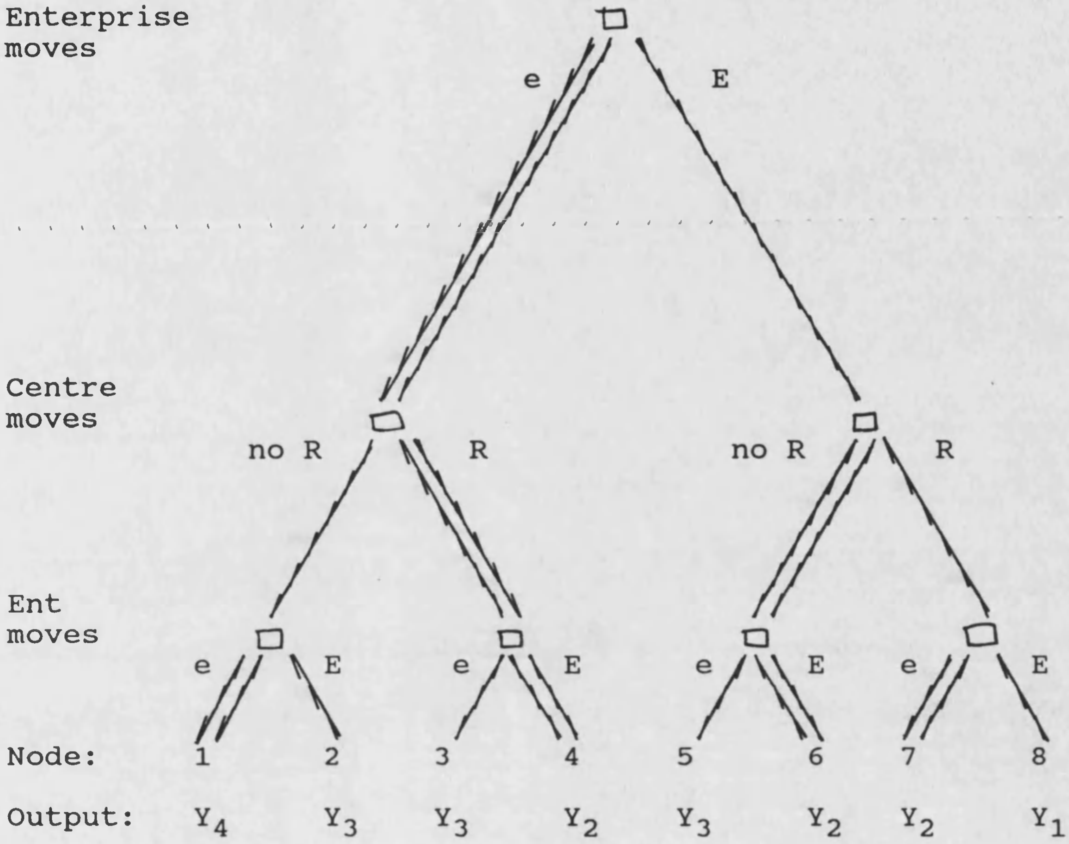
Figure A3.2: Subgame Perfect Equilibrium of Version Ia

Case B: $Y_3 - R < Y_4$



Target	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent
$Y^T=Y_1$	0ee Y_4	0eE Y_3	0ee Y_3-R	0eE Y_2-R	0Ee Y_3	0EE Y_2	0Ee Y_2-R	BEE Y_1-R

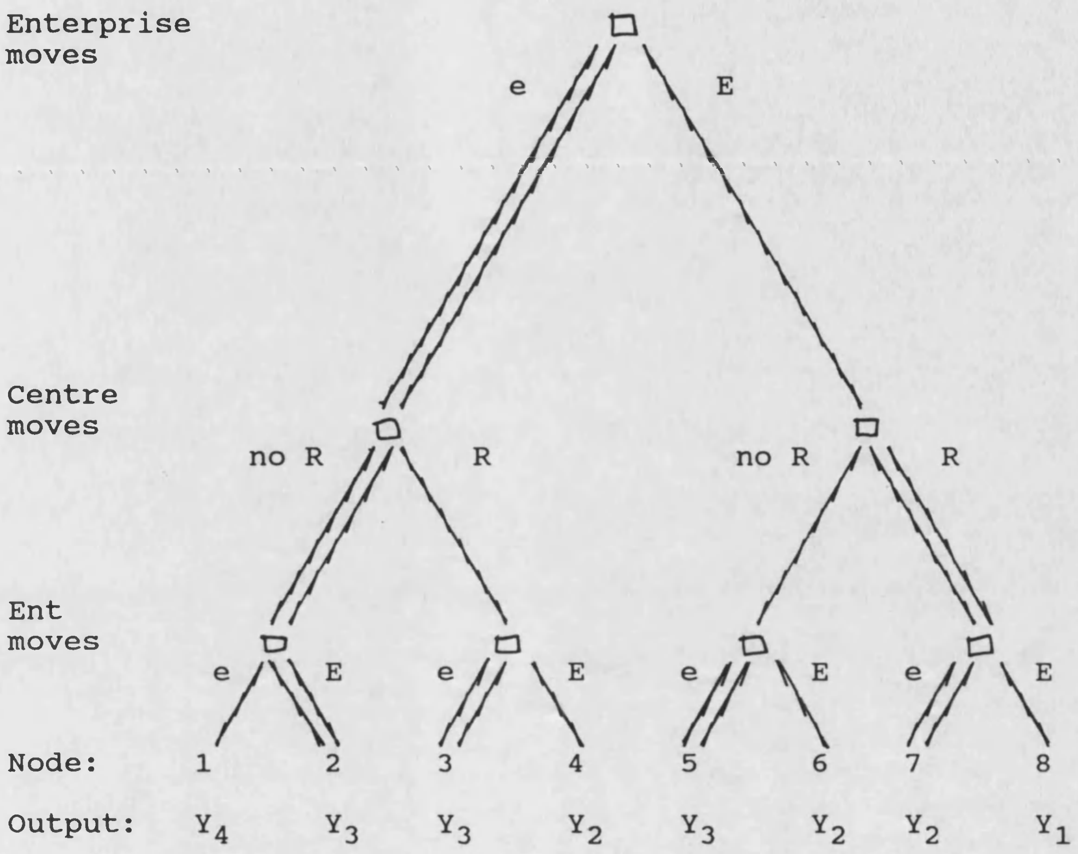
Figure A3.3: Subgame Perfect Equilibrium of Version Ib



Target	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent
$Y^T=Y_2$	Oee Y_4	OeE Y_3	Oee Y_3-R	BeE Y_2-R	OEe Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R

Figure A3.4: Subgame Perfect Equilibrium of Version Ic(i), $Y_2 - R > Y_3$

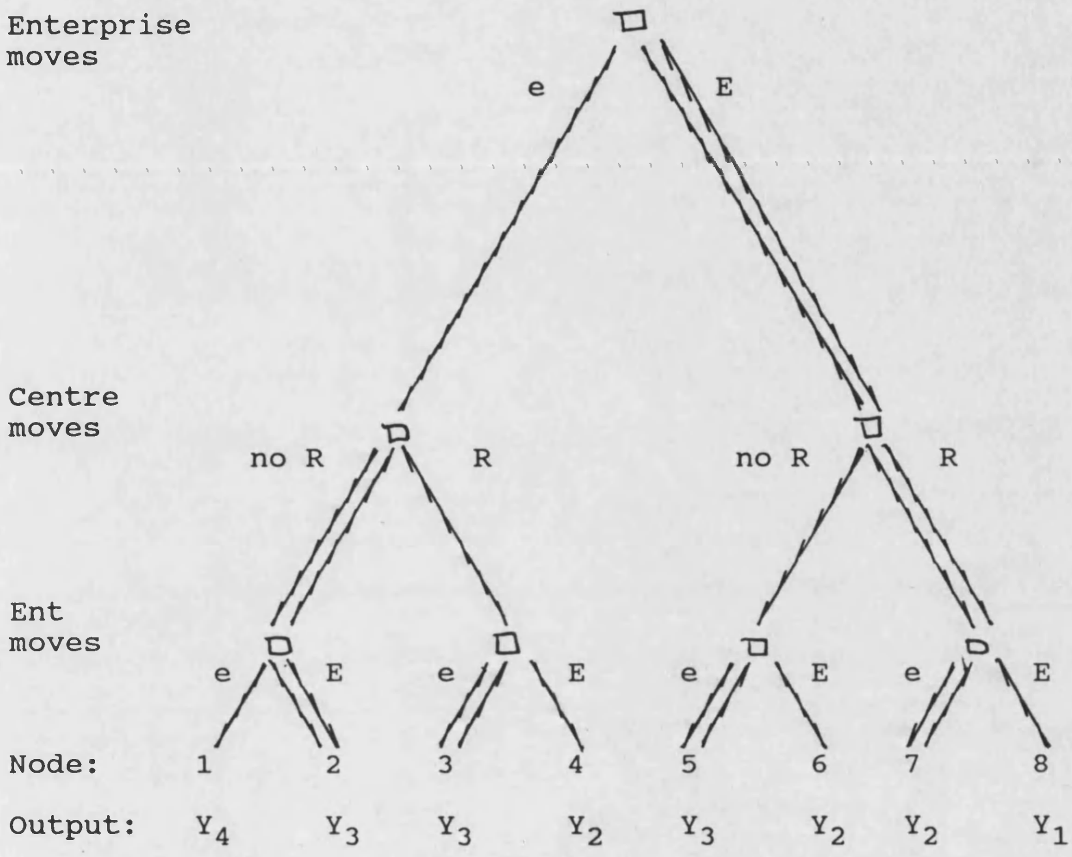
Equilibrium 1



Target	Payoffs		Payoffs		Payoffs		Payoffs		Payoffs		Payoffs		Payoffs		Payoffs	
	Ent	Cent	Ent	Cent	Ent	Cent	Ent	Cent	Ent	Cent	Ent	Cent	Ent	Cent	Ent	Cent
$Y^T = Y_3$	Oee	Y_4	BeE	Y_3	Bee	Y_3-R	BeE	Y_2-R	BEe	Y_3	BEE	Y_2	BEe	Y_2-R	BEE	Y_1-R

Figure A3.5: Subgame Perfect Equilibrium of Version Ic(i), Y_2-R > Y_3

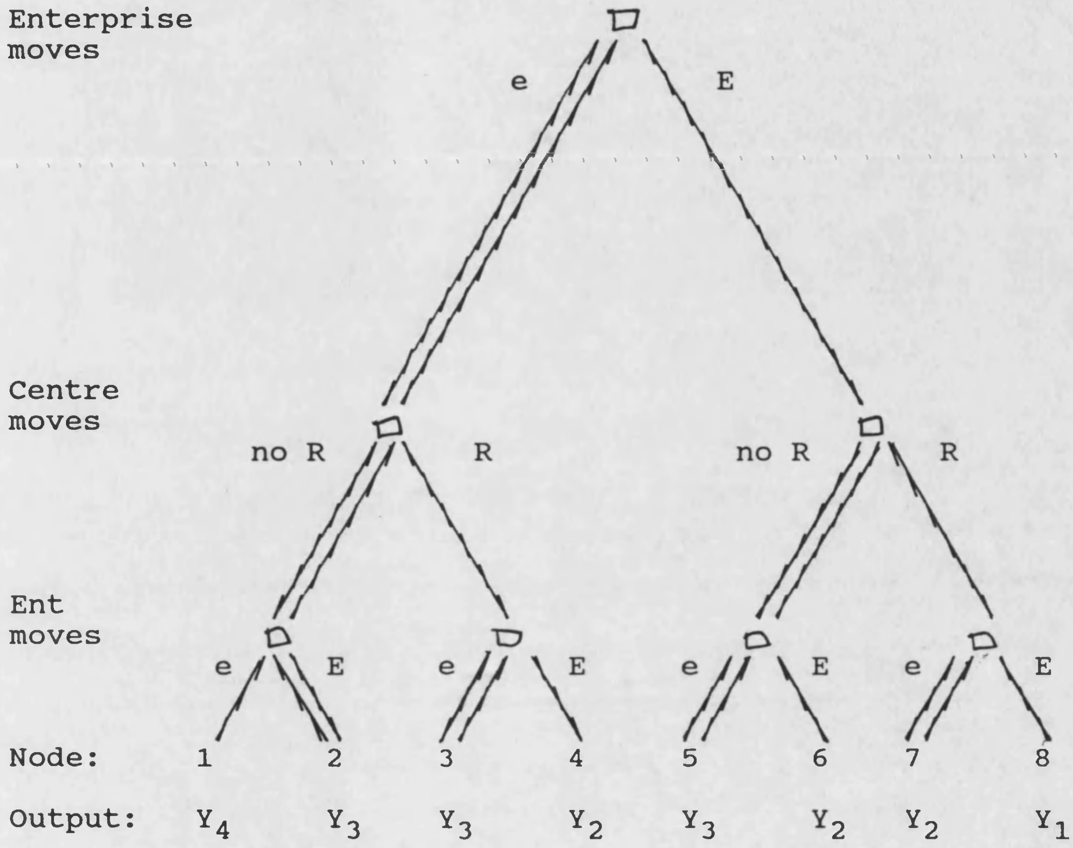
Equilibrium 2



Target	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent
$Y^T=Y_3$	0ee Y_4	BeE Y_3	Bee Y_3-R	BeE Y_2-R	BEe Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R

Figure A3.6: Subgame Perfect Equilibrium of Version Ic(ii), $Y_2 - R < Y_3$

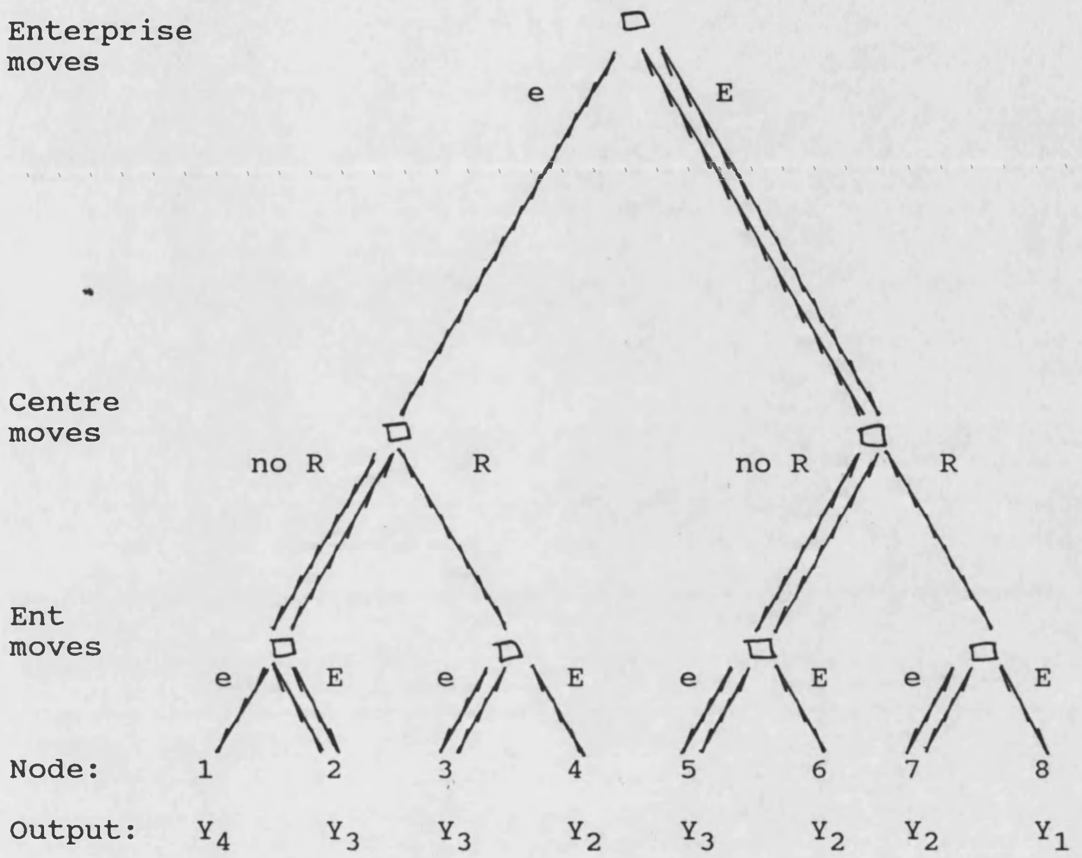
Equilibrium 1



Target	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent
$Y^T=Y_3$	Oee Y_4	BeE Y_3	Bee Y_3-R	BeE Y_2-R	BEe Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R

Figure A3.7: Subgame Perfect Equilibrium of Version Ic(ii), $Y_2-R < Y_3$

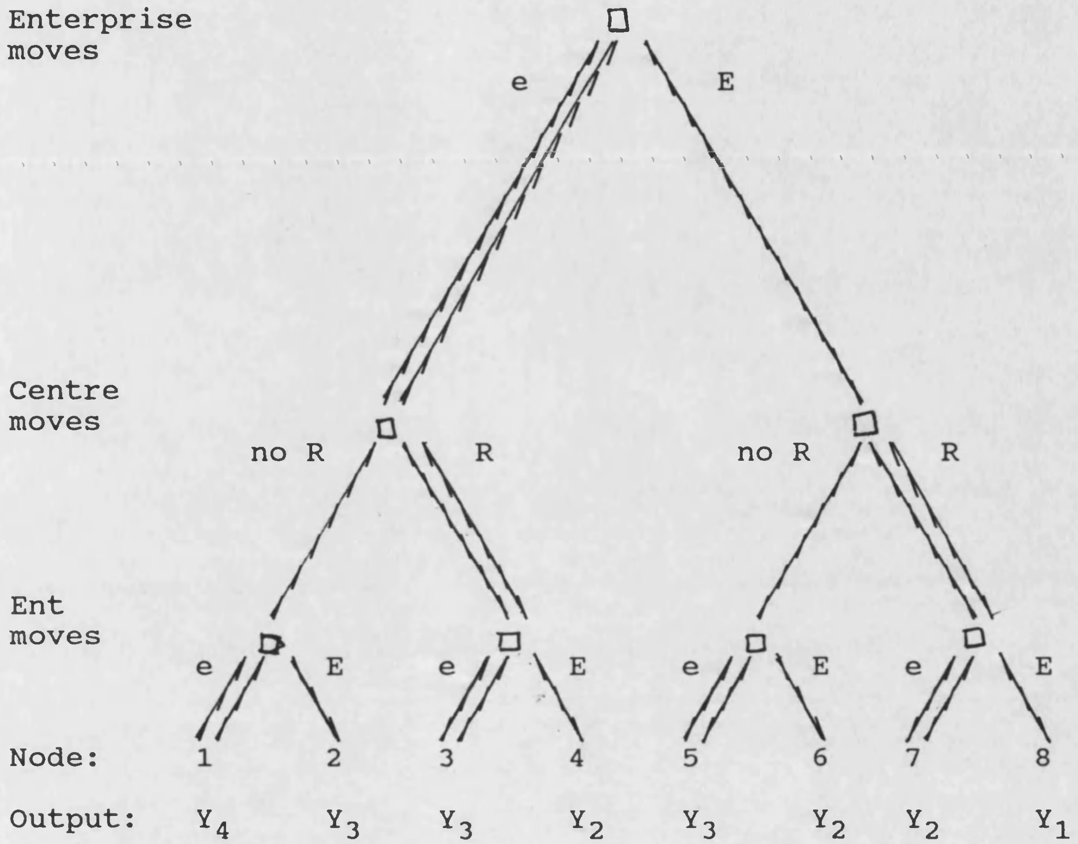
Equilibrium 2



Target	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent
$Y^T=Y_3$	Oee Y_4	BeE Y_3	Bee Y_3-R	BeE Y_2-R	BEe Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R

Figure A3.8: Subgame Perfect Equilibrium of Version Id(i), Y_3-R > Y_4

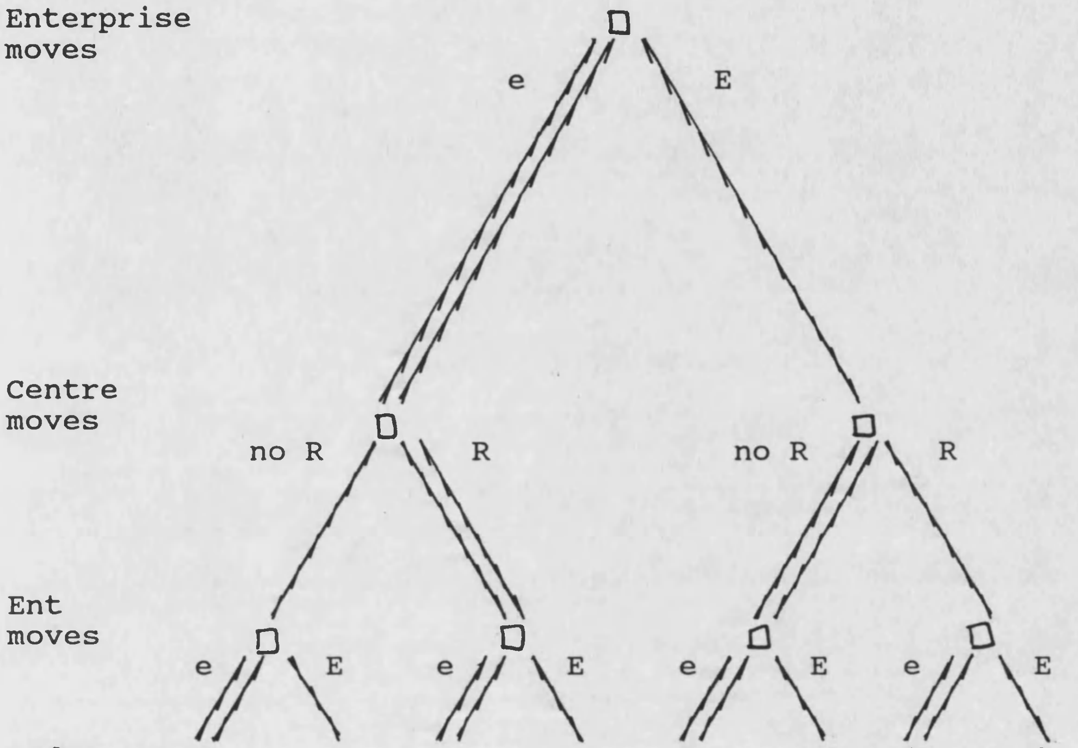
Case A: Y_2-R > Y_3



Target	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent
$Y^T=Y_4$	Bee Y_4	BeE Y_3	Bee Y_3-R	BeE Y_2-R	BEe Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R

Figure A3.9: Subgame Perfect Equilibrium of Version Id(i), Y_3-R > Y_4

Case B: Y_2-R < Y_3

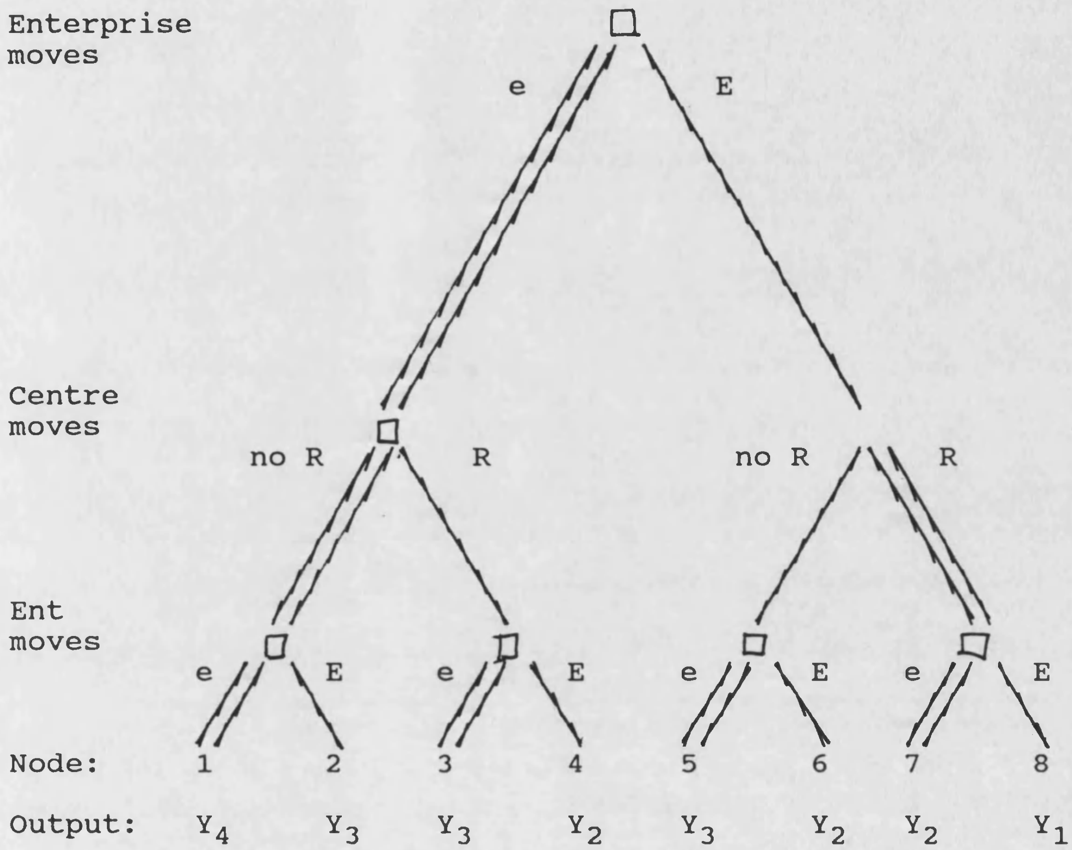


Node:	1	2	3	4	5	6	7	8
Output:	Y_4	Y_3	Y_3	Y_2	Y_3	Y_2	Y_2	Y_1

Target	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent
$Y^T=Y_4$	Bee Y_4	BeE Y_3	Bee Y_3-R	BeE Y_2-R	BEe Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R

Figure A3.10: Subgame Perfect Equilibrium of Version Id(ii), Y_3-R < Y_4

Case A: Y_2-R > Y_3



Target	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent
$Y^T=Y_4$	Bee Y_4	BeE Y_3	Bee Y_3-R	BeE Y_2-R	BEe Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R

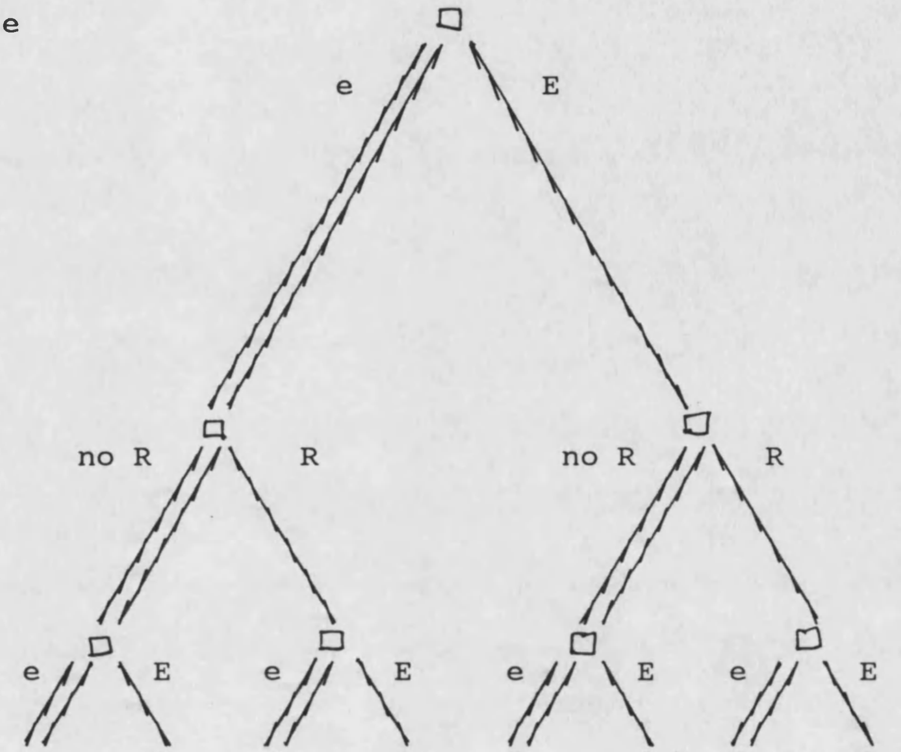
Figure A3.11: Subgame Perfect Equilibrium of Version Id(ii), Y_3-R < Y_4

Case B: Y_2-R < Y_3

Enterprise moves

Centre moves

Ent moves



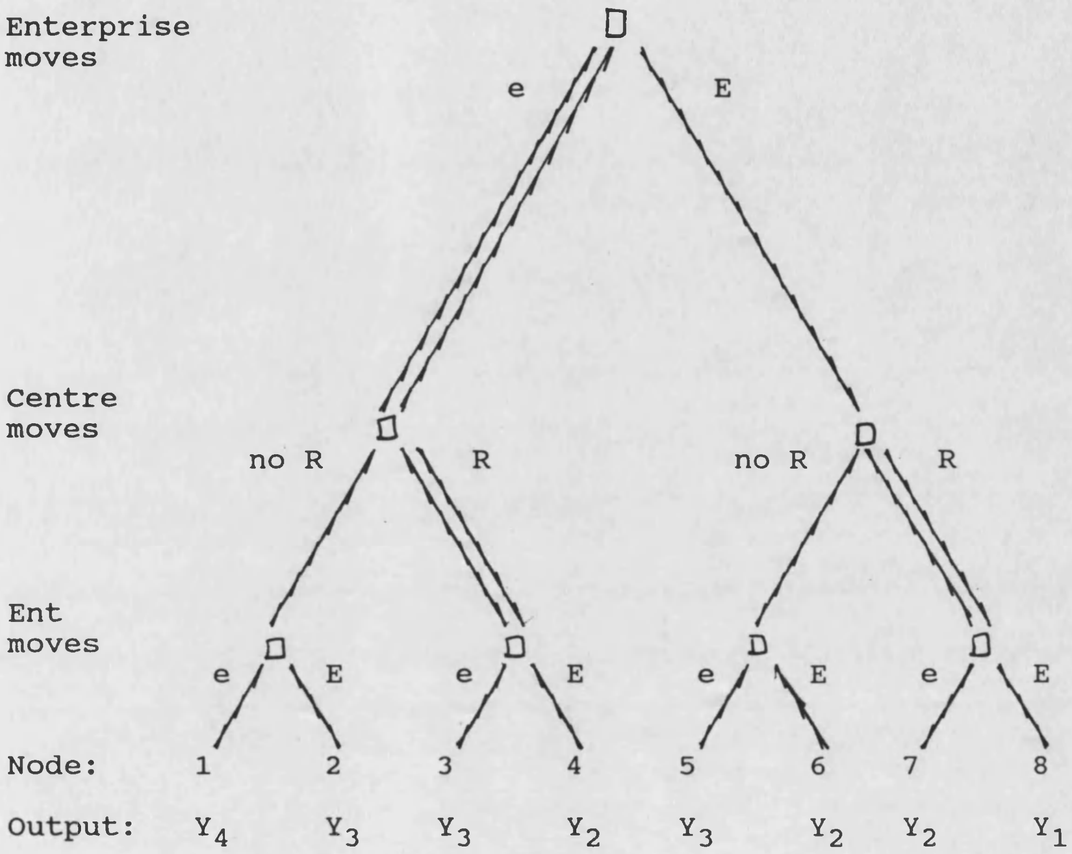
Node: 1 2 3 4 5 6 7 8

Output: Y_4 Y_3 Y_3 Y_2 Y_3 Y_2 Y_2 Y_1

Target	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent
$Y^T=Y_4$	Bee Y_4	BeE Y_3	Bee Y_3-R	BeE Y_2-R	BEe Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R

Figure A3.12: Subgame Perfect Equilibrium of Version III(i), Y_2-R > Y_3

Case A: Y_1-R > Y_2

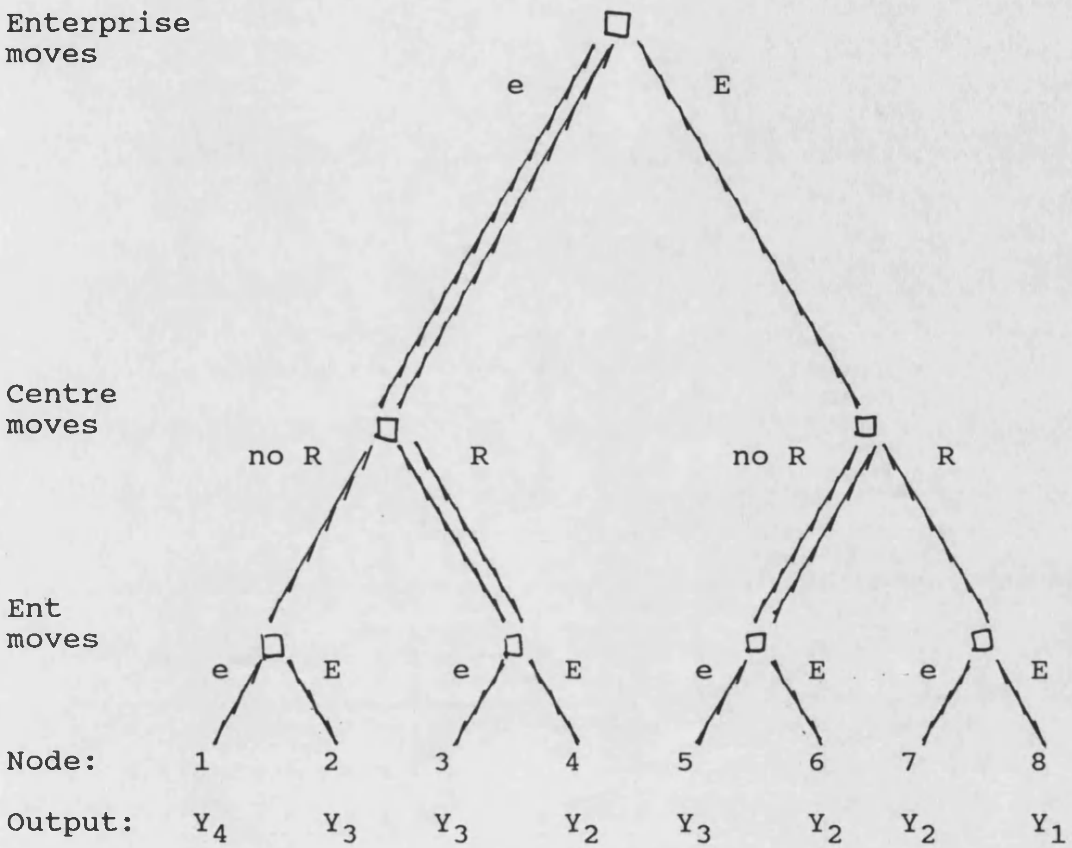


Target	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent
$Y^T=Y_1$	Oee Y_4	OeE Y_3	Oee Y_3-R	OeE Y_2-R	OEe Y_3	OEE Y_2	OEe Y_2-R	BEE Y_1-R
$Y^T=Y_2$	Oee Y_4	OeE Y_3	Oee Y_3-R	BeE Y_2-R	OEe Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R
$Y^T=Y_3$	Oee Y_4	BeE Y_3	Bee Y_3-R	BeE Y_2-R	BEe Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R
$Y^T=Y_4$	Bee Y_4	BeE Y_3	Bee Y_3-R	BeE Y_2-R	BEe Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R

For an explanation of the notation, see the beginning of the appendix.

Figure A3.13: Subgame Perfect Equilibrium of Version III(i), Y_2-R > Y_3

Case B: Y_1-R < Y_2

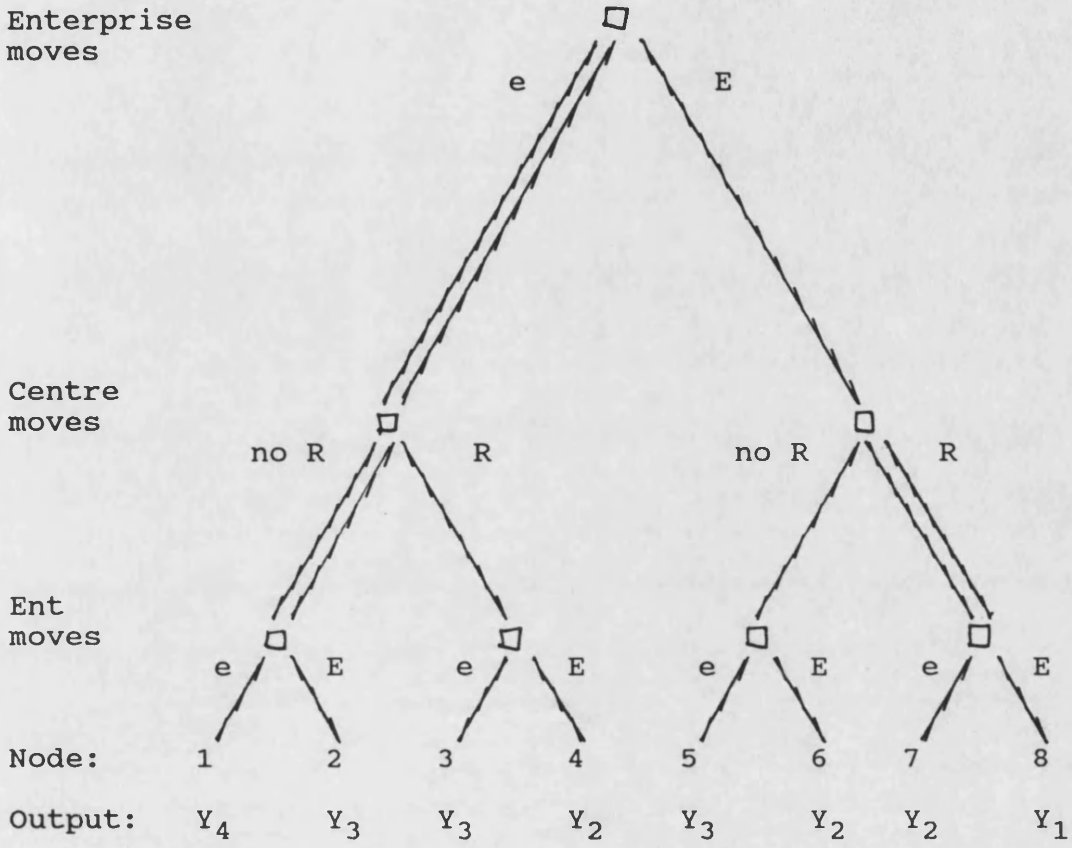


Target	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent
$Y^T=Y_1$	Oee Y_4	OeE Y_3	Oee Y_3-R	OeE Y_2-R	OEe Y_3	OEE Y_2	OEe Y_2-R	BEE Y_1-R
$Y^T=Y_2$	Oee Y_4	OeE Y_3	Oee Y_3-R	BeE Y_2-R	OEe Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R
$Y^T=Y_3$	Oee Y_4	BeE Y_3	Bee Y_3-R	BeE Y_2-R	BEe Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R
$Y^T=Y_4$	Bee Y_4	BeE Y_3	Bee Y_3-R	BeE Y_2-R	BEe Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R

For an explanation of the notation, see the beginning of the appendix.

Figure A3.14: Subgame Perfect Equilibrium of Version III(ii), $Y_2 - R < Y_3$

Case A: $Y_1 - R > Y_2$

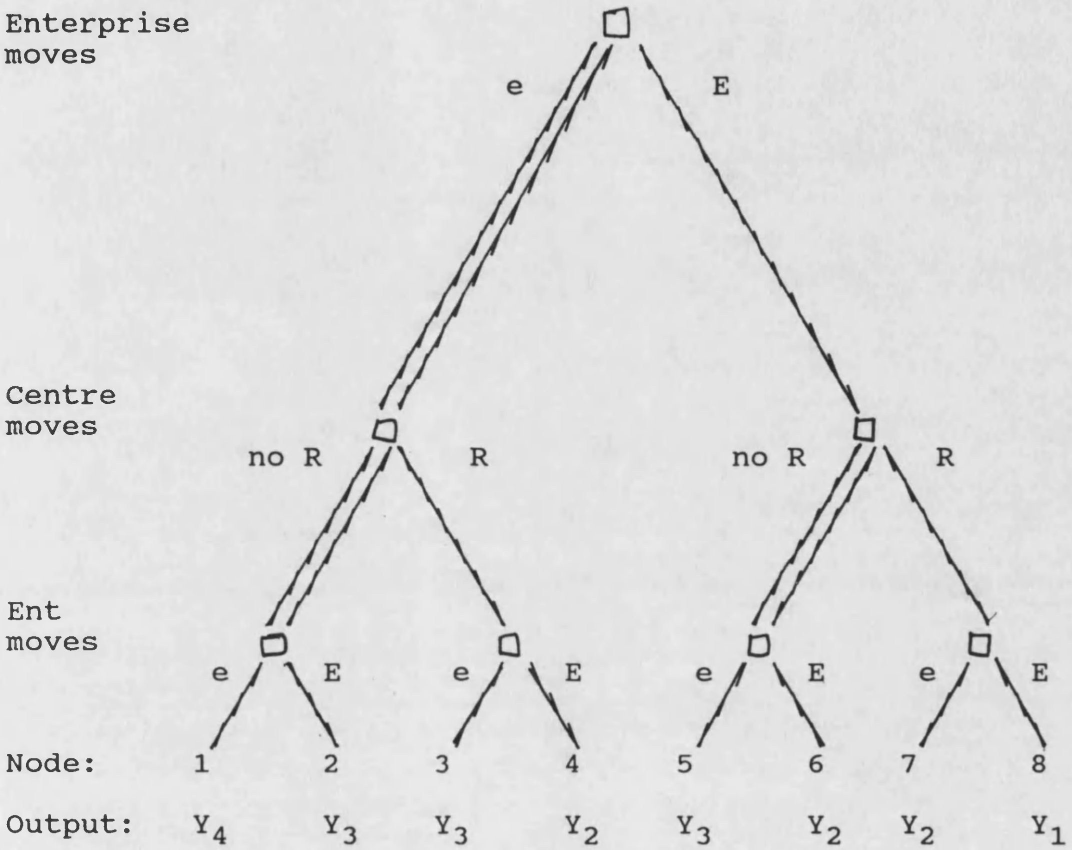


Target	Payoffs Ent	Cent	Payoffs Ent	Cent	Payoffs Ent	Cent	Payoffs Ent	Cent	Payoffs Ent	Cent	Payoffs Ent	Cent	Payoffs Ent	Cent	Payoffs Ent	Cent
$Y^T=Y_1$	$\underline{\text{Oee}}$	Y_4	OeE	Y_3	$\underline{\text{Oee}}$	Y_3-R	OeE	Y_2-R	$\underline{\text{OEe}}$	Y_3	OEE	Y_2	OEe	Y_2-R	$\underline{\text{BEE}}$	$\underline{Y_1-R}$
$Y^T=Y_2$	$\underline{\text{Oee}}$	Y_4	OeE	Y_3	Oee	Y_3-R	$\underline{\text{BeE}}$	Y_2-R	OEe	Y_3	$\underline{\text{BEE}}$	Y_2	$\underline{\text{BEe}}$	Y_2-R	BEE	Y_1-R
$Y^T=Y_3$	Oee	Y_4	$\underline{\text{BeE}}$	$\underline{Y_3}$	$\underline{\text{Bee}}$	Y_3-R	BeE	Y_2-R	$\underline{\text{BEe}}$	Y_3	BEE	Y_2	$\underline{\text{BEe}}$	Y_2-R	BEE	Y_1-R
$Y^T=Y_4$	$\underline{\text{Bee}}$	Y_4	BeE	Y_3	$\underline{\text{Bee}}$	Y_3-R	BeE	Y_2-R	$\underline{\text{BEe}}$	Y_3	BEE	Y_2	$\underline{\text{BEe}}$	Y_2-R	BEE	Y_1-R

For an explanation of the notation, see the beginning of the appendix.

Figure A3.15: Subgame Perfect Equilibrium of Version III(ii), $Y_2-R < Y_3$

Case B: $Y_1-R < Y_2$



Target	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent	Payoffs Ent Cent
$Y^T=Y_1$	0ee Y_4	0eE Y_3	0ee Y_3-R	0eE Y_2-R	0Ee Y_3	0EE Y_2	0Ee Y_2-R	BEE Y_1-R
$Y^T=Y_2$	0ee Y_4	0eE Y_3	0ee Y_3-R	BeE Y_2-R	0Ee Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R
$Y^T=Y_3$	0ee Y_4	BeE Y_3	Bee Y_3-R	BeE Y_2-R	BEe Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R
$Y^T=Y_4$	Bee Y_4	BeE Y_3	Bee Y_3-R	BeE Y_2-R	BEe Y_3	BEE Y_2	BEe Y_2-R	BEE Y_1-R

For an explanation of the notation, see the beginning of the appendix.

Appendix 3.2: A Note on Storming and Anti-Storming

In Chapter 3 I presented a very simple story that suggested that storming did not necessarily follow from the presence of output targets. Indeed, the story suggested that enterprises would first work hard and then take it easy, a work pattern one might call "anti-storming". That simple story relied on the possibility of a "large" stochastic shock to production. In this Appendix I present two simple models in which the production uncertainty is "small"; and again, storming behaviour does <u>not</u> necessarily follow from the presence of output targets.

First, however, it is worthwhile to present a collection of quotes from the literature on storming. The view that output targets are the main or only cause of storming in socialist enterprises is rather common; my point is that this view is incorrect.

<u>A Sample of the Literature on Storming</u>

1. "Uncertainty of supply has many consequences.... The combination of supply delays and the need to fulfil a plan by a given date cause [sic] the phenomenon of <u>shturmovshchina</u>, 'storming'...." (Nove 1977, p. 102)

2. "It is partly caused by the common tendency for materials to arrive late, which is caused by <u>shturmovshchina</u> in the supplying enterprise which is caused by <u>its</u> materials arriving late, and so on." (Nove 1977, p. 222)

3. "... [T]he bonus structure has tended to penalize 99 percent fulfillment, but offers substantial rewards

for 101 percent fulfillment. This discontinuous aspect of the bonus system, plus the other characteristics ... (especially supply inadequacy), lead to storming, or the production of a substantial portion of the monthly output in the final few days of the month." (Gregory and Stuart 1986, p. 221)

4. "... [E]mphasis on purely quantitative achievement tends to conflict with improvement of quality and with the introduction of new products. ... By encouraging myopic concentration on short-term results at the expense of long-term (one symptom of which has been the characteristic shturmovshchina, or 'storming', in the final stages of a planning period) ...." (Dobb 1966, p. 376)

5. "Rewards for plan fulfilment require not only a clearly defined measure of results, but also a time-period to which the results must be related. Hence the great importance of the calendar, and the phenomenon of 'storming' (shturmovshchina), of a mad rush to fulfil the plan in the last few days of the month, quarter or year, followed by a slack and disorganized period in which production falls sharply until the next mad rush." (Nove 1968, p. 177)

6. "... [A] manager had to fulfil his plan in every operational plan period - either one month or one quarter - in order to get regular bonuses and avoid trouble with superiors. The Micawber principle was in operation - 100.1 per cent fulfilment - happiness; 99.9 per cent - misery." (Dyker 1976, p. 40) "The planning process is a temporal one, with its own calendar, and the rhythm of planning tended to react with the rhythm of production in a rather perverse way. ... Once again the nub of the matter [shturmovshchina] is the Micawber and ratchet effects. Operational production plans were monthly or quarterly, and it was important that the output plan should be fulfilled in each month, rather than there being an alternation between underfulfilment and overfulfilment by a considerable degree. If, accordingly, production was behind schedule with a few days of the plan period to go, it is understandable that an energetic manager would go to almost any lengths to ensure fulfilment. (p. 43)

7. "We should note now that under the operation of the ratchet and Micawber principles managers will have an incentive to shturmovshchina irrespective of any supply uncertainty. ... [T]he concern to maintain even levels of plan fulfilment from one month to the next tended to exacerbate the tendency to sharply uneven tempi of production from one week to the next." (Dyker 1985, pp. 26-7)

8. "Because the performance of the enterprise is judged by the measure of fulfillment within the accounting

period, it becomes vitally important to fulfill the plan before the end of that period. It is the crucial role of the accounting period which largely explains the persistence of the uneconomic practice of 'storming'." (Berliner 1957, p. 162)

9. "Called the val system, this output target served as the main measure of managerial success." (Goldman 1968, p. 90) "Because waiting until the last minute is a universal trait, the val system also resulted in a very unbalanced production cycle. Like a student with a term-paper, no one cared at what specific time during the assignment period the task was completed as long as everything was finished at the zero hour on the last day. Consequently, in the Soviet factory, as in the dormitory, there seldom is much activity during the first twenty days of the month. In part, it is necessary to rest up from the rush of the last days of the preceding deadline. ... This practice was called shturmovshchina." (p. 92)

10. "Because the fulfillment of the plan is so important both to the directors and workers, production tends to be unevenly distributed over the month. The rate of production tends to be stepped up to a fever pitch as the end of the month approaches and the output goal appears to be incapable of fulfillment. As a result of this accelerated activity, which is referred to as 'storming' in the literature, workers tend to be exhausted in the first part of the following month, so that storming again becomes necessary towards the end of the following period." (Turgeon 1969, p. 257)

11. "Operating with such a bonus function it is not too surprising that enterprises should practise 'storming'; this involves peaks in production activity towards the end of a plan or bonus payment period, usually a quarter or a year. These peaks arise because 99.9 per cent plan fulfilment secures no bonus at all, while 100 per cent fulfilment earns substantial rewards. Thus, if plan fulfilment is not already assured a few weeks from the end of the relevant period, the marginal value of additional effort rises sharply. However, other factors also contribute to the phenomenon of storming, in particular the position in regard to material supplies, and the tautness of the initial plan, so that modifying the bonus function alone may not effect much change." (Cave and Hare 1981, p. 64)

A few additional comments are in order here. (1) Blaming storming in one enterprise on the late arrival of its supplies (Nove, quote 2) begs the question of what caused storming in the supplying enterprise. An explanation of storming along these lines is possible (for example, if substitutability between inputs is very limited, it takes only the late arrival of one input to cause the enterprise to storm) but ought to be set out explicitly.

(2) Blaming storming on managerial time preference (Dobb, quote 4 and Goldman, quote 9) requires unrealistic discount rates (see Alexeev 1989). A typical account of monthly storming would give a work pattern of about 10% of monthly output in the first ten days of the month, 25% in the second ten days, and the rest in the last ten days (ibid.).

(3) The statement that if plan fulfilment is not already assured as the end of the planning period approaches, "the marginal value of additional effort rises sharply" (Cave and Hare, quote 11), begs the question of why the manager didn't work harder earlier.

I now turn to the formal models.

The Basic Model

The basic model is presented in two versions. In the first version, we assume a simple linear production technology and allow utility to be of a general form; in the second version, we assume utility is quadratic and allow technology to be general. Both versions share the following framework. Production takes place over two periods, denoted $t = 1,2$. There is a single production input which we can think of as managerial or worker "effort" or labour, L_t. The enterprise's personnel suffer (von Neumann-Morgenstern) additively separable disutility of the form $U(L_1,L_2) \equiv U(L_1) + U(L_2)$, where $U' < 0$, $U'' < 0$. The enterprise faces a binding production target Y^T for total production over the two periods. This target must be fulfilled or the enterprise suffers utility of $-\infty$.

Production in each period is subject to a stochastic shock ϵ, i.e. $F(L_t) + \epsilon = Y_t$. The shock ϵ is assumed to have the very simple bimodal point distribution

$$\begin{aligned} \epsilon &= e \text{ with probability } 1/2 \\ &= -e \text{ with probability } 1/2 \qquad \text{where } e > 0 \end{aligned}$$

We assume e to be "small" (small enough, at any rate, to make Taylor approximations legitimate).

The sequence of events is as follows:

1. ϵ_1 realised
2. L_1 allocated, Y_1 produced
3. ϵ_2 realised
4. L_2 allocated, Y_2 produced

Thus in analysing the optimal plan of the enterprise, we can ignore ϵ_1 and start with no. 2 in the sequence of events. From now on we work only with ϵ_2 and suppress the subscript 2.

Version I: Linear Production Technology

With linear technology, we can simplify notation by working directly with labour input. Define L^T to be the total labour required to fulfil the output target. Also normalise the stochastic production shock so that total output after period 1 production and the realisation of the second stochastic shock (i.e. after no. 3 above) is defined as $L_1 + \epsilon$.

Since after no. 3 in the sequence of events (i.e. after the realisation of the second shock) we know exactly how much labour will be supplied in the second production period, we can write

$$L_2 = L^T - L_1 - \epsilon$$

Note that

$$EL_2 = L^T - L_1$$

Expected utility over both periods is

$$EU = U(L_1) + U(L^T - L_1 - \epsilon)$$

i.e.

$$EU = U(L_1) + \tfrac{1}{2}U(L^T - L_1 + e) + \tfrac{1}{2}U(L^T - L_1 - e)$$

Maximising this gives the first order condition

$$2U'(L_1) = U'(L^T - L_1 + e) + U'(L^T - L_1 - e)$$

Taking a Taylor approximation around $L^T - L_1$ gives

$$U'(L^T - L_1 + e) \approx U'(L^T - L_1) + eU''(L^T - L_1) + \frac{e^2}{2}U'''(L^T - L_1)$$

$$U'(L^T - L_1 - e) \approx U'(L^T - L_1) - eU''(L^T - L_1) + \frac{e^2}{2}U'''(L^T - L_1)$$

Plugging things into the FOC gives

$$U'(L_1) - U'(L^T - L_1) = \frac{e^2}{2}U'''(L^T - L_1)$$

or

$$U'(L_1) - U'(EL_2) = \frac{e^2}{2}U'''(EL_2)$$

Now, since U' and U'' are both strictly less than zero,

$$\text{sign}\ \{\ U'(L_1) - U'(EL_2)\ \} = -\text{sign}\ \{\ L_1 - EL_2\ \}$$

We are now able to say whether or not we will expect to observe a storming pattern in the allocation of labour. It turns out that the third derivative of the utility function is the key. If U''' is positive, then by the last equation $L_1 < EL_2$, i.e. we expect to observe storming. But if U''' is negative, then $L_1 > EL_2$; "anti-storming", i.e. working harder in the first period than in the second, will be typical. And if U''' = 0, i.e. we have quadratic utility, we will expect to see an even allocation of effort across production periods.

Several comments are in order here. First and most important, the model demonstrates again that the mere presence of output targets is <u>not</u> enough to generate storming behaviour. The fact that storming is in fact the rule in socialist economies means that something besides output targets must be behind this empirical regularity. Second, we usually have no prior prejudices about the sign of U'''. Either storming or anti-storming is a priori reasonable in this model.

Version II: General Production Technology, Quadratic Utility

Regarding the disutility of labour, we maintain the assumptions that $U' < 0$, $U'' < 0$, but now add the assumption that $U''' = 0$, i.e. we assume that the disutility of labour takes a quadratic form. The production technology $F(L_t)$ is however general; we require only that $F' > 0$ and $F'' < 0$. Define the inverse of F to be $G(Y_t)$. For a given output Y_t, $G(Y_t)$ is the labour required to produce it. Note that $G' > 0$, $G'' > 0$.

As before,

$$Y_2 \equiv F(L_2) = Y^T - F(L_1) - \epsilon$$

and again note that

$$EY_2 = Y^T - F(L_1)$$

Also note that

$$L_2 = G(Y^T-F(L_1)-\epsilon)$$

Now expected utility over both periods is

$$EU = U(L_1) + \tfrac{1}{2}U(G(Y^T-F(L_1)+e)) + \tfrac{1}{2}U(G(Y^T-F(L_1)-e))$$

The first order condition requires

$$2U'(L_1) = U'(G(Y^T-F(L_1)+e))G'(Y^T-F(L_1)+e)F'(L_1)$$
$$+ U'(G(Y^T-F(L_1)-e))G'(Y^T-F(L_1)-e)F'(L_1)$$

Define

$$S(L_1) \equiv Y^T - 2F(L_1)$$

If $S(L_1) > 0$, we will expect to observe a storming pattern in the allocation of effort. If $S(L_1) < 0$, we expect to observe "anti-storming". Note that

$$Y^T - F(L_1) \equiv F(L_1) + [Y^T - 2F(L_1)]$$
$$\equiv F(L_1) + S(L_1)$$

We now take a Taylor approximation to the FOC around $F(L_1)$. We begin with approximations to G and G'. The argument to $S(L_1)$ is suppressed.

$$G(Y^T-F(L_1)+e) \equiv G(F(L_1) + S + e)$$
$$\approx G(F(L_1)) + (S+e)G'(F(L_1)) + \frac{(S+e)^2}{2}G''(F(L_1))$$
$$= L_1 + (S+e)G'(F(L_1)) + \frac{(S+e)^2}{2}G''(F(L_1))$$

$$G(Y^T-F(L_1)-e) \equiv G(F(L_1) + S - e)$$
$$\approx G(F(L_1)) + (S-e)G'(F(L_1)) + \frac{(S-e)^2}{2}G''(F(L_1))$$
$$= L_1 + (S-e)G'(F(L_1)) + \frac{(S-e)^2}{2}G''(F(L_1))$$

$$G'(Y^T-F(L_1)+e) \equiv G'(F(L_1) + S + e)$$
$$\approx G'(F(L_1)) + (S+e)G''(F(L_1)) + \frac{(S+e)^2}{2}G'''(F(L_1))$$

$$G'(Y^T - F(L_1) - e) \equiv G'(F(L_1) + S - e)$$
$$\approx G'(F(L_1)) + (S-e)G''(F(L_1)) + \frac{(S-e)^2}{2} G'''(F(L_1))$$

Plugging G into U' and taking a Taylor approximation to U' around L_1 (remember U''' = 0), we get

$$U'(G(Y^T - F(L_1) + e)) \approx U'(L_1 + (S+e)G'(F(L_1)) + \frac{(S+e)^2}{2} G''(F(L_1)))$$

$$\approx U'(L_1) + \{ (S+e)G'(F(L_1)) + \frac{(S+e)^2}{2} G''(F(L_1)) \} U''(L_1)$$

$$U'(G(Y^T - F(L_1) - e)) \approx U'(L_1 + (S-e)G'(F(L_1)) + \frac{(S-e)^2}{2} G''(F(L_1)))$$

$$\approx U'(L_1) + \{ (S-e)G'(F(L_1)) + \frac{(S-e)^2}{2} G''(F(L_1)) \} U''(L_1)$$

Substituting all this into the FOC, and suppressing the arguments to the functions (everything is taking place at L_1), we get

$$2U'(L_1) \approx F'(L_1) * \{ [U' + (S+e)G'U'' + \frac{(S+e)^2}{2} G''U''][G' + (S+e)G'' + \frac{(S+e)^2}{2} G''']$$
$$+ [U' + (S-e)G'U'' + \frac{(S-e)^2}{2} G''U''][G' + (S-e)G'' + \frac{(S-e)^2}{2} G'''] \}$$

Multiplying this out is a bit messy, but note that within the {} we will get a $2U'(L_1)G'(F(L_1))$ term. When multiplied by the $F'(L_1)$ term outside the {} this becomes $2U'(L_1)$, since $F'*G' = 1$ by the inverse differentiation rule. This $2U'(L_1)$ cancels with the same term on the left hand side of the equation, yielding 0 on the left hand side. Eventually we get (it can be simplified further, but it just makes checking the algebra more tedious)

$$
\begin{aligned}
0 = {} & 2SF'G''U' \\
& + \frac{1}{2} \{ (S+e)^2 + (S-e)^2 \} F'U'G''' \\
& + 2SG'U'' \\
& + \frac{3}{2} \{ (S+e)^2 + (S-e)^2 \} G''U'' \\
& + \frac{1}{2} \{ (S+e)^3 + (S-e)^3 \} U''G''' \\
& + \frac{1}{2} \{ (S+e)^3 + (S-e)^3 \} F'G''G''U'' \\
& + \frac{1}{4} (S+e)^4 F'G''U''G'''
\end{aligned}
$$

Note that

$$\text{sign} \{ (S+e)^3 + (S-e)^3 \} = \text{sign} \{ S \}$$

We are now able to say something about when the model generates a storming pattern and when it generates an anti-storming pattern: it turns out to depend on G''', the third derivative of the inverse of the production function. If $G''' \geq 0$ then L_1 must be such that $S(L_1) < 0$, i.e. we have <u>anti-storming</u>. If $G''' < 0$ then we may have either storming or anti-storming. Note, by the way, that things simplify a lot if we have linear utility, i.e. $U'' = 0$. In this case, $G''' > 0$ gives anti-storming, $G''' < 0$ gives storming, and $G''' = 0$ gives even effort.

The lessons of this version are quite similar to those of version I. Again, most important of all, the model shows that more than just output targets is needed to generate storming behaviour. And again, we usually have no prior prejudice about the third derivative of the inverse of the production function. It is reasonable to expect a priori either storming or anti-storming in this model.

Chapter 4: Are Profit-Maximisers the Best Survivors? A Darwinian Model of Economic Natural Selection[1]

Introduction

In the previous two chapters I was concerned with the effects on incentives of a state policy of bailouts/rescues of enterprises, and how such a policy might arise. As I noted in passing in Chapter 2, though, a bailout policy has not only incentive effects but also what might be called "evolutionary" effects; enterprises which would otherwise leave an industry are able to survive with state support. In Schumpeterian terms, a bailout policy slows or stops the process of "creative destruction"; in more explicitly evolutionary terms, it slows or stops the process of "economic natural selection".

One natural question to ask is what are the effects of halting "economic natural selection" via bailouts. However, evolutionary modelling in economics is still not very well developed; the natural predecessor to this question - what are the effects of the presence of economic natural selection - has not been thoroughly investigated to date. It is primarily this latter question that I will address in this chapter.

"Economic natural selection" has sometimes been cited in support of the conventional neoclassical profit-maximisation model of the firm. In this view, the assumption of profit-maximisation by firms in formal economic models is plausible because in the real world, "economic natural selection" drives non-maximisers out of the market. The most famous exposition of this position is in Friedman's 1953 methodological essay:

> The process of "natural selection" helps to validate the hypothesis [of "rational and informed maximization of returns"] - or, rather, given natural selection, acceptance of the hypothesis can be based largely on the judgment that it summarizes appropriately the conditions for survival. (Friedman 1953, p. 22)

Though not without its critics (see e.g. Nelson and Winter 1982), this argument seems intuitively convincing. Nevertheless, if it is to be accepted as valid, "economic natural selection" would first need to be modelled explicitly. But when this is done, then, as I show in this chapter, the Friedman conjecture is shown to be false in some important cases. Specifically, only in perfect competition, when firms lack market power, are profit-maximisers the best survivors.

The main result of the chapter follows almost trivially from Darwinian definition of "economic natural selection", but nevertheless is at first surprising: absolute-profit maximisation does not "summarise appropriately the conditions for survival". The intuitive reason is that a firm maximising its own profit may help its non-maximising competitors to do even better. Put another way, a firm which does not maximise its profit may still earn profits which are larger than those of its profit-maximising competitors, if the costs to itself of its deviation from maximisation are smaller than the costs it imposes on the maximising competitors. The Friedman argument that economic natural selection will lead to the survival of profit-maximisers fails in the presence of this positive externality.[2] Only in the case of perfect competition, when firms have no market power and this externality disappears, is absolute-profit maximisation always an "appropriate summary". This result is a consequence of the Darwinian definition of economic natural selection, whereby it is the "fittest" firms which survive.

The above result is essentially an application to economics of Hamilton's theory of "spite" in evolutionary biology (Hamilton 1970, 1971). An act by an animal is "spiteful" if the animal harms both itself and another. Hamilton demonstrated that such a trait could be selected for if the population was not very large. The condition for the selection of a spiteful trait is that the decrease in an animal's own Darwinian fitness is smaller than the decrease in the fitness of the average member of the rest of the population; since the holder of the spiteful trait thus has a higher fitness than that of his intra-species competitors, the trait will be selected for.

The relevance of Hamilton's theory to the Friedman conjecture is straightforward. When firms have market power, the potential for "spiteful" behaviour exists. A firm which forgoes the opportunity to maximise its absolute profit may still enjoy a selective advantage over its competitors if its "spiteful" deviation from profit-maximisation harms its competitors more than itself.

The simple formal model of economic natural selection which this chapter presents is derived from the "evolutionary game theory" (EGT) analysis used in evolutionary biology (see e.g. Maynard Smith 1982) and is Darwinian in spirit. The basic approach is directly analogous to that used in EGT to define an "evolutionarily stable strategy" (ESS). In the paper which first introduced the concept, Maynard Smith and Price (1973, p. 73) give the intuition behind the ESS: "Roughly, an ESS is a strategy such that, if most of the members of a population adopt it, there is no 'mutant' strategy that would give higher reproductive fitness."

The standard EGT analysis assumes random pairwise contests between individuals drawn from an infinite population; two individuals are repeatedly chosen at random to play a given game. The intended application of the Friedman argument is firm behaviour in an industry, and so the model presented in this chapter is instead based on the special case of the ESS defined for finite populations in which individuals "play the field" (see the appendix to this chapter).[3] "Playing the field" means all the players in the game compete with each other simultaneously, which is the appropriate analogy for the standard model of competition between firms in an industry; the finite-population case is analogous to oligopoly.

In the model in the chapter, the firms which are most likely to survive are not those which maximise the absolute level of their profits, but rather those which maximise their "relative profits" (in a sense discussed below). This result is directly analogous to the "spitefulness" of the evolutionary biology ESS in finite populations (see the appendix and Knowlton and Parker 1979). It can also be interpreted as a formalisation of Alchian's statement in his 1950 paper on evolution and economic theory that "success (survival) accompanies <u>relative</u> superiority" (p. 213, emphasis added). It must be stressed, however, that the model does <u>not</u> suggest maximisation of "relative profits" as the best strategy for survival. In Hamilton's theory of spite, spiteful behaviour imposes costs on an animal, but larger costs on its competitors. Similarly, in the model which follows, "relative-profit maximisation" can cause a firm to be less likely to survive; but it also means the firm is more likely to survive than its competitors.

An Example

Before presenting the general model, we begin with a very simple example of quantity-setting duopoly to illustrate the main ideas. We have two identical firms which have no fixed costs and identical and constant marginal costs.

Firm 1 sells quantity q_1 and earns profit π_1, and similarly for firm 2. The firms face a smooth, downward-sloping demand curve. When total supply equals Q*, price is equal to marginal cost and both firms earn zero profits.

Consider now a form of "economic natural selection". After the firms produce and sell their quantities of output, "selection" takes place: with some probability p_i, firm i may or may not "survive" to produce in the next period. We also require that $0 < p_i < 1$, so that neither firm can guarantee its "survival". The interpretation of a failure to "survive" is left open for now. It could mean that the firm goes bankrupt; or the firm is forced to leave the market; or the firm stays in the market but the manager is fired; etc. This probability of survival must be related to profits in a way which captures the Darwinian notion of "survival of the fittest". We formalise this by a very natural requirement of "monotonicity": $p_i > p_j$ if and only if $\pi_i > \pi_j$. This monotonicity requirement is fully in the spirit of biological models of natural selection: it means simply that if firm i has a larger profit than firm j, then firm i is more likely to survive than firm j.

Figure 4.1 shows the case where both firms sell Q*/2 units of output. The total quantity sold is Q*, price is therefore equal to the marginal costs of both firms, and profits are zero. This is the symmetric competitive solution. It is also a "symmetric evolutionary equilibrium" in the following sense: say firm 1 continues to sell Q*/2 units of output, but firm 2 deviates and sells some other quantity. No matter what quantity the deviant firm 2 chooses to sell, firm 1 will always have a higher probability of survival than firm 2. In other words, the strategy of selling Q*/2 units of output is analogous to the ESS of evolutionary biology in that a deviant ("mutant") firm which uses another strategy will always have a lower profit than a firm which sells Q*/2 (compare the Maynard Smith and Price quote given earlier).

Figure 4.1

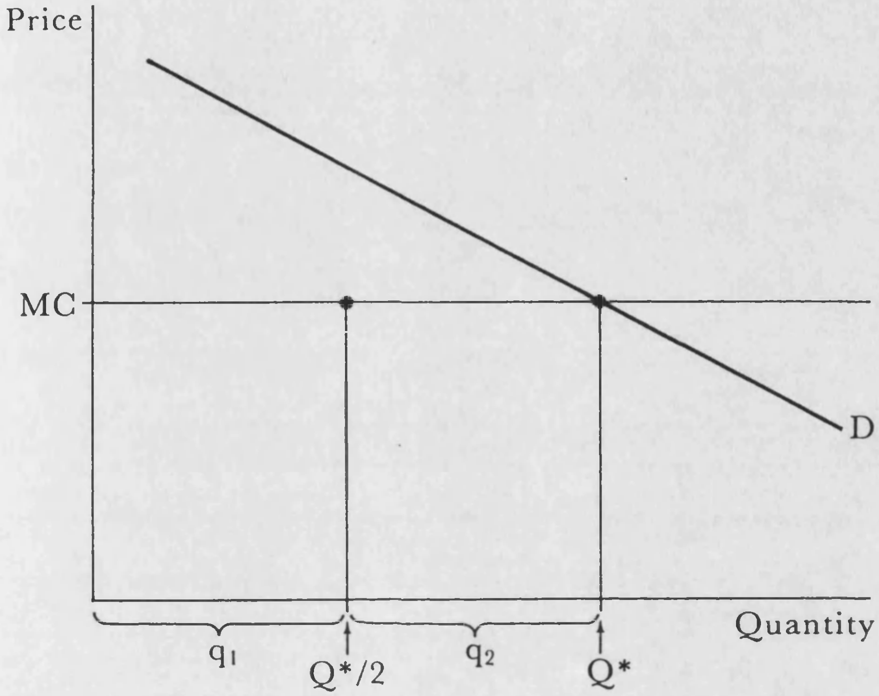


Figure 4.2

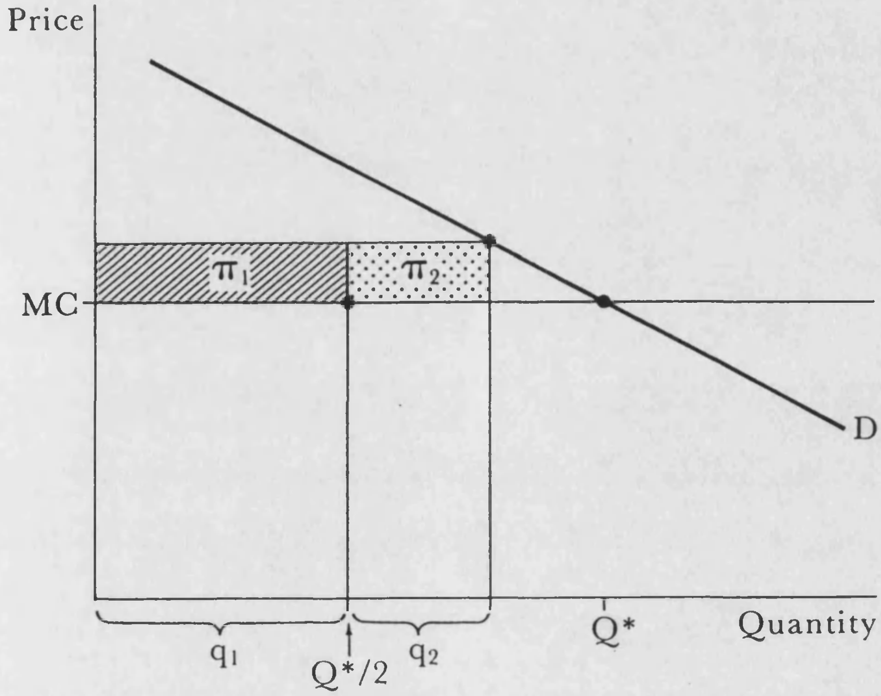
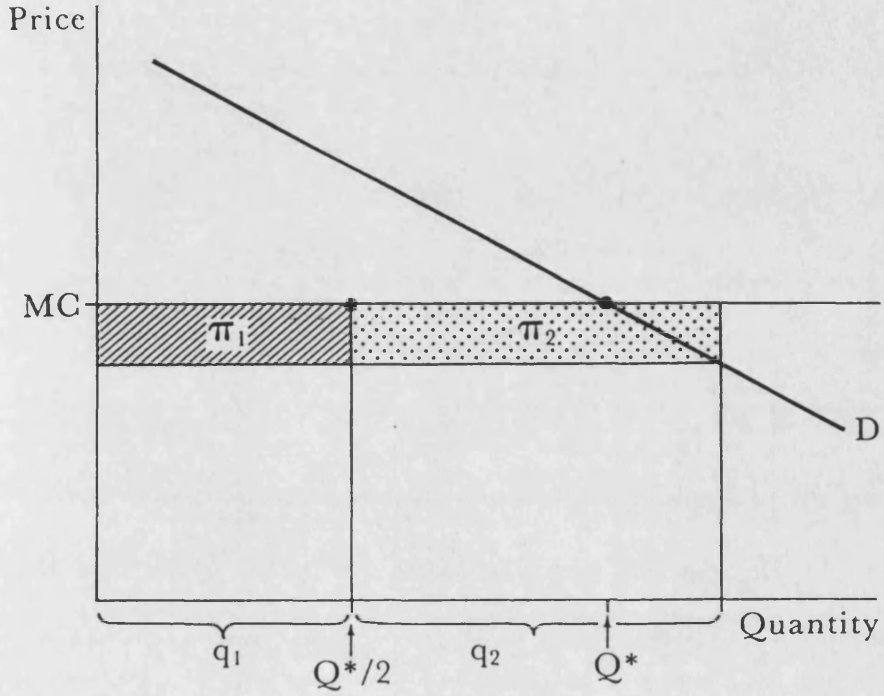


Figure 4.3



This is illustrated in figures 4.2 and 4.3. In both figures, firm 1 sells $Q^*/2$. In figure 4.2, firm 2 sells $q_2 < Q^*/2$ and therefore earns itself positive profits π_2. But firm 1 is selling a larger quantity at the same price, and so its profits π_1 exceed the profits of firm 2. Similarly, in figure 4.3, firm 2 sells $q_2 > Q^*/2$, driving price below marginal cost and thus suffering a loss. But firm 1 is selling a smaller quantity at the same price, and so its losses are smaller. In both cases firm 1 has a larger profit than that of the "deviant" firm 2, and therefore a higher probability of survival.

It is important to emphasise that the above argument holds <u>even if survival is based on absolute profits</u>. Say that firm i's probability of survival increases with its absolute level of profits: $p_i = f(\pi_i)$, $0 < f(\cdot) < 1$, $f' > 0$. But $f(\cdot)$ conforms to the monotonicity assumption above, and so we are still guaranteed that firm 1 will have a selective advantage should firm 2 sell some deviant quantity.

Indeed, note that in figure 4.2 firm 2 is making positive profits. It is actually making larger profits than it would if it had continued to sell $Q^*/2$ units. In fact, taking firm 1's quantity as given, firm 2 may actually be maximising its profit. But firm 1 is making profits which are larger still. This is an important point: the non-profit-maximiser is here more likely to survive than the profit-maximiser. What is more, say that the probability of survival is an increasing function of the level of profits, as in the previous paragraph. Then maximising profits also maximises the probability of survival. So in fact the non-survival-maximiser firm 1 is more likely to survive than the survival-maximiser firm 2! Firm 2 has improved its survival chances by raising, indeed maximising, its profit; but by raising firm 1's profits even more, firm 2 now stands at a selective disadvantage.

I now move on to a demonstration of these points in a more general model.

The General Model

There are N players. In period t, all engage in G_t, a play of the game G. The format of G_t is "all versus all"; all the players engage each other simultaneously. N is constant for all t. Players are identical except possibly for their choice of strategy. Each player i has in each period t a strategy s_{it}, drawn from the set of pure strategies S, which it uses in G_t. I will consider only the case where $s_{it} = s_i$ for all t; the actual choices of strategy by individual players do not change as the game is played. Players are thus "born" with strategies and cannot change them in response to changing circumstances. I am therefore assuming (non-rational) behaviour by players which is directly analogous to animal behaviour in the usual EGT approach. At the end of G_t, each player i receives a payoff π_{it} which is a function of his strategy and the strategies of the other players in that period; I will usually drop the t subscript. I will sometimes also write π_i as $\pi(s_i \mid s_{-i})$, where s_{-i} denotes the strategies of the other players.

We could think of players as corresponding to firms, as in the duopoly example above. Another interpretation which is perhaps more appealing (given that the industry size is assumed constant) is as follows. Players in the game represent the managers of firms in an industry of size N. Each firm is in the industry permanently, and its owners regularly hire and fire a manager. The manager's strategy determines the behaviour of the firm. Once hired the manager doesn't change his strategy, and the firm changes strategy by replacing the manager.

Entry, Strategy Choice, and Survival

It is possible to divide "economic natural selection" into three parts. First, there is the decision of whether or not to enter the game. In biology, this is the problem of whether to reproduce, and if so, how many offspring to produce. In economics, this is the "entry" decision, for both firms and managers. In the model, N is assumed constant. This means the entry decision by players is assumed away: as soon as one player is selected out of the game ("dies", "goes bankrupt", "is fired"), a new player enters.

Second, there is the "strategy choice rule", the rule which determines the choice of strategy by a new player. In biology, the strategy choice rule is given by genetic inheritance and chance mutation. In economics, it is a much more difficult problem to address. For now we assume the following role for "mutation" in order to maintain the parallel between the model here and the standard evolutionary game theory model. Say we have a situation in which all N players share the same strategy. Now say one of the N players is selected out of the game and is replaced by a new player. This new player may with some positive probability choose any strategy in the strategy set S. I will return to the subject of the strategy choice rule later in the chapter, when discussing evolutionary stability.

Third, there is the "survival rule", the rule by which payoffs are associated with "survival". If players are interpreted as firms, the "survival rule" summarises the market forces which drive poor performers out of the industry. In the managerial interpretation of the model, the "survival rule" is the rule used by the owners of the firm to decide whether to fire the existing manager and hire a new one.

The survival rule in this model is applied to each player at the end of each period t; it determines p_{it}, the probability that player i survives to participate in G_{t+1}, the next play of the game. The main restriction on the survival rule is a form of monotonicity: $p_{it} > p_{jt}$ if and only if $\pi_{it} > \pi_{jt}$. This means, for example, firm i is more likely to survive market pressures than firm j, or the manager of firm i is more likely to keep his job than the manager of firm j, if and only if the profits of firm i exceed the profits of firm j. To ensure that some selection always takes place, we also assume that $0 < p_{it} < 1$, i.e. no player is ever guaranteed of survival or failure.[4]

The monotonicity assumption is compatible with a wide range of possibilities concerning survival. In particular, it is important to point out that monotonicity is compatible both with survival based on the absolute level of a player's payoff and with survival based on a player's performance compared to his competitors. For example, we could have $p_{it} = f(\pi_{it})$, $f' > 0$, so that survival of player i is based on the absolute level of his payoff. Or we could have $p_{it} = f(\pi_{it}/\Sigma\pi)$, $f' > 0$, so that survival is based on player i's share of the total of payoffs earned by all players.

This wide range of possible survival rules means we have a wide range of possible rationales for the model. Consider the managerial interpretation of the model. One possibility is in terms of principal-agent/imperfect information/moral hazard models. Unable to observe perfectly the actions of their manager, the owners choose an incentive scheme which determines whether or not the manager keeps his job. This incentive scheme may be based on the manager's absolute performance in generating profits for his firm; or it may reward the manager based on his performance relative to other managers (see e.g. Lazear and Rosen 1981 and Holmström 1982); etc. Another possibility is that the owners of a firm are boundedly rational (as opposed to the managers, who are non-rational); unable to choose or control a manager perfectly, they use a rule of thumb in hiring and firing their manager. This rule of thumb may be based on the absolute level of the firm's profits; or it may be based on the firm's share of industry profits; etc. A similar range of rationales is possible if players are interpreted as firms.

Because players never change strategies, we can also think of the survival rule as operating on strategies. In other words, it is the fittest strategies which will best survive the process of economic natural selection. This is analogous to the EGT analysis in evolutionary biology, where genes determine strategies and the fittest genes survive.

Also analogous to the evolutionary biology analysis is the fact that because the model assumes that players do not change their strategies, the "rationality" of any results of the model will come from the survival and strategy choice rules rather than directly from the "rationality" of the players. The model is therefore, as already noted, Darwinian in spirit.

Definition of Evolutionary Equilibrium

The definition of the evolutionary biology finite-population ESS comes in two parts: an equilibrium condition, based on payoffs received when N-1 players have the ESS strategy and one mutant player has some other strategy; and a stability condition, based on payoffs when 2 or more mutants have some other strategy. (Note that in a sense the equilibrium condition therefore has a notion of stability built into it.) The model in this chapter has been constructed so that the definition of a "symmetric evolutionary equilibrium" (SEE) can proceed in the same fashion as the definition of the equilibrium condition for the finite-population ESS. Stability is discussed later in the paper.

We begin with a population in which N-1 players have the SEE strategy $s^{SEE} \in S$, and so each receives payoff π^{SEE}. There is also one deviant player whose strategy $s^{D} \in S$ is one other than s^{SEE}, and whose payoff is π^{D}. For convenience, say this deviant player is player number d. So

$$\pi^{SEE} \equiv \pi(s^{SEE} \mid s^D, s^{SEE}, s^{SEE}, \ldots)$$
$$\equiv \pi_i \equiv \pi(s_i \mid s_{-i}) \quad \text{for } i \neq d \tag{1}$$

$$\pi^D \equiv \pi(s^D \mid s^{SEE}, s^{SEE}, s^{SEE}, \ldots)$$
$$\equiv \pi_d \equiv \pi(s_d \mid s_{-d}) \tag{2}$$

<u>Definition</u>: A strong (weak) SEE is given by a strategy $s^{SEE} \in S$ which has the property that, if N-1 players have this strategy and one deviant player has some other strategy s^D, then for any deviant strategy $s^D \in S$,

$$\pi^{SEE} > (\geq) \quad \pi^D \tag{3}$$

where π^{SEE} and π^D are given in equations (1) and (2).

In other words, a strong (weak) SEE exists where, in a population of N-1 SEE players and one deviant player, the SEE players do strictly better than (at least as well as) the deviant player no matter what the deviant's strategy. The point is that, by monotonicity of the survival rule, the deviant thus has a lower probability of survival than his SEE strategist competitors. The intuition is identical to that behind the evolutionary biology ESS - see the Maynard Smith and Price quote at the beginning of the chapter.

It is of interest to compare the SEE to the Nash equilibrium concept. We are considering the symmetric case, so we can define a strong (weak) symmetric Nash equilibrium (SNE) as a strategy $s^{SNE} \in S$ which, for any alternative strategy $s^D \in S$, satisfies

$$\pi(s^{SNE} \mid s^{SNE}, s^{SNE}, \ldots)$$
$$> (\geq)\ \pi(s^{D} \mid s^{SNE}, s^{SNE}, \ldots) \tag{4}$$

The difference between the SNE and the SEE is that the NE concept compares the payoffs for a single player under different strategies (with the strategies of the other players unchanging), whereas the SEE concept compares the payoffs of different players (with the strategies of all the players unchanging). The symmetric evolutionary <u>equilibrium</u> <u>concept</u> is thus based on <u>relative</u> payoffs, a result which reflects the Darwinian nature of selection among players. This is true in spite of the fact that in the model, <u>survival</u> <u>itself</u> for a player may well be based on the <u>absolute</u> level of his payoff, a point illustrated in the duopoly example above. The Nash <u>equilibrium</u> <u>concept</u>, by contrast, is based on <u>absolute</u> payoffs. In non-Darwinian "evolutionary" economics models (e.g. satisficing models and learning models), Nash equilibria and "absolute profit-maximisation" <u>will</u> be candidates for "appropriate summaries" of the conditions for survival, or, perhaps, "appropriate benchmarks".[5]

It is useful to express the SEE as the Nash equilibrium of a different game. Say N-1 players are identical strong SEE strategists. Again the single deviant player is player number d with strategy s^D. The definition of a symmetric evolutionary equilibrium is equivalent to defining the SEE strategy as that s^D which solves

$$\max_{s^D \epsilon S} \{ \pi^D - \pi^{SEE} \} \tag{5}$$

Since the SEE is symmetric by definition, we can write the payoff to an SEE player given by equation (1) as the average of the payoffs of all the SEE players:

$$\pi^{SEE} \equiv \pi(s_i \mid s_{-i}) \text{ for } i \neq d \equiv \frac{1}{N-1} \sum_{i \neq d}^{N} \pi(s_i \mid s_{-i}) \tag{6}$$

Substituting (6) and (2) into equation (5), we have rewritten the definition of the symmetric evolutionary equilibrium strategy s^{SEE} as the symmetric solution to

$$\max_{s_d \epsilon S} \{ \pi(s_d \mid s_{-d}) - \frac{1}{N-1} \sum_{i \neq d}^{N} \pi(s_i \mid s_{-i}) \} \tag{7}$$

This is, in fact, the same definition as that for the symmetric non-cooperative Nash solution to Shubik's zero-sum "beat-the-average" game (Shubik and Levitan 1980); it is easy to see how the game gets its name. The "beat-the-average" (BTA) game is a zero-sum, relative maximisation game. Since the solution concepts for this evolutionary game and the "beat-the-average" game coincide, we have here a demonstration that absolute-profit maximisation does not "summarise appropriately the conditions for survival", and that relative-profit maximisation (in this model at least) is a more appropriate summary.

More generally, there is a one-to-one correspondence between the SEE and the symmetric NE in the beat-the-average game. That any SNE in the BTA game is also an SEE can be demonstrated by assuming otherwise and showing this leads to a contradiction. Assume that there is an SNE in the BTA game which is not an SEE. Because it isn't an SEE, there exists a strategy s^D which, if all but one player adopts s^{BTA} and one adopts s^D, means that $\pi^D > \pi^{BTA}$. But then the player with strategy s^D must be beating the average. So s^{BTA} must not be a symmetric Nash solution to the BTA game, and we have a contradiction. Similarly, any SEE is also an SNE in the BTA game. Assume that there is an SEE which is not an SNE in the BTA game. Then there exists a strategy s^D such that, if player d adopts s^D and all the other players adopt s^{SEE}, then player d is beating the average,

$$\pi_d > \frac{1}{N-1} \sum_{i \neq d} \pi_i \qquad \text{i.e.} \quad \pi^D > \pi^{SEE}$$

But then s^{SEE} does not fit the definition of a symmetric evolutionary equilibrium strategy, and again we have a contradiction.

Now, what happens to the SEE in the case when players lack strategic power and are unable to influence directly each others' payoffs? In other words, what is the SEE in case of perfect competition, when players have no market power? Returning to equation (7), say that player d cannot through his own actions change the payoffs of others; he lacks strategic power. Then the maximisation problem becomes simply

$$\max_{s_d \in S} \pi_d(s_d \mid s_{-d})$$

i.e. maximise the absolute payoff. In the absence of strategic power, and only in this case, the problems of maximising relative and absolute payoffs will always coincide. That is, only under conditions of perfect competition is absolute-profit maximisation always an "appropriate summary" of the conditions for survival.

Two points regarding this result should be noted. First, it applies only to choice variables which give players strategic power vis-à-vis each other. Whenever an agent's decision regarding a variable has no effect on his competitors' payoffs, relative- and absolute-maximisation coincide with respect to that variable. For example, a firm's choice of production technology may have no direct effects on its competitors, and so here absolute- and relative-profit maximisation (cost minimisation) coincide with respect to the choice of technology - even if the firm has market power via its choice of output. Similarly, local managers of a large firm with regional branches may be unable to influence each other's payoffs, and when comparing the survival probabilities of the regional managers, absolute-profit maximisation will be an "appropriate summary" - even if a regional manager has market power vis-à-vis other firms within his region.

Second, the presence of strategic power is a necessary, but not a sufficient, condition for relative- and absolute-maximising behaviour to differ. Relative- and absolute-maximisation may coincide for some arrangements of payoffs, even when players have strategic power. For example, when the game is zero-sum to start with, the relative-maximisation SEE/BTA and the absolute-maximisation SNE coincide.[6]

It is worth noting that the SEE solution coincides not only with the symmetric solution to the "beat-the-average" game but also with the symmetric solution to the "maximise-profit-share" game (see Shubik and Levitan 1980). We can therefore also interpret the results of this section as providing an "evolutionary" argument for studying these two relative-maximisation games.

Stability and Dynamics

In this section we consider the question of "evolutionary stability" - the behaviour of the model out of "evolutionary equilibrium", with a mixture of SEE and non-SEE players.

The definition of the degree of stability used here is a natural extension of the definition of equilibrium, and is again borrowed from the analysis of the evolutionary biology finite-population ESS. We say that an SEE is Y-stable under a given strategy choice rule if, for a population with a total of anywhere from 2 to Y deviants with any deviant strategies, the payoff of an SEE player is strictly greater than the payoffs of all the deviants.

An SEE is globally stable if this holds for any number of deviants up to N-1 (since we need at least one SEE player for the definition to make sense). Note that equilibrium is defined so that a single deviant will be at a selective disadvantage relative to his SEE competitors; stability is defined so that 2 or more deviants will be at a selective disadvantage.

A natural question to ask is the following: will an SEE strategy be the most frequently observed strategy in the long run? The answer is "not necessarily", for four reasons. These reasons are particularly instructive because they apply both to the case of perfect competition (when the Friedman conjecture is valid) as well as to the case when players have market power.

1. The SEE may not be globally stable, or may not exist at all.

For example, payoffs may be such that "it pays to be different". Say that if most firms in an industry sell product A and a minority sells the close substitute B, B has "novelty value" and sells better; if most firms sell B and a minority sells A, A has "novelty value"; and that product-specific fixed costs mean a firm cannot sell both A and B. An SEE does not exist for this example, because the deviants always do better. An "evolutionary equilibrium" in such an industry would have a mixture of firms, some selling A, some B. The biological equivalent of this is a "genetic polymorphism" (Maynard Smith 1982).[7]

2. The stability of an SEE depends crucially on the strategy choice rule which determines the strategy a new player will use.

This is why the strategy choice rule appears in the definition of stability above. Consider the following illustration. We first specify two possible strategy choice rules: (i) <u>imitation</u>, as suggested by Alchian in his 1950 paper. Specifically, we begin in a population using at most two different strategies; if only one strategy is being used by all players, a new player can choose either that strategy or some other strategy at random from the strategy set S; and if two strategies are in use, a new player chooses one of the two. This specification conforms to the "mutation" assumption made earlier. The main feature of this strategy choice rule is that no more than two strategies will ever be in use in a population at any one time. (ii) <u>random choice</u>; new players choose their strategies at random from S, and their choice is not constrained. Under this strategy choice rule, any number of any of the strategies in S may be in use in a population at any moment.

The duopoly example at the beginning of the chapter is easily extended to the N-firm case. The SEE strategy is for each firm to sell Q^*/N, which, as in the duopoly case, coincides with the symmetric zero-profit competitive solution. The proof that this is the SEE also proves that the SEE is globally stable under the imitation strategy choice rule. There are two cases. First, say that some firms are selling the SEE quantity Q^*/N, and the rest are selling some other deviant quantity $q^D < Q^*/N$. Price is now above marginal cost, and all firms are making profits. But the SEE firms are selling the larger quantity and thus are making the larger profits, and are therefore at a selective advantage relative to the deviant players. Similarly, say that some firms are selling the SEE quantity and the rest are selling $q^D > Q^*/N$. Price has been driven below marginal cost and all the firms are making losses; but the largest losses are being made by the deviants.

However, the SEE is not stable at all under the random strategy choice rule. Consider a population with N-2 SEE players, and two deviant players which sell quantities $q^{D1} > Q^*/N$ and $q^{D2} < Q^*/N$ such that $q^{D1} + q^{D2} \neq 2Q^*/N$. All the firms are now earning either positive or negative profits. But if positive profits are being earned, the largest belong to the deviant firm selling q^{D1}; and if the firms are making losses, the smallest losses are being made by the firm selling q^{D2}. The SEE players do not maintain their selective advantage when faced with such a "simultaneous invasion".[8]

The conclusions of evolutionary modelling can be very sensitive to behavioural assumptions; here, with respect to strategy choice. The model of this chapter with random choice of strategy by new players is very much in the spirit of Friedman's argument. The quote from Friedman's methodological essay which begins this chapter is preceded by the statement, "Let the apparent immediate determinant of business behavior be anything at all - habitual reaction, random chance or what not." The random choice of strategy corresponds to "random chance", and the feature of the model that new players do not change their strategies corresponds to "habitual reaction". However, the preceding example demonstrates that the conclusions of the model can change drastically if choice of strategy is determined not by "random chance" but by "imitation" (or some other "what not").

3. Bias in the strategy choice rule.

The point here is straightforward. If new players predominately choose some non-SEE strategy and avoid choosing the SEE strategy, then naturally the former will be frequently observed and the latter will not.

4. The "absolute-payoff effect".

Say that the survival rule is a function of <u>absolute</u> profits, such that the probability of survival $p_{it} = f(\pi_{it})$, $f' > 0$. Say also that an SEE is globally stable under some strategy choice rule. An SEE player always has a selective advantage over a non-SEE competitor. But the payoff to an SEE player in a population of all or mostly SEE players may be very low on an absolute scale, and the payoff to a non-SEE player in a population of all or mostly non-SEE players may be very high on an absolute scale (though if he has any SEE competitors, they will have even higher payoffs). With the above survival rule, populations with many SEE players will not persist long, and populations with few SEE players will persist longer. To take an extreme case, it may be possible that the largest possible payoffs are earned when <u>no</u> SEE players are present; such a state could persist a long time. (This "absolute payoff effect" will not arise if the survival rule is a function of relative profits such as, say, $p_{it} = f(\pi_{it}/\Sigma\pi)$, $f' > 0$.)

Figure 4.4

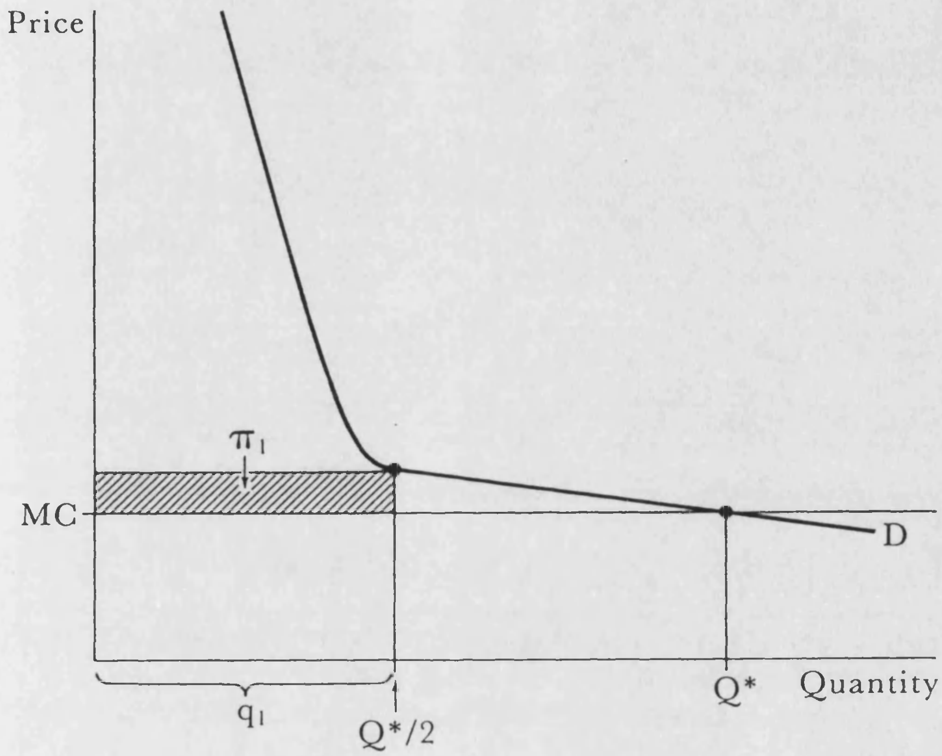
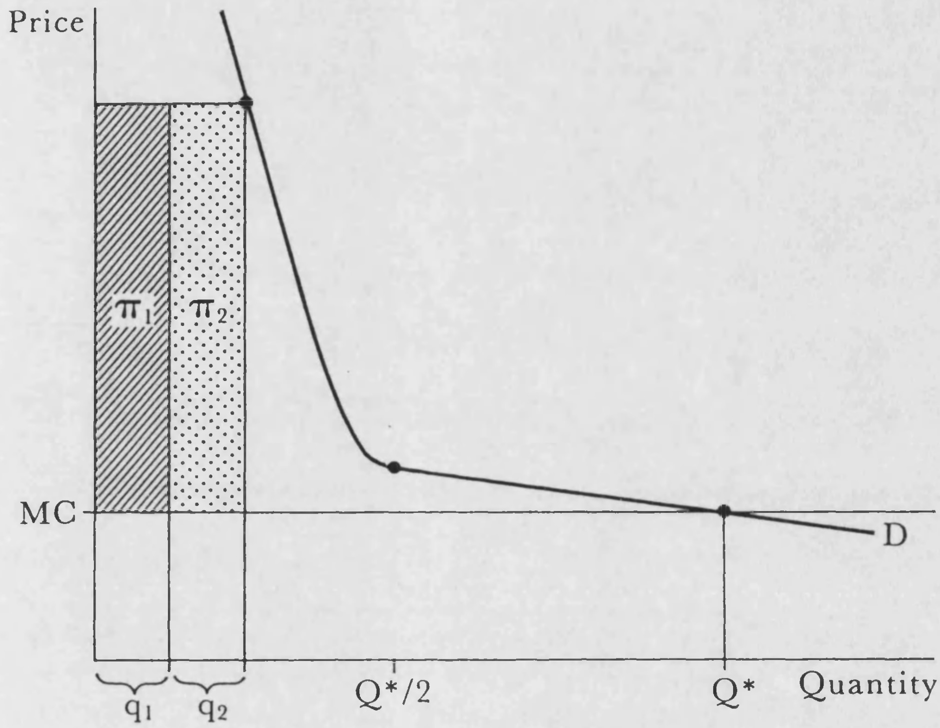


Figure 4.5



Consider again the duopoly example. The shaded area in figure 4.4 depicts the profit an SEE firm earns when his competitor sells nothing. This is the largest possible profit an SEE firm can earn. The two shaded areas in figure 4.5 are the profits earned by two non-SEE firms which are selling very small quantities; say that they have formed a cartel and are splitting the monopoly profits. At these low quantities, demand is very inelastic and the profits earned by a cartel member are larger than the largest profit an SEE firm could earn. If the survival rule is based on absolute profits, the cartel could persist a long time.

Indeed, let us relax the restriction on the probability of survival and say that a firm is certain to survive selection at the end of the period if and only if its profits equal or exceed one-half the monopoly profits (i.e. the symmetric cartel profits).[9] Then an SEE firm will still always be at a selective advantage compared to a non-SEE competitor; but the cartel in figure 4.5 would last forever. Note that a member of the cartel could raise his profits even more by expanding output. But if he did, he would drive the profits of the other firm down so that the other firm would <u>not</u> survive indefinitely; and when the other firm is replaced, it could well be with a firm which sells an even larger quantity, driving down the profits of the first firm so that now it too could not survive indefinitely.

The moral of this story is that a model of economic natural selection can have a Darwinian condition that the "fittest survive" and yet feature the survival, the evolutionary success, of firms which maximise neither absolute profits nor relative profits.[10]

Simple Markov Dynamics

We now turn to a dynamic analysis of the model.[11] The focus will be on the frequency of occurrence over time of various industry "states". The mathematical tool used is that of finite Markov chains, and so from now on I will assume that the strategy set S is finite. There are M possible strategies.

A population state is identified by the numbers of players following each strategy. The number of possible population states[12] L is

$$L \equiv \binom{M+N-1}{N} = \frac{(M+N-1)!}{N!(M-1)!}$$

We start the population in some state. In the first period the players play the game G_1. At the end of the first period we apply the survival rule. After choosing in this way the players to remove, we apply the strategy choice rule for each new replacement player and assign each a strategy. The "natural selection process" is now complete: the population is in a new state and ready to play the game G_2 in the second period. The process is repeated for periods 2, 3, ..., etc.

This process can be analysed as a Markov chain. The states of the chain are the states of the population. Denote the set of all possible states as I. A transition probability q_{ij} is the probability that, being in state $i \in I$, in the next period the population moves to state $j \in I$. To make things easier, I assume that the strategy choice rule is independent of past events; it depends only on player payoffs and player strategies this period. We therefore have a Markov chain with stationary transition probabilities; given a state, and knowing the survival and strategy choice rules, we can calculate the probabilities of transition to other states, and these transition probabilities are independent of time.

It is convenient to write the transition probabilities in matrix form. Call q this matrix; the entry in row i column j is q_{ij}, the probability of transition from state i to state j.

If the above evolutionary process proceeds indefinitely, we can ask what proportion of the time will the population be in which state, i.e. what is its long-run or "stationary" distribution. Denote the stationary distribution by w, a row vector of L components. Each component w_i corresponds to a state i, and gives us the proportion of time spent by the population in state i.

($\Sigma w = 1$, since the population is always in one of the L possible states.)

So far the set-up is rather general. Points (2) and (4) in the previous section can however be illustrated with a much simplified version. I narrow consideration to:

1. A population of only two players, i.e. $N = 2$.

2. A strategy set S with only two strategies, i.e. $M = 2$. One of these two is a strong and globally stable SEE, s^{SEE}. The other strategy will be used to demonstrate the "absolute payoff" effect, and so I will call it s^{AP}.

3. The two survival rules mentioned earlier in the chapter. According to the first, player i's probability of survival at the end of period t is a function of his level of payoff that period:

$$p_{it} = f(\pi_{i,t}) \qquad 0 < f(\cdot) < 1,\ f' > 0$$

According to the second, player i's probability of survival at the end of period t is a function of his share of the sum of the payoffs of all players that period:

$$p_{it} = g(\pi_{i,t}/\Sigma\pi) \qquad 0 < g(\cdot) < 1,\ g' > 0$$

4. The two strategy choice rules introduced earlier in the chapter, "random choice" and "imitation" . "Random choice" here means that a new player will

choose either of the two possible strategies with a probability of 1/2. "Imitation" here will have the following specific definition. Say that in the previous period both players had the same strategy s^{AP}. Then a new player entering the game will adopt as his strategy s^{AP} with probability $1-\epsilon$, ϵ small, and with probability ϵ he will adopt s^{SEE} as his strategy. Similarly, if in the previous period both players had s^{SEE}, a new player will choose s^{SEE} with probability $1-\epsilon$ and s^{AP} with probability ϵ. If in the previous period one player had s^{SEE} and one had s^{AP}, a new player will choose each with a probability of 1/2. Note both strategy choice rules conform to the "mutation" assumption made earlier in the chapter. In fact, this form of the "imitation" strategy choice rule corresponds fairly closely to the analogue used in biological evolutionary models, where like beget like except for a small probability of mutation.

We now calculate transition probabilities and examine the stationary distribution of states. We have two strategies and two players, so there are three possible states for the population:

state 1: (SEE, SEE)

state 2: (SEE, AP)

state 3: (AP, AP)

Corresponding to each state is w_i, the frequency of occurrence of that state in the stationary distribution.

The transition matrix q is 3x3; the entry in e.g. row 2, column 3, q_{23}, is the probability of moving from state 2 (one SEE player, one AP player) at the end of one period to state 3 (both AP players) at the beginning of the next period.

The payoff matrix for the game is the following:

Figure 4.6: Payoffs in the 2-player game

		Player II s^{SEE}	Player II s^{AP}
Player I	s^{SEE}	(a,a)	(b,c)
Player I	s^{AP}	(c,b)	(d,d)

Notation: (player I's payoff, player II's payoff)

We require s^{SEE} to be a strong and globally stable SEE strategy; here this means $b > c$. To bring out certain features of the model I will make two further restrictions on the payoffs. First, state 1, where both play the SEE strategy, is not a strong Nash equilibrium. This means requiring $c > a$. Second, state 3, where both play the AP strategy, *is* a strong Nash equilibrium. This means $d > b$. (Together these also mean that state 3 is the only Nash equilibrium.) Put all these restrictions together and we have

$$d > b > c > a \qquad (8)$$

Since the largest payoff occurs when both play the AP strategy, we are assured of an "absolute payoff effect".

Case 1: Random strategy choice and absolute payoff survival rule

The transition matrix for this case is the following: (As a shorthand I will write $f_a \equiv f(a)$.)

$$q = \begin{bmatrix} \tfrac{1}{4}(1+f_a)^2 & \tfrac{1}{2}(1-f_a{}^2) & \tfrac{1}{4}(1-f_a)^2 \\ \tfrac{1}{4}(1+f_b)(1-f_c) & \tfrac{1}{2}(1+f_b f_c) & \tfrac{1}{4}(1-f_b)(1+f_c) \\ \tfrac{1}{4}(1-f_d)^2 & \tfrac{1}{2}(1-f_d{}^2) & \tfrac{1}{4}(1+f_d)^2 \end{bmatrix}$$

By (8) and the strict monotonicity of f, we have

$$f_d > f_b > f_c > f_a \qquad (9)$$

Using this we can say the following about the elements of the transition matrix:

$$q_{21} > q_{23} \qquad (10)$$

$$q_{33} > q_{11} \qquad (11)$$

$$q_{13} > q_{31} \qquad (12)$$

$$q_{12} > q_{32} \qquad (13)$$

Equation (10) demonstrates the "Darwinian" character of the definition of an SEE, whereby the SEE strategy gives a player a selective advantage over a non-SEE strategist. In state 2, with one SEE player and one AP player, the SEE player has a larger payoff; and so we are more likely to jump next period into state 1 (both SEE players) than into state 3 (both AP players).

Equations (11)-(13) demonstrate the "absolute payoff effect". The payoffs of the AP players in state 3 exceed the payoffs of the SEE players in state 1. This is reflected in equation (11) - the probability of staying in state 3 is greater than the probability of staying in state 1. Similarly, from equations (12)-(13) we see that the probabilities of moving into other states out of state 1 are greater than they are for moving out of state 3.

These effects are also apparent if we look at the stationary distribution of the population. It turns out that the expressions for w_i are cumbersome, and it is easier to work with the ratio w_1/w_3. If this ratio is greater than 1, the SEE strategy will be the more frequently observed strategy in the long run. It can be shown that for any three-state Markov chain with stationary transition probabilities,

$$\frac{w_1}{w_3} = \frac{q_{31}(q_{21}+q_{23}) + q_{32}q_{21}}{q_{13}(q_{21}+q_{23}) + q_{12}q_{23}} \qquad (14)$$

The "direct" absolute payoff effect is $q_{13} > q_{31}$; the population is more likely to go directly from state 1 to state 3 in successive periods than it is to go in the opposite direction. The result is to lower w_1/w_3. The "indirect" absolute payoff effect is $q_{12} > q_{32}$; the population is more likely to go to state 2 directly from state 1 than it is directly from state 3. The Darwinian selective advantage effect is $q_{21} > q_{23}$; the population is more likely to go directly from state 2 to state 1 than it is to go to state 3. We can interpret $q_{32}q_{21}$ as the probability of going from state 3 to state 1 via state 2, and $q_{12}q_{23}$ as the probability of going from state 1 to state 3 via state 2. Inequalities (10) and (13) above, the indirect absolute payoff effect and the Darwinian effect, mean that $q_{32}q_{21} \gtrless q_{12}q_{23}$.

In fact, in this 2-player game with random strategy choice and the absolute-payoff survival rule, the absolute payoff effect dominates the Darwinian effect. That is, the AP strategy will be more frequently observed than the SEE strategy in the long run; $w_1/w_3 < 1$.

<u>Theorem:</u> In the 2-player version with random strategy choice and the absolute-payoff survival rule, $w_1/w_3 < 1$.

<u>Proof:</u> As a shorthand in the proof we will treat values of the function f evaluated at the parameters a,b,c,d as parameters themselves, to avoid having to write f' when differentiating. Substituting the transition probabilities from the matrix q into (14), and engaging in some algebraic manipulation, we eventually get

$$\frac{w_1}{w_3} = \frac{2(1-f_bf_c)(1-f_d) + (1-f_d{}^2)(f_b-f_c)}{2(1-f_bf_c)(1-f_a) + (1-f_a{}^2)(f_c-f_b)} \tag{15}$$

I now proceed to show that the expression in (15) is less than 1. The first step is to show that (15) is increasing in f_b and decreasing in f_c. The quotient rule of differentiation plus some algebra eventually tell us that $d(w_1/w_3)/df_b$ has sign

$\{\ 2(1-f_bf_c)(1-f_a)(1-f_d^2) - 2f_c(1-f_a^2)(f_c-f_b)(1-f_d)$
$+ 2(1-f_bf_c)(1-f_d)(1-f_a^2) + 2f_c(1-f_d^2)(f_b-f_c)(1-f_a)\ \}$. By (9) this is greater than zero. One can show similarly that $d(w_1/w_3)/df_c$ has sign
$\{\ (1-f_d^2(1-f_a)(f_b^2-1) + (1-f_a^2)(1-f_d)(f_b^2-1)\ \}$. By (9) this is less than zero.

Equation (9) requires $f_b < f_d$ and $f_c > f_a$. But since (15) is increasing in f_b and decreasing in f_c, if we can show that (15) is always less than 1 for $f_b = f_d$ and $f_c = f_a$, we have shown that (15) is always less than 1 for $f_b < f_d$ and $f_c > f_a$. The second step is thus to substitute $f_b = f_d$ and $f_c = f_a$ into (15) and show the resulting expression is still always less than 1. Performing this substitution, then multiplying out and simplifying gives us

$$\frac{2 - 2f_af_d - f_a - f_d + 3f_af_d^2 - f_d^3}{2 - 2f_af_d - f_a - f_d + 3f_a^2f_d - f_a^3} \qquad (16)$$

This expression can be shown to be less than 1 in a fashion similar to that used above. The quotient rule of differentiation plus rather a lot of tedious algebra tells us the derivative of (16) with respect to f_a has sign
$2(f_d - f_a)^2\{3(1 - f_d) - 3f_af_d(1 - f_d) + (f_d - f_a)$
$- f_d(f_d - f_a)\}$ which is greater than zero for $f_d > f_a$ and equal to zero for $f_d = f_a$. Thus the expression in (16) is increasing in f_a, and approaches a limiting value as $f_a \to f_d$ from below. But setting $f_a = f_d$ in (16) gives us 1 as the limiting value, so for $f_a < f_d$ the expression in (16)

is strictly less than 1. This completes the proof.

This theorem suggests at the very least that some doubts are in order concerning the static evolutionary analysis in the first part of this chapter. Since the SEE strategy in this simple but straightforward example is not the most frequently observed strategy in the long run, we can legitimately question even the use of the term "symmetric evolutionary equilibrium strategy". These doubts are less strong, however, in the remaining cases analysed here.

Case 2: Imitative replacement and absolute payoff survival rule

The transition matrix for this case is rather ugly and is not reproduced here. It simplifies considerably, however, if we ignore second-order effects and assume that $\epsilon^2 \approx 0$. This means that now $q_{31} \approx q_{13} \approx 0$ (intuitively, the chances are minute that a "double mutation" will occur and take us from "both play SEE" to "both play AP" or visa versa). Also, it can be shown that

$q_{32} \approx 2\epsilon(1-f_d)$

and

$q_{12} \approx 2\epsilon(1-f_a)$

Lastly, in state 2 the strategy choice probabilities are 1/2, 1/2 and so the transition probabilities for the second row of the matrix are the same as in case 1 above.

We can plug all this into equation (14) to get

$$\frac{w_1}{w_3} \approx \frac{(1+f_b)(1-f_c)(1-f_d)}{(1-f_b)(1+f_c)(1-f_a)}$$

This ratio may be greater or less than 1. Thus if f_d is close to 1, the ratio is close to 0 and SEE players will rarely be observed. Intuitively, state 3 is "nearly" an absorbing state (meaning once the system bounces into state 3, it will be a long time before it bounces out to a different state) because the payoffs of the AP players are large when they face each other. On the other hand, if f_b is close to f_d, and f_c is close to f_a, terms in the numerator and denominator will approximately cancel to leave $(1+f_b)/(1+f_c)$ which is > 1. Intuitively, the advantage of an SEE player when facing an AP is large; this choice of parameters means f_b-f_c is close to the maximum difference permitted by equation (9).

<u>Case 3: Random strategy choice and relative payoff survival rule</u>

The transition matrix is exactly the same as for case 1, except with g's in place of the f's. But now

$$g_a = g(a/(a+a)) = g(1/2)$$
$$g_b = g(b/(b+c))$$
$$g_c = g(c/(b+c))$$
$$g_d = g(d/(d+d)) = g(1/2)$$

As g is strictly monotonically increasing, we have

$$g_b > g_a=g_d > g_c \qquad (17)$$

Since $g_a=g_d$, we have $q_{11}=q_{33}$, $q_{12}=q_{32}$, and $q_{13}=q_{31}$. Since $g_b>g_c$, $q_{21}>q_{23}$. Plugging all this into equation (14), we find that $w_1/w_3 > 1$, i.e. the SEE is the more frequently observed strategy. This is as expected; because payoffs are equal to 1/2 in state 1 (all SEE) and state 3 (all AP), the absolute payoff effect no longer operates to promote state 3.

Conclusion

The basic result of this chapter follows from an application of Hamilton's evolutionary biology theory of "spite" to the Friedman conjecture that profit-maximisation is an "appropriate summary" of the conditions for survival. In a Darwinian "survival of the fittest" regime, the Friedman conjecture is correct only in perfect competition. When firms have market power, the possibility of "spiteful" behaviour exists: a firm may forgo profit-maximisation and lower its profits and even its survival chances, but if the profits of its competitors are lowered still further, the "spiteful" firm will be the more likely survivor. This was formalised in a model using another theory borrowed from evolutionary biology, evolutionary game theory; other formalisations are also possible. The model also demonstrates the sensitivity of an economic natural selection model to very basic assumptions about the behaviour of agents and the character of the selection mechanism.

Notes to Chapter 4

1. An earlier version of this chapter appeared in the Journal of Economic Behavior and Organization (Vol. 12, No. 1, August 1989). I would like to thank the editors and two anonymous referees of JEBO, Stanislaw Gomulka, Herbert Levine, David de Meza, Ariel Rubenstein, Max Steuer, John Sutton, and a number of seminar audiences for helpful suggestions and discussions. All remaining errors and omissions are mine.

2. Hansen and Samuelson (1988), in a paper which came to hand after this chapter was written, have also demonstrated this point.

3. That the definition of the standard infinite population ESS is inappropriate for finite populations was first shown by Riley (1979). The approach to evolutionary stability in finite populations drawn on here is not that suggested by Riley but rather that proposed in the appendix to this chapter (and independently proposed by Knowlton and Parker 1979 and Maynard Smith 1988).

4. This condition is rather stronger than is actually necessary, since monotonicity ensures that in a population with heterogeneous payoffs not everybody will be guaranteed of survival. It is stated this way mostly for clarity's sake.

5. Examples of non-Darwinian satisficing models and learning models are Nelson and Winter (1982) and Canning (1988), respectively. By contrast, Friedman and Rosenthal (1986) and Samuelson (1987) present game theoretic models which are essentially Darwinian in spirit. In these models selection takes place among strategies, and the change in the number of players using a particular strategy depends on the payoff to players using that strategy compared with the payoff to players using a different strategy. Selection in these models is therefore similar to selection in the model in this paper; as noted above, we can think of the selection rule in our model as operating on strategies, with the fittest strategies surviving.

6. The proof is by contradiction. (1) Say we have a zero-sum game in which an SEE/BTA solution is not an absolute-maximisation SNE solution. Since it isn't an SNE, a player could increase his payoff by deviating. Since it's a zero-sum game, the sum of the payoffs of the other players must then decrease. But then the deviant is now beating the average. Thus the original situation must not have been an SEE/BTA solution, and we have a contradiction. (2) Say we have a zero-sum game in which an absolute-maximisation SNE is not an SEE/BTA. Then a player could beat the average by choosing a deviant strategy. Since the game is zero-sum, to beat the average the deviant must have increased his payoff as well as lowered the sum of the payoffs of his competitors. But

since he increased his payoff, the original situation must not have been an absolute-maximisation SNE, and we have a contradiction.

7. Defining the stability conditions for a genetic polymorphism in a finite population is problematic, however; see the appendix.

8. This "simultaneous invasion" is similar to a simultaneous invasion in the standard EGT analysis (Maynard Smith 1982), except that in the latter a successful simultaneous invasion requires <u>both</u> deviants to have a higher fitness than the ESS players.

9. It is not necessary in this example to relax the monotonicity assumption as well. This is because, by assumption, the monopoly profits are the largest industry profits which can be earned. If firm 1 is earning more than one-half the monopoly profits, firm 2 must be earning less than one-half the monopoly profits; thus $p_{1t} = 1$ and $p_{2t} < 1$. Only in the symmetric cartel will both firms be assured of survival.

10. A similar point is made in the context of a different model by Nelson and Winter (1982).

11. The analysis which follows is distantly related to that in Winter (1971). Probably the most important difference is the focus here on the case where players have strategic power; Winter looks only at the competitive case, where firms are price-takers.

12. This is the problem of how many ways there are to place N identical balls in M urns.

Appendix 4.1: Evolutionarily Stable Strategies for a Finite Population and a Variable Contest Size[1]

Introduction

In two papers in the Journal of Theoretical Biology, Riley (1979) and Vickery (1987) re-examine in the context of finite populations the concept of an evolutionarily stable strategy (ESS) proposed by Maynard Smith (Maynard Smith and Price 1973; Maynard Smith 1974; Maynard Smith 1982). Both authors argue that "when interaction is between pairs of agents drawn at random from a finite population, a strategy which satisfies Maynard Smith's conditions may not be protected against invasion by a mutant strategy" (Riley 1979, p. 110).

In this appendix I show that this conclusion results from the fact that the standard mathematical definition of an ESS given by Maynard Smith and Price (Maynard Smith and Price 1973, p. 17; Maynard Smith 1982, p. 14) is inappropriate for finite populations. I suggest instead a more general approach which is faithful to the original idea as proposed by Maynard Smith and Price.[2] The concept of an ESS is generalised to cover the cases of a finite population and in addition a variable contest size. It is shown that the Maynard Smith and Price definition of an ESS is a special case of this generalised ESS with an infinite population and a contest size of two (pairwise contests). An important implication of the generalised

ESS is that in finite populations we expect to observe "spiteful" behaviour (in the sense of Hamilton 1970, 1971). The appendix then proposes a notion of the degree of stability. The last part of the appendix consists of an extended example: a symmetric two-pure-strategies two-player game for a finite population (the "Hawk-Dove" model is such a game). It is shown that a mixed strategy ESS is globally stable against invasion by any one type of mutant strategist, and that two different mutants can begin to invade if their strategies satisfy a certain condition.

The Standard ESS for Pairwise Contests and an Infinite Population

The definition of a standard ESS for pairwise contests in an infinite population is as follows. (See Maynard Smith and Price 1973, p. 17, and Maynard Smith 1982, p. 14; the presentation below draws heavily on Selten 1983, pp. 274-7.) In a contest of any size, a strategy which maximises a player's payoff, taking as given the strategies of his opponents, is a "best reply" to his opponents' strategies. An "alternative best reply" for a player is some different strategy which is also a "best reply". A Nash equilibrium occurs in a contest if each player has adopted a "best reply".

Consider a large population of players, most of whom play the ESS strategy s^{ESS} and a small number of whom are mutants who play the mutant strategy s^M. The players engage in random pairwise contests. The expected fitness or payoff of an ESS player is denoted π^{ESS}, and that of a mutant player is π^M. The strategy s^{ESS} is an evolutionarily stable strategy if (a) it is a Nash equilibrium in a two-player contest, i.e. s^{ESS} is a best reply to itself; and (b) if s^M is an alternative best reply to s^{ESS}, then the payoff to an ESS player who faces a s^M player in a contest (denoted $\pi(s^{ESS} \mid s^M)$) is greater than the payoff to a s^M player who faces another s^M player in a contest (denoted $\pi(s^M \mid s^M)$). That is, s^{ESS} is an evolutionarily stable strategy if it satisfies the following two conditions.

(a) Equilibrium condition: s^{ESS} is a Nash strategy for the two-player game, i.e.

$$\pi(s^M \mid s^{ESS}) \leq \pi(s^{ESS} \mid s^{ESS}) \tag{1}$$

for any alternative strategy s^M.

(b) Stability condition: if s^M is an alternative best reply to s^{ESS}, i.e. we have

$$\pi(s^M \mid s^{ESS}) = \pi(s^{ESS} \mid s^{ESS}) \tag{2}$$

then

$$\pi(s^M \mid s^M) < \pi(s^{ESS} \mid s^M) \tag{3}$$

for any alternative best reply s^M.

The rationale for this definition is as follows. Consider a large population of ESS players. A mutation occurs, producing a small number of players with mutant strategy s^M. The proportion of the population with this mutant strategy is ϵ. Then

$$\pi^{ESS} = (1-\epsilon)\pi(s^{ESS} \mid s^{ESS}) + \epsilon\pi(s^{ESS} \mid s^{M}) \qquad (4)$$

and

$$\pi^{M} = (1-\epsilon)\pi(s^{M} \mid s^{ESS}) + \epsilon\pi(s^{M} \mid s^{M}) \qquad (5)$$

The mutation will be selected against if

$$\pi^{M} < \pi^{ESS}$$

i.e. if

$$(1-\epsilon)\pi(s^{M} \mid s^{ESS}) + \epsilon\pi(s^{M} \mid s^{M}) < (1-\epsilon)\pi(s^{ESS} \mid s^{ESS}) + \epsilon\pi(s^{ESS} \mid s^{M}) \qquad (6)$$

The equilibrium condition (a) above follows from requiring (6) to be satisfied for a sufficiently small ϵ. The stability condition (b) comes directly from (6) for an s^M which is an alternative best reply.

However, this definition and justification for the ESS holds true only for infinite populations. If the population is not infinite, the ϵ in equation (4) is not the same as the ϵ in equation (5). The probability that a s^M player faces another s^M player is smaller than the probability that an ESS player faces a s^M player, because the s^M player cannot play himself in a contest.

The Generalised ESS - (a) Equilibrium Condition

I first consider a generalised equilibrium condition for an evolutionary game. The population is of size N, and the players engage in contests of size C. The standard Maynard Smith ESS will be a special case of the generalised ESS with $N = \infty$ and $C = 2$. Notation is as follows: $\pi(s^X \mid s^Y, s^Z, s^Z, \ldots)$ has as its C arguments the strategies of all the players in a contest and denotes the payoff of the player with the first-named strategy (here strategy X). Ellipses indicate that all the remaining players in the contest have the last-named strategy (here strategy Z).

We begin with a population composed entirely of ESS players. Say that one ESS player is removed and replaced with a mutant s^M player. The probability that an ESS player will have the mutant as one of his opponents in a given contest is (C-1)/(N-1). So equation (4) becomes

$$\pi^{ESS} = \left(1 - \frac{C-1}{N-1}\right)\pi(s^{ESS} \mid s^{ESS}, s^{ESS}, s^{ESS}, \ldots) + \frac{C-1}{N-1}\pi(s^{ESS} \mid s^M, s^{ESS}, s^{ESS}, \ldots) \qquad (4')$$

Equation (5) is now simply

$$\pi^M = \pi(s^M \mid s^{ESS}, s^{ESS}, \ldots) \qquad (5')$$

because the single mutant will be playing only against ESS players.

The equilibrium condition (a) above now becomes

(a') Equilibrium condition:

$\pi^M \leq \pi^{ESS}$

for any alternative strategy s^M, where π^{ESS} and π^M are given by equations (4') and (5')

In other words, in a population of N-1 ESS players and 1 mutant player, we do not expect the mutant to do better than a typical ESS player. Equilibrium condition (a') is thus faithful to the description of an ESS given by Maynard Smith and Price in their original 1973 article: "Roughly, an ESS is a strategy such that, if most of the members of a population adopt it, there is no 'mutant' strategy that would give higher reproductive fitness." (Maynard Smith and Price 1973, p. 15)

Condition (a') is equivalent to saying that $\pi^M - \pi^{ESS}$ as a function of s^M reaches its maximum value of zero when $s^M = s^{ESS}$. That is, s^{ESS} is a solution to

$$\max_{s^M} \quad \pi^M - \pi^{ESS} \tag{6}$$

Substituting (4') and (5') into this maximisation problem, we see that s^{ESS} is a solution to

$$\max_{s^M} \quad \pi(s^M \mid s^{ESS}, s^{ESS}, \ldots) - \frac{C-1}{N-1}\,\pi(s^{ESS} \mid s^M, s^{ESS}, s^{ESS}, \ldots) \tag{7}$$

As N -> ∞, (7) gives us the Nash equilibrium, i.e. the equilibrium condition (a) for the standard Maynard Smith definition of an infinite population ESS. Equation (7) is an important result: it tells us that in a finite population of all ESS players and no mutants, an ESS strategist is not in general maximising his payoff/fitness. Rather, in such a population he is maximising the difference between his payoff and the weighted payoff of a typical other ESS player. This kind of behaviour can be called "spiteful" (Hamilton 1970, 1971) in the sense that an ESS player pursues not only a larger payoff for himself but also a lower payoff for his competitors. From equation (7) we can see that the degree of "spitefulness" increases with a decrease in the population size, and so is most likely to be observed in small populations.

Equation (7) also tells us that the generalised ESS depends on the population size, and the ESS for a finite population game will not in general be identical with the ESS for an infinite population game. This is the source of Riley's and Vickery's peculiar result that a population of Maynard Smith "ESS" strategists can be successfully invaded by a mutant - the standard Maynard Smith "ESS" is not an ESS in finite populations.

The case of C=N is of some interest. Because the contest includes all members of the population, we may interpret the case of C=N as an example of what Maynard Smith (1982, pp. 23-7) calls "playing the field". The ESS in this case has a nice intuitive interpretation which can be demonstrated as follows. Substituting C=N into equation (7) yields

$$\max_{s^M} \; \pi(s^M \mid s^{ESS}, s^{ESS}, s^{ESS}, \ldots) - \pi(s^{ESS} \mid s^M, s^{ESS}, s^{ESS}, \ldots) \qquad (8)$$

Now, number the players 1...i...N. Denote by s_{-i} the set of strategies of all the players except for player i; and define $\pi(s_i \mid s_{-i})$ to be the payoff to player i with strategy s_i, taking as given s_{-i}, the strategies of the other N-1 players. Also say that the single mutant player is player number m. Thus $\pi^{ESS} \equiv \pi(s_i \mid s_{-i})$, $i \neq m$; and $\pi^{M} \equiv \pi(s_m \mid s_{-m})$. Write the payoff to an ESS player as the average of the payoffs of all the ESS players:

$$\pi^{ESS} \equiv \frac{1}{N-1} \sum_{i \neq m}^{N} \pi(s_i \mid s_{-i})$$

Substituting for π^{M} and π^{ESS} in equation (8), we have rewritten the definition of the ESS in the playing the field case as that s_m which is a symmetric solution to

$$\max_{s_m} \quad \pi(s_m \mid s_{-m}) \quad - \quad \frac{1}{N-1} \sum_{i \neq m}^{N} \pi(s_i \mid s_{-i}) \tag{9}$$

(We require a symmetric solution because all the mutant's opponents share the ESS strategy.) Equation (9) is, in fact, the same definition as that for the Nash solution to Shubik's zero-sum "beat the average" (BTA) game (Shubik and Levitan 1980). (As in the evolutionary model of the preceding chapter, there is a one-to-one correspondence between the playing the field ESS and the symmetric Nash equilibrium in the BTA game. The proof is identical and is not repeated here.) It is easy to see how the "beat the average" game gets its name. The BTA game is a zero-sum, relative-maximisation game. In the C=N "playing the field" case, therefore, the "spitefulness" of the ESS can be interpreted in terms of zero-sum behaviour on the part of players.

The Generalised ESS - (b) Stability Condition

I now turn to question of stability. Consider the following situation. Say a generalised ESS exists for some game with a finite population. This means, by the equilibrium condition (a') above, that there does not exist a mutant strategy such that, in a population of N-1 ESS strategists and 1 mutant strategist, the mutant has a strictly larger payoff than an ESS player. However, if there are <u>two</u> identical mutant strategists, the mutants may have larger payoffs. More generally, it may be that an ESS is locally but not globally stable in the following sense: in a population with Y or fewer identical mutants and N-Y or more ESS players, $\pi^M < \pi^{ESS}$, but in a population with Y+1 mutants and N-Y-1 ESS players, $\pi^M > \pi^{ESS}$. This suggests a natural definition of stability. Denoting by M the number of mutants in a population, we have

(b') Stability: A strategy s^{ESS} is Y-stable if, in a population with a total of up to Y identical mutant strategists with any mutant strategy $s^M \neq s^{ESS}$,

$$\pi^M < \pi^{ESS} \qquad \text{for all } 2 \leq M \leq Y$$

The ESS is globally stable if Y = N-1.

Note the similarity between stability condition (b') and equilibrium condition (a'). Equilibrium has been defined with reference to a population with 1 mutant; stability, with reference to a population with 2 or more mutants.

To find the degree of stability of an ESS in a given game, we must calculate the expected payoffs π^{ESS} and π^{M}. Denote by $\pi(s^{ESS} \mid C-1-j,\ j)$ the expected payoff to an ESS strategist in a contest of size C where he faces j identical mutant strategists and C-1-j other ESS strategists. Similarly, $\pi(s^{M} \mid C-1-j,\ j)$ denotes the payoff to a mutant when he faces such opponents in a contest. Making use of standard binomial coefficients, and assuming a large number of contests for each player, we have

$$\pi^{ESS} = \sum_{j=0}^{C-1} \frac{\binom{M}{j}\binom{N-1-M}{C-1-j}}{\binom{N-1}{C-1}} \pi(s^{ESS} \mid C-1-j,\ j)$$

$$\pi^{M} = \sum_{j=0}^{C-1} \frac{\binom{M-1}{j}\binom{N-M}{C-1-j}}{\binom{N-1}{C-1}} \pi(s^{M} \mid C-1-j,\ j)$$

An Extended Example - The "Hawk-Dove" Game

Consider a symmetric two-pure-strategy two-player game. The payoff matrix can be written

	strategy	opponent's strategy A	opponent's strategy B
player receiving the payoff	A	a	b
	B	c	d

We assume that a < c and d < b. A player may adopt as his strategy either of the two pure strategies A and B; or he may play a mixed strategy, i.e. he may have as his strategy a probability of playing one or the other pure strategies. We will define a player's strategy s as the probability of playing pure strategy A. Maynard Smith (1982, chapter 2) shows that, if a < c and d < b, for an infinite population a mixed strategy ESS exists with the ESS probability of playing strategy A

$$s^{ESS} = \frac{(b-d)}{(b-d+c-a)} \tag{10}$$

To calculate the mixed strategy ESS for the finite population case, we perform the maximisation in equation (7) for C=2, i.e. we solve

$$\max_{s^M \epsilon [0,1]} \pi(s^M \mid s^{ESS}) - \frac{1}{N-1} \pi(s^{ESS} \mid s^M) \tag{11}$$

where

$$\pi(s^M \mid s^{ESS}) \equiv s^M(s^{ESS}a+(1-s^{ESS})b) + (1-s^M)(s^{ESS}c+(1-s^{ESS})d)$$

$$\pi(s^{ESS} \mid s^M) \equiv s^{ESS}(s^M a+(1-s^M)b) + (1-s^{ESS})(s^M c+(1-s^M)d)$$

The first order condition for this maximisation problem is (after some manipulation)

$$(N-2)s^{ESS}a + ((N-1) - (N-2)s^{ESS})b + (-1 -(N-2)s^{ESS})c - (N-2)(1-s^{ESS})d = 0 \tag{12}$$

A little more manipulation of (12) gives us the mixed strategy ESS:

$$s^{ESS} = \frac{\frac{N-1}{N-2} b - d - \frac{1}{N-2} c}{b - d + c - a} \qquad (13)$$

By setting s^{ESS} to the corner solutions 0 and 1 and still assuming $c > a$ and $b > d$, we get the additional requirements for a mixed strategy: $(N-2)(b-d) > (c-b)$ and $(N-2)(c-a) > (b-c)$.

A mixed strategy ESS has the property that, in a population of N-1 ESS strategists and 1 mutant strategist, the payoff to the single mutant playing any mixture of strategies in the support of the ESS will always be equal to the payoff to an ESS strategist. In the contest we are analysing, the only pure strategies available, A and B, are both in the support of the ESS. This means that in this example, $\pi^M = \pi^{ESS}$ in a population with 1 mutant and N-1 ESS strategists, for any mutant strategy s^M. We will make use of this fact below. (It can be easily verified by substituting s^{ESS} from equation (13) along with the definitions for $\pi(s^{ESS} \mid s^{ESS})$, $\pi(s^{ESS} \mid s^M)$, $\pi(s^M \mid s^{ESS})$ and $\pi(s^M \mid s^M)$ into equation (6).)

It is of interest to compare the infinite population ESS with the finite population ESS. Subtracting (13) from (10) gives us

$$s^{ESS}_{\infty} - s^{ESS}_{N} = \frac{\frac{1}{N-2} (c-b)}{b-d+c-a} \qquad (14)$$

which is > or < 0 as c > or < b. In the Hawk-Dove model (Maynard Smith 1982, chapter 2), where s is the probability of playing Hawk, $c < b$. The implication is that in finite populations the ESS is to play Hawk more often than in infinite populations, and that the smaller the population the greater the probability of playing Hawk. Note that as $N \to \infty$, the difference between the infinite and finite population mixed strategy ESS goes to zero.

I now show that the finite population ESS is globally stable against invasion by a single type of mutant. In a population with M mutants,

$$\pi^{ESS} = \left(1-\frac{M}{N-1}\right)\pi(s^{ESS} \mid s^{ESS}) + \frac{M}{N-1}\,\pi(s^{ESS} \mid s^{M}) \quad (15)$$

$$\pi^{M} = \left(1-\frac{M-1}{N-1}\right)\pi(s^{M} \mid s^{ESS}) + \frac{M-1}{N-1}\,\pi(s^{M} \mid s^{M}) \quad (16)$$

Subtracting (16) from (15) and engaging in a bit of algebraic manipulation allows us to write

$$\begin{aligned}\pi^{ESS}-\pi^{M} = &\left\{ \left(1-\frac{1}{N-1}\right)\pi(s^{ESS} \mid s^{ESS}) + \frac{1}{N-1}\,\pi(s^{ESS} \mid s^{M}) \right\} \\ &- \left\{ \pi(s^{M} \mid s^{ESS}) \right\} \\ &+ \frac{M-1}{N-1}\left\{ \pi(s^{ESS} \mid s^{M}) + \pi(s^{M} \mid s^{ESS}) \right. \\ &\qquad \left. - \pi(s^{ESS} \mid s^{ESS}) - \pi(s^{M} \mid s^{M}) \right\}\end{aligned}$$

The first term in {} is the expected payoff to an ESS strategist in a population with only one mutant strategist. The second term in {} is the expected payoff to a mutant strategist in a population with only one mutant strategist. These two terms must sum to zero because, as noted above, a mixed strategy ESS ensures that the expected payoff of the single mutant will always be equal to the expected payoff of an ESS strategist. Substituting the definitions for $\pi(s^{ESS} \mid s^M)$, $\pi(s^{ESS} \mid s^{ESS})$, $\pi(s^M \mid s^{ESS})$ and $\pi(s^M \mid s^M)$ into the remaining term in {} and engaging in a fair amount of algebraic manipulation eventually yields

$$\pi^{ESS}-\pi^M = \frac{M-1}{N-1}(s^{ESS}-s^M)^2(b-d+c-a) \tag{17}$$

We required earlier that b>d and c>a, and so this expression is > 0 for all $s^M \neq s^{ESS}$ and all M up to N-1 (since we need at least one ESS player in the population for the expression to make sense). Equation (17) therefore demonstrates the global stability of a population of ESS mixed strategists against invasion by a single type of mutant.

I now show under what condition two different mutant strategists may begin simultaneous invasion of a population of ESS strategists. We have two mutant strategies, s^{M1} and s^{M2}. In a population of N-2 ESS strategists and one of each type of mutant, we have

$$\pi^{ESS} = \left(1-\frac{2}{N-1}\right)\pi(s^{ESS} \mid s^{ESS}) + \frac{1}{N-1}\pi(s^{ESS} \mid s^{M1}) + \frac{1}{N-1}\pi(s^{ESS} \mid s^{M2}) \tag{17}$$

$$\pi^{M1} = \left(1-\frac{1}{N-1}\right)\pi(s^{M1} \mid s^{ESS}) + \frac{1}{N-1}\pi(s^{M1} \mid s^{M2}) \tag{18}$$

$$\pi^{M2} = \left(1-\frac{1}{N-1}\right)\pi(s^{M2} \mid s^{ESS}) + \frac{1}{N-1}\pi(s^{M2} \mid s^{M1}) \tag{19}$$

Subtracting (18) from (17) and once again engaging in a bit of algebraic manipulation yields

$$\pi^{ESS}-\pi^{M1} = \{ (1 - \frac{1}{N-1})\pi(s^{ESS} \mid s^{ESS}) + \frac{1}{N-1} \pi(s^{ESS} \mid s^{M1}) \}$$
$$- \{ \pi(s^{M1} \mid s^{ESS}) \}$$
$$+ \frac{1}{N-1} \{ \pi(s^{ESS} \mid s^{M2}) + \pi(s^{M1} \mid s^{ESS}) - \pi(s^{ESS} \mid s^{ESS}) - \pi(s^{M1} \mid s^{M2}) \}$$

The first term in {} is the expected payoff to an ESS strategist in a population with one s^{M1} strategist and N-1 ESS strategists. The second term in {} is the expected payoff to a s^{M1} strategist in the same population. As before, these terms sum to zero. Substituting the definitions of the payoff functions into the remainder of the expression and then simplifying eventually yields

$$\pi^{ESS}-\pi^{M1} = \frac{1}{N-1} (s^{ESS}-s^{M1})(s^{ESS}-s^{M2})(b-d+c-a) \qquad (20)$$

Note that equation (20) is completely symmetrical, and so the expression for $\pi^{ESS}-\pi^{M2}$ will be exactly the same.

We are interested in the conditions under which the mutants can begin to invade. Equation (20) tells us that the s^{M1} mutant strategist (and, by symmetry, the s^{M2} mutant strategist) will have a larger payoff than an ESS strategist if and only if $(s^{ESS}-s^{M1})(s^{ESS}-s^{M2}) < 0$. That is, for the two mutants to both have a higher payoff than the ESS players, the two mutant strategies must "bracket" the ESS, with one mutant playing pure strategy A with a higher probability than an ESS strategist and the other mutant playing pure strategy A with a lower probability than an ESS strategist.

Conclusions and Suggestions for Further Research

This appendix has presented a general formulation of the evolutionarily stable strategy (ESS) first proposed by Maynard Smith and Price (1973). The most important implication of this formulation is that ESS strategists may engage in "spiteful" behaviour in a finite population, and this tendency to spitefulness increases with a decrease in the population size. The empirical content of this implication remains to be seen.

A possible area for further work would be to extend the results of this appendix to the case of polymorphic populations with different "types" of players, each with a different pure strategy. However, this may not be straightforward. The problem is that we cannot simply begin by saying, as we can in the infinite-population case, that in an evolutionarily stable population state the different types of players will have equal expected payoffs. This is because in the finite-population case the relative proportions of players cannot be treated as continuous variables. (This is a flaw in Vickery's analysis of polymorphic populations (Vickery 1987, pp. 137-8).) Take as an example the game analysed in the previous section. If the population is infinite and type A players have a greater payoff than type B players for some proportion of player types, then we can simply raise the proportion of A players until the payoffs of the two types become equal - any proportion is possible. If, however, the population is finite, the possible proportions of player types is restricted because the numbers of type A and B players must be integers. Since equality of payoffs of player types will not in general be possible in a finite population, it is not obvious how to define an evolutionarily stable population state.

Probably more rewarding would be to extend the generalised ESS to the case of a large or infinite population which is divided into "groups" of finite size. Say, for example, we have a species which is divided into groups (e.g., prides, packs, hives, ...). Say also that the groups are genetically and environmentally isolated, and roughly constant in size. In effect, these "groups" are, in the terminology of the appendix, "populations". This means we can interpret the "finite population ESS" presented in the appendix as a "finite group ESS" as well. That is, the "spiteful" behaviour which is evolutionarily stable in a finite population will also be evolutionarily stable in a population which is large or infinite but which is divided into such groups. Developing a theory which loosens these very strict assumptions about genetic and environmental isolation is a possibly important area for further research.

Notes to Appendix 4.1

1. A version of this Appendix appeared in the Journal of Theoretical Biology (Vol. 132, No. 4, 22 June 1988). I would like to thank Stanislaw Gomulka, Ariel Rubenstein, Max Steuer, and an anonymous referee of the Journal for helpful suggestions and discussions on this subject. All remaining errors and omissions are mine.

2. I would like here to refer the reader to Maynard Smith's response to Vickery (Maynard Smith 1988), and the paper by Knowlton and Parker (1979), both of which came to hand only after this appendix was written. The reader will note that the approaches to the finite-population ESS used by Knowlton and Parker and by Maynard Smith in their analysis of very specific (and different) models, and the general finite-population ESS approach proposed in this appendix, are essentially the same. Knowlton and Parker also point out the "spitefulness" of the finite-population ESS in their model.

Chapter 5: Redistribution of Profit in Polish Industry: An Introduction to the "Lista 500" Dataset[1]

Introduction

The previous chapters in this dissertation have been concerned with theoretical aspects of bailouts and rescues of firms and enterprises. The remainder of the dissertation has a much more empirical orientation. The ultimate goal of this chapter and the next is to examine the evidence on whether a policy of bailouts and rescues of enterprises in financial difficulties was followed in Poland in the 1980s. The data on which this investigation relies is the "Lista 500". The Lista 500 is the annual list of the 500 largest enterprises in Polish industry published in the journal Zarządzanie. The Lista 500 enterprises typically account for over half of nation-wide value added in industry. The industrial coverage is extensive, with the important omission of the Polish coal mining industry. The data available include not only measures of inputs (employment, capital stock) and outputs (sales, value added), but more importantly for my purposes in this dissertation, figures on profits, taxes and subsidies. The data extend back to 1983, not long after the "first stage" of the Polish economic reform began in 1982, and has been published annually since. I will use data for the years 1983-88.

Details of the Lista 500 data, and of the financial accounts of Polish industrial enterprises, are not well known in the West. In this chapter I will therefore present a basic survey of the Lista 500 data, and in particular of the role of the tax and subsidy systems in the redistribution of enterprise profits. The next chapter will then take a close look at the specific question of bailouts/rescues of enterprises.

Data Definitions, and Tax and Subsidy Coverage

The tax and subsidy information in the Lista 500 are extensive but not complete. Some taxes and subsidies get lumped together, and some definitions have changed over time. We have used the following definitions.

1. Sales - Costs = "Profit 1"

   "Profit 1" in Polish terminology is called "Accumulation". We will sometimes also call it "Original Profit".

2. "Profit 1" - Turnover Tax = "Profit 2".

   Turnover tax is essentially a product-specific sales tax.

3. "Profit 2" + Subsidy 1 = "Profit 3"

   "Profit 3" in Polish terminology is called "Financial Result".

4. "Profit Tax Owed" = 65% of "Profit 3"

   "Profit Tax" in Polish terminology is called "Income Tax".

5. "Subsidy 2" = Profit Tax Owed - Profit Tax Paid

   The profit tax was originally intended to be a linear tax, but in practice many exemptions from this tax were available.

6. "Profit 3" - Profit Tax Paid = "Profit 4"

   "Profit 4" will sometimes be called "Final Profit".

7. Profit rate = profit / real fixed capital stock.

The focus of the analysis will be the redistribution process that begins with "Original Profit" (Profit 1, Accumulation) and ends with "Final Profit" (Profit 4). The Lista 500 tax and subsidy data is unfortunately not complete; some taxes are included in costs, and some are paid out of "Final Profit". Nevertheless, the two taxes for which we have data are the two most important sources of tax revenue for the state budget. Turnover tax and profit tax together typically accounted for over 70% of tax revenue from the socialised sector of the economy. There is an anomaly here, however, which has an important effect on the analysis, namely the taxation of alcohol. In 1988, for example, turnover tax revenue from all enterprises was 3434.2 billion złoty, and from industrial enterprises 2588.4 billion złoty. Of this revenue, 1066.4 billion złoty was turnover tax revenue from alcohol sales, all of it generated by one firm, Polmos.[2] For this reason I omit Polmos from the analysis of the Lista 500. I should also note here that in some years (1985 and 1987) the fertiliser producer Azoty Włocławek has anomalous profit/loss data, and in these years it too is excluded from the sample.[3]

What I call subsidy 1 contains most of the subsidies paid to state enterprises.[4] It includes product subsidies, the "foreign trade compensation" subsidy, the "unfavourable difference in prices" subsidy, and "other balancing of negative profit" subsidies. In particular, food subsidies are included in subsidy 1 (they are paid to enterprises in the food processing sector and therefore figure in the Lista 500 data). I should note, however, that subsidy 1 is calculated as a residual; it is not given directly in the Lista 500 data. For this reason subsidy 1 unavoidably contains a (fortunately small) "balance of extraordinary gains and losses item".[5]

Subsidy 2 (profit tax exemptions) was available to enterprises on the grounds of export sales, economical use of fuel and energy, and production of high quality goods. In practice these exemptions at the economy-wide level typically lowered the effective tax rate from 65% to under 50%. Most of the enterprises in the Lista 500 benefited (to varying degrees) from these tax exemptions.

The original Lista 500 data give a mixed real/nominal fixed capital stock figure, except for 1983 when no figure at all is supplied.[6] Data for the real and nominal fixed capital stock in socialised industry as a whole from the Rocznik Statystyczny is used to calculate approximate real fixed capital stocks valued in prices of the year concerned. For 1983 an even rougher approximation is used, namely the enterprise capital stock figures for 1984-88. A number of enterprises appeared in the 1983

Lista 500 but not in these subsequent years; I do not have any fixed capital stock at all for these enterprises.

It is sometimes convenient to group firms by their original profitability and by their final profitability. The categories for original profitability are taken, with some modifications, from Kornai (1986a, and personal communication with the author). His categories are based on all real assets, i.e. inventories are included. A firm with a profitability which is negative is designated a "loss-maker"; between 0 and 6%, a "low profitability" firm; more than 6% up to 20%, "medium profitability"; and above 20%, "high profitability". Data from the Rocznik Statystyczny on inventories held by enterprises is used to calculate roughly comparable categories based on real fixed capital only; my original profitability cut-offs are 0%, 6.8%, and 22.7%. The cut-offs for the final profitability categories are obtained from the original profitability cut-offs with a correction for the average net tax rate; we multiply the cut-offs by final profit ÷ original profit, the aggregate rate of retention of original profits. This method of calculating final profitability categories will be discussed again below, when cross-tabulations by profitability are presented.

Taxation and Subsidisation of Enterprises

1. The Lista 500 set of industrial enterprises in the

period 1983-88 was, in aggregate and at the industrial branch level, profitable before taxes and subsidies, even when the hugely profitable Polmos is excluded (see Tables 5.1-5.6). Roughly the same pattern holds when we look at all state-owned industrial enterprises.[7] It is important to note that the observed branch profitability patterns were heavily influenced by government price controls. Observed pre-tax/subsidy profitability in this period is not a good guide to what profitability would have been at market-set prices. If energy and food prices had risen to market-clearing levels, for example, the observed profitability patterns would have changed markedly.

2. Polish industry was on the whole a significant generator of net tax revenue; considerably more was collected via taxes and than was paid out via subsidies, even when tax revenue from alcoholic spirits is excluded. Put another way, the net taxation rate of profit 1 was high. Define the net taxation rate of profit 1 as (profit 1 - profit 4) / profit 1. Tables 5.7 and 5.8 show net taxation rates for the Lista 500 as a whole and by profitability categories, for the period 1983-88; the former uses all available data for all enterprises in each year, the latter uses data for only those enterprises for which we have data in all six years. Although the net taxation rate for the sample as a whole was rather high, it declined substantially over 1983-88, from nearly 70% to about 50% of pre-tax/subsidy profits. The pattern by profitability category shows a clearly progressive

effective net tax. Loss-makers received on average a subsidy greater than the losses incurred (this is the meaning of a tax rate on losses exceeding 100%). The net tax rate for profit-makers was on average increasing with original profitability.

3. The ranking of industrial branches by original profitability is much different from the ranking by final profitability. That is, the cumulative impact of taxation and subsidisation on industrial branch profitability is severe. Tables 5.1 to 5.6 show the effects of the stages of profit redistribution on profit rates by industry and by profitability category for 1983-88. The tables also demonstrate the selective impact of turnover tax and subsidy 1 according to original profitability. The incidence of turnover tax is borne largely by those enterprises whose original profitability is high; the change in profitability moving from column 1 to column 2 is very large for this category and quite small for the other three categories. Subsidy 1 mostly benefits loss-makers. Profit tax, by contrast, is not so selectively targeted by profitability.

4. Table 5.9 presents the distribution by industrial branch for those enterprises in the 1988 Lista 500 that were loss-makers before taxes and subsidies (i.e. according to profit 1). Several points regarding loss-making enterprises are worth noting. First of all, the number of loss-makers is not large, only about 11% of the

sample. Second, most of these loss-makers are in the food processing sector; the rest are largely enterprises producing agricultural inputs. During this period both food products and agricultural inputs were highly subsidised and sold at state-controlled prices that were set very low. Third, none of these loss-makers were loss-makers at the end of the tax/subsidy process; all received a subsidy sufficient to cover their losses. These three features, with minor variations, form a consistent pattern in the Lista 500 data over the entire period 1983-88.[8]

This pattern in loss-making enterprises by industry, and the selective application of turnover tax and subsidy 1, reflect the use of turnover tax and product subsidies as tools in product pricing policy. Turnover tax was used to raise tax revenue via those products that, at a given level of aggregate supply, would command a high price relative to production costs. Product subsidies were used where central policy dictated a price which was insufficient to cover production costs. State control of prices thus had a very strong influence on profitability, both at the sector and enterprise level. A by-product of this policy is that (aside from some obvious cases) it is very difficult to identify which are the efficient, truly "profitable" sectors, and which are not. The problem is even worse at the enterprise level; only with market-clearing prices would it be possible to identify the truly "unprofitable" enterprises.

I will return to the topic of loss-making enterprises in the next chapter.

Cross-tabulation by Profitability

A convenient starting point for analysing the redistribution of profit is cross-tabulation according to profitability. Such a cross-tabulation "transition matrix" was calculated for Hungarian manufacturing by Kornai and Matits and reported in Kornai (1986b). Kornai and Matits choose four ranges of profitability, defined as the ratio of profits to all real assets (including inventories). Firms are then categorised according to their "original profitability", i.e. profitability before all taxes and subsidies. The firms in each of the four groups are then categorised according to their "final profitability", i.e. profitability after all taxes and subsidies. The cross-tabulation matrix is constructed by taking each of the four "original profitability" categories of firms and calculating the proportions of each group that come under the four "final profitability" categories. Each element of the matrix thus gives the proportion of enterprises from a given original profitability category which ends up in a given final profitability category. It is important to note that the same ranges of profitability are used for the "original" and "final" categories.

The Kornai-Matits cross-tabulation matrix for the Hungarian state-owned manufacturing sector in 1982 is reproduced below.

Cross-tabulation Matrix for Hungarian State-owned Manufacturing, 1982

The matrix contains only the transition proportions, i.e. the percentages of enterprises in an original profitability category which move into the various final profitability categories. The actual numbers of firms are not published in Kornai's article.

Profitability is defined here as profits divided by the value of all real assets (including inventories).

Source: Kornai (1986b), and personal communication from Prof. Kornai to the author, December 1987.

Hungary 1982	Final Profitability			
Original Profitability	Loss Maker	Low 0-6%	Medium 6-20%	High > 20%
Loss-Maker	23.3	50.0	12.2	14.5
Low Prof'bility 0-6%	3.8	85.3	10.3	0.6
Medium Prof'ity 6-20%	0.0	73.4	20.6	6.0
High Prof'bility > 20%	0.8	39.4	51.5	8.3

Points worth noting:

1. Over three-quarters of firms which began as loss-makers ended up as profit-makers. This cited by Kornai as

direct evidence of what he has termed the "soft budget constraint": loss-makers are rescued. On the other hand, given that bankruptcies in Hungary at this time were virtually non-existent, it is surprising that nearly a quarter of firms which began as loss-makers remained loss-makers. It would be useful to know what devices were used to keep them solvent.

2. Very few of the firms which began at a high profitability remained highly profitable after profit redistribution. Kornai cites this as evidence of an egalitarian tendency to reduce the profits of successful firms (Kornai 1986b, p. 1698), what he has elsewhere labelled "levelling". However, it is not clear that the cross-tabulation matrix above is very good evidence of this. The problem is that, for example, a single linear profit tax, set at a high rate but enforced uniformly, could show a similar pattern to that above. Because any sort of profit tax will lower the profits of profit-makers, a cross-tabulation matrix constructed in the manner chosen by Kornai and Matits will typically show a substantial proportion of firms moving from a high or medium profitability category to a lower profitability category. Without further information, such a movement therefore cannot be taken as proof that the enterprise tax system is egalitarian or progressive.

The source of this latter problem is in the use of the same profitability ranges for original and final profitability. If net tax revenues (i.e. all taxes minus all subsidies) paid by enterprises are large - if the enterprises are a significant source of tax revenue to redistributed to other sectors - then any system of profit taxes will lower the profitability of at least some enterprises.

We can compensate for this problem by calculating final profitability categories as described at the beginning of this chapter. That is, we multiply the original profitability categories by (1 - the aggregate net tax rate on original profit), i.e. we multiply by the aggregate rate of retention of original profit. (The same adjustment was suggested independently by Matits (n.d.).)

The justification is as follows: if a hypothetical, revenue-neutral tax reform were introduced such that the profits of all firms were taxed at the same rate (and the losses of all loss-makers were subsidised at this same rate), the categorisation by profitability any given firm would remain unchanged. That is, under this hypothetical, "impartial", linear tax/subsidisation system, a firm whose original profitability was high would also have a high final profitability, a firm whose original profitability was medium would also have a medium final profitability, etc. A cross-tabulation matrix for an economy which introduced such a tax system would in fact be an identity matrix, with ones down the diagonal and zeros everywhere else. This means we have a useful benchmark for our revised cross-tabulation matrices; deviations from the identity matrix measure deviations from a perfectly impartial linear tax/subsidy system.

In Poland, net tax revenues paid by enterprises are large; if we constructed cross-tabulation matrices for our sample of Polish enterprises without adjusting final profitability categories in this way, the potential for misinterpretation could be great. Note, however, that if net tax revenues are zero, the distortion disappears because the categories for original and final profitability are the same. Data in Matits (n.d., Table 4) give an aggregate net tax rate on original profit of 23% for Hungarian manufacturing in 1982. This is substantially lower than the tax rate for our sample but still large enough to allow possibly significant distortions as a result of not correcting final profitability categories.[9]

The cross-tabulation matrices constructed using our modified final profitability categories for our Polish sample, 1983-88, are contained in Tables 5.10-5.15. Below is reproduced the matrix for 1988, and for comparison, the cross-tabulation matrix for 1988 constructed using the same method as Kornai and Matits (identical original and final profitability categories). Several points relating these cross-tabulations should be noted.

1988 Cross-tabulation Matrix
Modified Final Profitability Categories

Final Profitability

Total Original Profitability	Loss Maker	Low 0-3.2%	Medium 3.2-10.5	High >10.5%	Row
Loss-Maker	0 0.0	9 16.1	35 62.5	12 21.4	56 11.2
Low Prof'bility 0-6.8%	0 0.0	48 70.6	19 27.9	1 1.5	68 13.6
Medium Prof'ity 6.8-22.7%	0 0.0	16 8.4	156 81.7	19 9.9	191 38.3
High Prof'ity > 22.7%	0 0.0	2 1.1	76 41.3	106 57.6	184 36.9
Column Total	0 0.0	75 15.0	286 57.3	138 27.7	499 100.0

1988 Cross-tabulation Matrix
Unmodified Final Profitability Categories

Final Profitability

Total Original Profitability	Loss Maker	Low 0-6.8%	Medium 6.8-22.7	High >22.7%	Row
Loss-Maker	0 0.0	32 57.1	23 41.1	1 1.8	56 11.2
Low Prof'bility 0-6.8%	0 0.0	64 94.1	4 5.9	0 0.0	68 13.6
Medium Prof'ity 6.8-22.7%	0 0.0	121 63.4	70 36.6	0 0.0	191 38.3
High Prof'ity > 22.7%	0 0.0	32 17.4	119 64.7	33 17.9	184 36.9
Column Total	0 0.0	249 49.9	216 43.3	34 6.8	499 100.0

1. Each cell contains both the number of enterprises and the percentage of enterprises in that row found in that cell. This enables us to judge the significance of the various categories in relation to the total number of firms. No correction for varying size of firms is made, however.

2. As noted earlier, Kornai and Matits used the value of all real assets including inventories to calculate profitability. We use real assets only, with the cut-offs for original profitability modified accordingly.

3. Kornai and Matits' calculations were based on the entire Hungarian state manufacturing sector. Our sample differs in at least two respects. First, we have data on only the 500 largest enterprises in Polish industry. Second, we deliberately exclude the firm Polmos from our sample, for reasons discussed earlier. The exclusion of Polmos, and hence alcoholic beverages, from our sample has a significant effect on the aggregate net taxation rate and hence on our modified final profitability categories.

4. Our Polish data set contains data on most but not all taxes and subsidies. Our coverage of taxes and subsidies is probably roughly comparable to that used by Kornai and Matits in calculating their cross-tabulation matrix. From the matrix it is clear that there is a positive, though perhaps weak, correlation between original and final profitability. Kornai and Matits (1984) report other

results stemming from the same project. In this paper they distinguish four stages of profitability, and concentrate on the redistribution from original profits (stage 1) to "profits according to the balance sheet" (stage 3) and "profitability after redistribution" (stage 4). The definition of "final profitability" used in the cross-tabulation matrix is based on balance sheet profits (communication from Prof. Kornai to the author, December 1987) and thus may best correspond to stage 3 in the Kornai-Matits paper. Kornai and Matits (1984, p. 232) report figures for the correlation between original profitability and stage 3 and stage 4 profitability consistent with this. Their correlation coefficient between original and stage 3 profitability in 1979 is 0.29, and in 1980 is 0.28, i.e. weakly positive and consistent with the cross-tabulation matrix for 1982. The correlation coefficient between original and stage 4 profitability, on the other hand, is 0.07 in 1979 and -0.01 in 1980. I report Polish correlation coefficients in the next section.

5. The bias induced by using unmodified final profitability categories is readily apparent. For 1988, when unmodified categories are used, about half of the sample have a low final profitability; when the categories are adjusted as described above, over half have a medium final profitability and only 15% a low final profitability.

6. The main conclusion that follows from the Polish cross-tabulation matrices using adjusted final profitability categories (Tables 5.10-5.15) is as follows. The cross-tabulations for all years are very similar. They show that the enterprise tax/subsidy system was consistently progressive rather than linear. The most marked deviation from linearity was in the treatment of loss-makers; not only were they all bailed out, but most had a final profitability which was either medium or high. Deviations from linearity were much less for profit-making enterprises.

A similar conclusion about the tax/subsidy system follows from an examination of the correlation between original and final profitability.

Profitability Correlation Coefficients

It is useful to have a single number which summarises the pattern of profit redistribution. The sample correlation coefficient $\hat{r}$ between original and final profitability is a convenient measure. It has the useful property that if taxes on enterprise profits / subsidies on enterprise losses were based on a single linear rate with no exemptions, the correlation coefficient between original and final profitability would be one.[10] The correlation coefficient is therefore related to our cross-tabulation matrices (using adjusted final profitability categories), with the difference that it provides a single measure which does not depend on an arbitrary categorisation of original profitability.

Below are two tables summarising the correlation between original and final profitability for the years 1983-88. Correlations for all enterprises taken together and for the subcategories of enterprises by profitability are given. No attempt is made to correct for the varying sizes of enterprises. The definitions and data are the same as those used in constructing the cross-tabulation matrices, with the exception that here we used the subset of 393 enterprises for which we have data in all six years. This means the changes in the correlation coefficients are not affected by changes in the sample of enterprises.

It is worth re-emphasising here that the exclusion of the enterprise Polmos makes a huge difference in our results. Because of the tax revenue generated by alcoholic beverages, Polmos has an original profitability which is enormous and a final profitability which is unexceptional. When Polmos is included in the sample the overall correlation coefficient drops to about 0.20; furthermore, changes in the taxes paid by Polmos completely swamp the changes in the taxes/subsidies of the other enterprises as reflected in the correlation coefficient.

The first table presents values of the sample correlation coefficient $\hat{r}$. Stars indicate statistical significance under the null hypothesis that the true correlation coefficient r is normally distributed with mean zero; one star (two stars) means we can reject the hypothesis that the correlation coefficient is equal to zero at the 5% (1%) level (a two-tailed test).

If we want to gauge the significance of the changes of non-zero correlation coefficients, we are faced with a statistical difficulty, because when the true r has a non-zero mean the sample $\hat{r}$ has a distribution which is not a simple function and we cannot easily calculate standard errors, etc. However, Fisher has shown that

$$z = \frac{1}{2} \ln \frac{1 + \hat{r}}{1 - \hat{r}}$$

is approximately normally distributed with mean

$$\mu = \frac{1}{2} \ln \frac{1 + r}{1 - r}$$

and variance $1/(n-3)$, where n is the sample size (Mood 1950, p. 314). The second table below presents values of Fisher's z, together with standard errors. (Note that the values of z approximate those of $\hat{r}$ when both are small.)

Correlation of Original and Final Profitability

6 Year Sample, 1983-88 (393 enterprises)

I. Sample correlation coefficients

	1983	1984	1985	1986	1987	1988
All Enterprises	.48**	.45**	.33**	.28**	.40**	.47**
By Original Profitability						
Loss-Makers	-.55**	-.60**	-.55**	-.61**	-.57**	-.41**
Profit-Makers	.51**	.48**	.41**	.44**	.52**	.68**
of which						
Low	.36**	.25*	.29*	.20	.28*	-.10
Medium	.39**	.21*	.36**	.38**	.40**	.51**
High	.32**	.29**	.12	.15	.24**	.67**

II. Fisher's z measure of correlation (standard errors in parentheses)

	1983	1984	1985	1986	1987	1988
All Enterprises	.52**	.48**	.35**	.29**	.42**	.51**
	(.05)	(.05)	(.05)	(.05)	(.05)	(.05)
By Original Profitability						
Loss-Makers	-.61**	-.69**	-.62**	-.71**	-.65**	-.43**
	(.15)	(.14)	(.13)	(.14)	(.15)	(.14)
Profit-Makers	.56**	.53**	.44**	.48**	.57**	.83**
	(.05)	(.05)	(.06)	(.05)	(.05)	(.05)
of which						
Low	.38**	.25*	.30*	.20	.29*	-.10
	(.12)	(.13)	(.14)	(.13)	(.13)	(.14)
Medium	.42**	.21*	.38**	.40**	.42**	.56**
	(.08)	(.08)	(.08)	(.08)	(.08)	(.08)
High	.33**	.30**	.12	.15	.25**	.81**
	(.09)	(.09)	(.09)	(.09)	(.09)	(.09)

* indicates significantly different from zero in a two-tailed test at the 5% level
** indicates significantly different from zero in a two-tailed test at the 1% level

There was a steady overall decline 1983-86 in the linearity ("neutrality", "unbiasedness") of the enterprise tax/subsidy system, as measured by $\hat{r}$ and z. This occurred at the same time as a steady decline in the net taxation rate of profits (see Table 5.7). A possible explanation would be an increase in tax exemptions and ad hoc subsidies over this period; further evidence is needed here. The apparent increase in the linearity of the tax/subsidy system in 1987-88 is slightly encouraging. The correlation coefficients are generally higher than those Kornai and Matits calculated for Hungarian manufacturing; however, differing accounting definitions, sample coverage, and sample sizes, suggest caution in the comparison.

The treatment of firms whose original profit was negative, i.e. loss-makers, was particularly perverse. The significant and negative correlation indicates that of the loss-making enterprises, those with the lowest original profitability on average ended up with the highest final profitability. Tax/subsidy treatment of profit-making firms also deviated significantly from linearity, but original and final profitability were usually still related; both $\hat{r}$ and z were in the range of .3 to .5 over the period. When we move from profit-makers as a group to the three sub-categories of profit-making enterprises, we see that values of $\hat{r}$ and z fall noticeably across the board. Medium-profitability enterprises appear to have faced the most consistently linear tax/subsidy policy. High-profitability enterprises have had an uneven time; in 1985-86 original and final profit were not significantly correlated at all, but 1987 brought some improvement and in 1988 the correlation was quite high.

These correlations should however be interpreted with some caution. The correlations for profit-makers as a whole are always higher than the correlations for the separate categories, a feature which is not intuitively attractive. The fact that pooling the sample / increasing the sample size leads to an increase in the correlation measures does make comparisons with the Kornai-Matits correlations somewhat easier; they had a rather larger sample (over 1,000 enterprises) but still had lower correlation coefficients. Furthermore, movements in the former seem to be driven primarily by movements in the correlation for the high profitability category. This may be because of the sensitivity of the correlation measures to extreme outliers: the high profitability category is not bounded from above. It may be, for example, that large jump in the correlation for the high profitability category (and maybe even for the sample as a whole) is caused by a very large jump in the final profitability of just a few enterprises.

This concludes the general survey of the Lista 500 data. In the next chapter I turn to the specific question of whether in fact enterprises in the Lista 500 were bailed out by the state if they fell into financial difficulties.

Table 5.1: Effects of Profit Redistribution on Profit Rates, 1983

Profit Rate = Profit per Real Fixed Capital, in %

Profit Rate According to Profit Definition	1	2	3	4
Entire Sample	11.3	5.3	8.4	3.6
By Industry				
Fuel & Energy	37.0	8.1	9.0	2.2
Metallurgy	1.6	1.5	3.3	1.7
Electro-Machinery	16.4	10.9	12.3	5.4
Chemicals	8.2	6.4	8.1	3.1
Bldg Materials etc	9.3	7.9	7.8	2.5
Wood & Paper	7.0	5.5	6.1	3.2
Light Industry	21.8	8.7	9.8	4.2
Food Industry	-1.3	-7.6	9.3	4.6
By Original Profitability				
Loss-Makers	-8.8	-8.9	3.3	2.0
Low Profitability	3.5	3.3	4.2	2.4
Medium Profitability	12.6	10.0	10.5	4.7
High Profitability	49.6	19.2	20.0	6.1
By Final Profitability				
Low Profitability	1.1	0.4	2.6	1.4
Medium Profitability	15.4	6.2	9.9	3.9
High Profitability	29.2	21.4	24.9	11.0

Start profitability cut-offs are approximately
0.00 %, 6.80 %, and 22.70 %
Final profitability cut-offs are approximately
0.00 %, 2.15 %, and 7.17 %
Average net tax rate is 68.4 percent
Sample of 477 enterprises

Table 5.2: Effects of Profit Redistribution on Profit Rates, 1984

Profit Rate = Profit per Real Fixed Capital, in %

Profit Rate According to Profit Definition	1	2	3	4
Entire Sample	11.5	5.6	8.7	4.1
By Industry				
Fuel & Energy	34.2	7.0	7.8	2.5
Metallurgy	3.4	3.3	4.8	2.4
Electro-Machinery	16.1	10.7	12.7	6.5
Chemicals	7.6	5.5	7.9	3.4
Bldg Materials etc	7.9	5.8	6.1	2.4
Wood & Paper	7.8	5.2	6.2	3.2
Light Industry	26.8	10.8	12.0	5.3
Food Industry	2.3	-5.8	8.9	4.4
By Original Profitability				
Loss-Makers	-7.1	-7.8	4.1	2.2
Low Profitability	3.1	2.8	4.1	2.3
Medium Profitability	11.9	9.9	10.6	5.2
High Profitability	49.1	18.4	19.3	7.7
By Final Profitability				
Low Profitability	1.5	0.3	2.6	1.3
Medium Profitability	14.7	6.6	9.8	4.4
High Profitability	30.5	20.4	24.9	13.1

Start profitability cut-offs are approximately
0.00 %, 6.80 %, and 22.70 %
Final profitability cut-offs are approximately
0.00 %, 2.44 %, and 8.16 %
Average net tax rate is 64.1 percent
Sample of 499 enterprises

Table 5.3: Effects of Profit Redistribution on Profit Rates, 1985

Profit Rate = Profit per Real Fixed Capital, in %

Profit Rate According to Profit Definition	1	2	3	4
Entire Sample	11.6	5.8	9.2	4.2
By Industry				
Fuel & Energy	28.1	6.7	7.7	2.4
Metallurgy	3.1	2.9	4.3	2.0
Electro-Machinery	16.1	11.2	13.0	6.6
Chemicals	8.9	6.6	9.4	3.7
Bldg Materials etc	6.6	4.1	5.0	1.6
Wood & Paper	11.3	8.7	10.1	4.6
Light Industry	29.0	10.1	11.8	4.9
Food Industry	1.6	-6.5	9.4	4.4
By Original Profitability				
Loss-Makers	-7.2	-7.8	4.0	1.9
Low Profitability	3.6	3.4	4.4	2.3
Medium Profitability	13.2	10.6	11.6	5.4
High Profitability	48.9	19.0	20.2	8.1
By Final Profitability				
Low Profitability	1.9	0.4	3.0	1.3
Medium Profitability	15.4	7.0	10.5	4.5
High Profitability	29.1	20.4	26.2	13.3

Start profitability cut-offs are approximately
0.00 %, 6.80 %, and 22.70 %
Final profitability cut-offs are approximately
0.00 %, 2.45 %, and 8.18 %
Average net tax rate is 64.0 percent
Sample of 498 enterprises

Table 5.4: Effects of Profit Redistribution on Profit Rates, 1986

Profit Rate = Profit per Real Fixed Capital, in %

Profit Rate According to Profit Definition	1	2	3	4
Entire Sample	10.4	5.5	9.0	4.4
By Industry				
Fuel & Energy	27.6	5.2	7.0	2.3
Metallurgy	3.4	3.3	4.5	2.2
Electro-Machinery	14.2	10.4	12.6	6.8
Chemicals	6.5	4.7	8.3	3.7
Bldg Materials etc	5.5	3.5	4.2	1.6
Wood & Paper	6.2	4.5	6.4	2.7
Light Industry	28.2	12.7	14.1	6.0
Food Industry	2.2	-4.6	11.0	5.6
By Original Profitability				
Loss Makers	-8.8	-8.8	4.8	2.6
Low Profitability	3.5	3.3	4.3	2.3
Medium Profitability	12.7	10.5	11.3	5.4
High Profitability	45.9	18.5	20.0	9.2
By Final Profitability				
Low Profitability	1.6	0.7	3.2	1.4
Medium Profitability	14.6	6.9	10.6	4.9
High Profitability	26.3	20.1	28.1	16.1

Start profitability cut-offs are approximately
0.00 %, 6.80 %, and 22.70 %
Final profitability cut-offs are approximately
0.00 %, 2.88 %, and 9.63 %
Average net tax rate is 57.6 percent
Sample of 499 enterprises

Table 5.5: Effects of Profit Redistribution on Profit Rates, 1987

Profit Rate = Profit per Real Fixed Capital, in %

Profit Rate According to Profit Definition	1	2	3	4
Entire Sample	11.6	7.4	10.5	5.8
By Industry				
Fuel & Energy	24.9	4.9	6.2	2.4
Metallurgy	5.4	5.2	6.4	2.8
Electro-Machinery	15.1	11.9	13.4	8.5
Chemicals	9.7	8.0	11.5	6.4
Bldg Materials etc	6.4	4.6	5.5	2.3
Wood & Paper	9.1	7.5	8.8	4.2
Light Industry	27.9	15.7	16.9	7.8
Food Industry	2.6	-3.8	11.5	6.8
By Original Profitability				
Loss-Makers	-17.1	-17.2	8.1	5.0
Low Profitability	3.1	3.0	4.2	2.3
Medium Profitability	13.2	11.5	12.4	6.7
High Profitability	43.0	21.5	22.5	12.3
By Final Profitability				
Low Profitability	1.9	1.4	3.8	1.8
Medium Profitability	15.7	8.8	11.6	6.1
High Profitability	27.3	22.9	30.3	19.2

Start profitability cut-offs are approximately
0.00 %, 6.80 %, and 22.70 %
Final profitability cut-offs are approximately
0.00 %, 3.40 %, and 11.36 %
Average net tax rate is 50.0 percent
Sample of 498 enterprises

Table 5.6: Effects of Profit Redistribution on Profit Rates, 1988

Profit Rate = Profit per Real Fixed Capital, in %

Profit Rate According to Profit Definition	1	2	3	4
Entire Sample	12.1	7.5	11.5	5.6
By Industry				
Fuel & Energy	33.7	6.5	7.1	3.0
Metallurgy	8.0	7.9	8.6	3.7
Electro-Machinery	16.4	13.2	14.1	7.4
Chemicals	10.0	8.5	11.3	5.5
Bldg Materials etc	6.2	4.4	5.2	2.6
Wood & Paper	9.1	7.9	8.6	4.6
Light Industry	27.4	16.1	17.1	7.4
Food Industry	-8.5	-15.5	12.9	6.7
By Original Profitability				
Loss-Makers	-26.4	-26.4	8.6	4.9
Low Profitability	2.8	2.6	4.0	1.9
Medium Profitability	13.7	12.0	12.9	6.3
High Profitability	48.8	24.4	25.1	12.1
By Final Profitability				
Low Profitability	2.8	2.2	3.6	1.7
Medium Profitability	15.2	8.5	12.8	6.1
High Profitability	29.4	22.3	34.5	18.2

Start profitability cut-offs are approximately
0.00 %, 6.80 %, and 22.70 %
Final profitability cut-offs are approximately
0.00 %, 3.16 %, and 10.55 %
Average net tax rate is 53.5 percent
Sample of 499 enterprises

Table 5.7: Net Tax Rate on Original Profit, in %

Data used is for all available enterprises in each year (Polmos is excluded).

	1983	1984	1985	1986	1987	1988
All Enterprises	68.4	64.1	64.0	57.6	50.0	53.5
By Original Profitability						
Loss-Makers	122.5	131.3	127.0	130.0	129.0	118.6
Profit-Makers	76.1	71.4	71.4	68.3	58.9	63.8
of which						
Low	32.6	27.1	36.5	34.2	25.4	31.4
Medium	63.0	56.3	59.0	57.6	49.0	54.1
High	87.8	84.2	83.4	80.0	71.4	75.2

Note: Net tax rate = (Profit 1 - Profit 4) / Profit 1.

Table 5.8: Net Tax Rate on Original Profit, in %

Data used is for only those enterprises for which we have data for every year (Polmos is excluded).

	1983	1984	1985	1986	1987	1988
All Enterprises	70.2	68.1	66.7	60.7	51.5	52.4
By Original Profitability						
Loss-Makers	125.8	135.0	127.7	130.5	128.3	117.7
Profit-Makers	76.7	73.9	73.7	70.8	61.5	66.0
of which						
Low	32.1	29.4	41.7	34.4	25.8	31.2
Medium	63.1	58.0	60.5	60.4	51.0	55.0
High	88.1	85.3	84.4	80.6	72.7	76.7

Note: Net tax rate = (Profit 1 - Profit 4) / Profit 1.

Table 5.9: Loss-making Enterprises in 1988

Sample of 500 largest state-owned industrial enterprises (Polmos is included).

Total number of loss-makers	56
of which	
A. Food Processing	43
of which	
meat products	23
food oil products	6
poultry products	5
grain products	5
sugar products	3
B. Other Industry	13
of which	
fodder production	6
fertiliser production	3

Note: Coal-mining excluded.

Table 5.10: Cross-tabulation by Profitability, 1983

(Modified final profitability categories are used)

1983 Total Original Profitability	Final Profitability: Loss Maker	Low 0-2.1%	Medium 2.1-7.2	High > 7.2%	Row
Loss-Maker	1 1.6	18 29.0	40 64.5	3 4.8	62 13.0
Low Prof'bility 0-6.8%	0 0.0	35 38.5	55 60.4	1 1.1	91 19.1
Medium Prof'ity 6.8-22.7%	0 0.0	5 2.7	154 81.9	29 15.4	188 39.4
High Prof'ity > 22.7%	0 0.0	2 1.5	63 46.3	71 52.2	136 28.5
Column Total	1 0.2	60 12.6	312 65.4	104 21.8	477 100.0

Table 5.11: Cross-tabulation by Profitability, 1984

(Modified final profitability categories are used)

1984 Total Original Profitability	Final Profitability: Loss Maker	Low 0-2.4%	Medium 2.4-8.2	High > 8.2%	Row
Loss-Maker	2 2.9	22 32.4	36 52.9	8 11.8	68 13.6
Low Prof'bility 0-6.8%	0 0.0	36 45.0	43 53.8	1 1.3	80 16.0
Medium Prof'ity 6.8-22.7%	0 0.0	10 5.0	156 77.6	35 17.4	201 40.3
High Prof'bility > 22.7%	0 0.0	5 3.3	59 39.3	86 57.3	150 30.1
Column Total	2 0.4	73 14.6	294 58.9	130 26.1	499 100.0

Table 5.12: Cross-tabulation by Profitability, 1985

(Modified final profitability categories are used)

1985 Total Original Profitability	Final Profitability Loss Maker	Low 0-2.4%	Medium 2.4-8.2	High > 8.2%	Row
Loss-Maker	1 1.3	28 36.8	38 50.0	9 11.8	76 15.3
Low Prof'bility 0-6.8%	0 0.0	47 63.5	27 36.5	0 0.0	74 14.9
Medium Prof'ity 6.8-22.7%	0 0.0	13 7.0	142 76.8	30 16.2	185 37.1
High Prof'bility > 22.7%	0 0.0	5 3.1	74 45.4	84 51.5	163 32.7
Column Total	1 0.2	93 18.7	281 56.4	123 24.7	498 100.0

Table 5.13: Cross-tabulation by Profitability, 1986

(Modified final profitability categories are used)

1986 Total Original Profitability	Final Profitability Loss Maker	Low 0-2.9%	Medium 2.9-9.6	High > 9.6%	Row
Loss-Maker	2 3.1	16 24.6	36 55.4	11 16.9	65 13.0
Low Prof'bility 0-6.8%	0 0.0	53 60.9	33 37.9	1 1.1	87 17.4
Medium Prof'ity 6.8-22.7%	0 0.0	18 9.5	144 76.2	27 14.3	189 37.9
High Prof'ity > 22.7%	0 0.0	3 1.9	88 55.7	67 42.4	158 31.7
Column Total	2 0.4	90 18.0	301 60.3	106 21.2	499 100.0

Table 5.14: Cross-tabulation by Profitability, 1987

(Modified final profitability categories are used)

1987 — Final Profitability

Total Original Profitability	Loss Maker	Low 0-3.4%	Medium 3.4-11.4	High >11.4%	Row
Loss-Maker	0 0.0	13 24.5	29 54.7	11 20.8	53 10.6
Low Prof'bility 0-6.8%	0 0.0	54 64.3	29 34.5	1 1.2	84 16.9
Medium Prof'ity 6.8-22.7%	0 0.0	18 9.7	145 78.0	23 12.4	186 37.3
High Prof'ity > 22.7%	0 0.0	2 1.1	90 51.4	83 47.4	175 35.1
Column Total	0 0.0	87 17.5	293 58.8	118 23.7	498 100.0

Table 5.15: Cross-tabulation by Profitability, 1988

(Modified final profitability categories are used)

1988 — Final Profitability

Total Original Profitability	Loss Maker	Low 0-3.2%	Medium 3.2-10.5	High >10.5%	Row
Loss-Maker	0 0.0	9 16.1	35 62.5	12 21.4	56 11.2
Low Prof'bility 0-6.8%	0 0.0	48 70.6	19 27.9	1 1.5	68 13.6
Medium Prof'ity 6.8-22.7%	0 0.0	16 8.4	156 81.7	19 9.9	191 38.3
High Prof'ity > 22.7%	0 0.0	2 1.1	76 41.3	106 57.6	184 36.9
Column Total	0 0.0	75 15.0	286 57.3	138 27.7	499 100.0

Notes to Chapter 5

1. This chapter is a revised version of "Redistribution of Profit, Financial Flows, and Economic Reform in Polish Industry: Evidence from the 'Lista 500'", presented at the Symposium on Monetary Policy, Financial Flows, and Reforms in Centrally Planned Economies, Gerzenzee, Switzerland, 2-4 March 1989. Parts of this chapter appeared (in somewhat different form) in "State-Owned Enterprises in Poland: Taxation, Subsidisation, and Competition Policies", Paper prepared for the PHARE Project, DGII, European Commission, February 1990.

The work on the Lista 500 arises from a project directed by Stanislaw Gomulka of the London School of Economics and funded by the Suntory-Toyota International Centre for Economics and Related Disciplines. While most of the chapter was written I was an IREX Developmental Fellow, and I also benefited from a productive visit to the European University Institute in the course of analysing the data. The generous financial support of STICERD and IREX and the hospitality of the EUI are gratefully acknowledged. I would also like to thank Staszek Gomulka, Mario Nuti, Janos Kornai, and Tadeusz Baczko, for suggestions, support and encouragement. I would like to thank as well the Swiss National Fund for Scientific Research, the Dept. of Political Economy of the University of Geneva, and Prof. Pawel Dembinski, for making participation in the symposium possible.

2. Rocznik Statystyczny 1989, p. 117, and Lista 500 1988.

3. In 1985 and 1987 Azoty Włocławek reported very large losses according to profit 3 and profit 4, but with no indication of how these losses would have been covered. Furthermore, the Lista 500 data also show that in these years the same enterprise reported non-negative figures for its enterprise development fund as a percentage of its profit 3, which appears inconsistent with the reported negative values of profit 3.

4. By definition, subsidy 1 ≡ financial result - accumulation + turnover tax. If we calculate subsidy 1 for 1987 using aggregate figures for all state-owned enterprises we obtain the figure of 2055.2 billion złoty; all state subsidies in 1987 amounted to 2527.2 billion złoty. Data from the Rocznik Statystyczny 1988, pp. 99, 113.

5. Later years of the Lista 500 dataset provide a figure which is very close to our subsidy 1. I have used the definition of subsidy 1 as a residual for all years, however, for consistency reasons.

6. To be precise, for 1983-87 the figure given is based on the fixed capital stock in 1982 zloty, probably for 1982, with subsequent years calculated by adding investment in current prices. The 1988 figure is a similar mixture of a 1986 base in 1986 prices plus investment in subsequent

years in current prices.

7. With the differences that the food branch minus alcohol would not be profitable, and the coal branch is not profitable. See e.g. the Rocznik Statystyczny Przemysłu 1988, pp. 114-121.

8. It is worth noting the two main gaps in the Lista 500 data regarding loss-makers: the coal branch (deliberately excluded from the data), and the milk products branch (whose individual enterprises were too small to make the Lista 500, but whose combined subsidy in 1988 was nearly as large as the official Polish defence budget).

9. Though these distortions may still be minimal. For example, it may be the case that in Hungary, as in Poland, all alcohol is produced by one firm in the manufacturing sector which is very highly taxed. It could well be that if the tax revenues of such a firm were excluded, the net tax rate would be near zero. More information on the construction and use of the Kornai-Matits data would be necessary before we could assess the scale of distortion, if any.

10. More specifically, the correlation would be one if there were both a linear tax on profits and an additional (possibly zero) lump-sum tax proportional to the enterprise capital stock. A tax along the lines of the latter was in fact implemented in Poland beginning in 1989 (the so-called "dividend").

Chapter 6: How Polish Enterprises Are Subsidised[1]

Introduction

This chapter is devoted specifically to an analysis of rescues of loss-making enterprises. The focus of the chapter will be the distribution of subsidies to state-owned enterprises. In particular, I will use the Lista 500 data for the period 1983-87 to look for evidence that subsidies are adjusted on an ad hoc, enterprise-specific, ex post basis, and that a policy of bailouts of ailing enterprises is in operation. In Kornai's terminology, I am looking for evidence of a "soft budget constraint". Although anecdotal evidence for the existence of a bailout policy in the East European socialist economies is fairly abundant, hard evidence based on detailed enterprise-level data has been much scarcer. This chapter is an attempt to help fill this gap.

As we shall see, the evidence in support of the above characterisation of the Polish subsidy system is quite strong. Specifically, the main subsidy distributed to enterprises responds very clearly to changes in pre-subsidy enterprise profit. For loss-makers, a change in subsidy is explained almost completely by a change in pre-subsidy profits, and is nearly one-to-one - i.e. an increase in pre-subsidy losses is very predictably matched by a 60-90% increase in subsidy. Profit-makers that receive the subsidy are also compensated in this way, but on a much smaller scale: about 15-30% of a decrease in pre-subsidy profit would be covered by an increase in subsidy. In short, during the period covered by the data, the budget constraints of Polish state-owned enterprise were, in fact, "soft".

The Allocation of Subsidy 1

As we saw in the previous chapter, a significant though not very large fraction of the Lista 500 sample (typically 10%-15%) is composed of loss-makers according to original profit, but at most one or two of these are loss-makers according to final profit. It is what I call subsidy 1 which eliminates these losses.

A good idea of how the state distributes subsidy 1 can be had from a cross-tabulation showing enterprise profitability according to profit 2 (pre-subsidy profitability) vs. profitability according to profit 3 (post-subsidy profitability). For our purposes it is now probably more informative to use the same profitability categories for both pre- and post-subsidy profitability; any movement within the cross-tabulation matrix therefore arises only from the receipt of a subsidy and not from differences between the pre- and post-subsidy profitability categories. For comparability with the cross-tabulation matrices of the previous chapter, the pre-subsidy profitability categories are derived from the original profitability categories used earlier, with a correction for turnover tax paid.[2]

Below is reproduced the cross-tabulation for the 1987 allocation of subsidy 1; the results for other years are very similar. The aggregate subsidy rate (total subsidy 1 / total profit 2) for the sample was quite substantial at 42.5%, raising profitability from 7.37% to 10.51%. The most striking feature of the cross-tabulation matrix is again the treatment of loss-makers. All 57 loss-makers became profitable after receipt of subsidy 1, and nearly all reached the level of either medium or high profitability.

1987 Cross-tabulation Matrix, Allocation of Subsidy 1

Pre-Subsidy 1 Profitability	Post-Subsidy 1 Profitability: Loss Maker	Low 0-4.3%	Medium 4.3-14.5	High >14.5%	Row Total
Loss Maker	0 0.0	6 10.5	36 63.2	15 26.3	57 11.4
Low Prof'bility 0-4.3%	0 0.0	30 57.7	22 42.3	0 0.0	52 10.4
Medium Prof'ity 4.3-14.5%	0 0.0	0 0.0	187 91.7	17 8.3	204 41.0
High Prof'ity > 14.5%	0 0.0	0 0.0	0 0.0	185 100.0	185 37.1
Column Total	0 0.0	36 7.2	245 49.2	217 43.6	498 100.0

Nevertheless, we cannot conclude from the cross-tabulation matrix alone that subsidy 1 is used simply as a rescue subsidy. As I pointed out briefly in Chapter 2, the mere presence of enterprise subsidies is not proof that budget contraints are "soft"; the subsidies must be conditional on the enterprise facing financial difficulties. First of all, loss-makers are the main, but not the only, recipients of subsidy 1. In 1987, for example, loss-makers accounted for 70% of all subsidy 1. The cross-tabulation matrix shows that some low and medium profitability enterprises receive subsidy 1. Indeed, even some high profitability enterprises receive some payment of subsidy 1, as is evidenced from the table below showing aggregate pre- and post-subsidy profitability.

Effects of Subsidy 1 Allocation on Profit Rates, 1987

Profit Rate According to Profit Definition	2	3
Entire Sample	7.4	10.5
By Pre-Subsidy Profitability		
Loss Makers	-9.4	5.4
Low Profitability	2.7	3.7
Medium Profitability	9.0	9.8
High Profitability	23.6	24.7

More fundamentally, we cannot exclude the possibility that the subsidies received are simply lump-sum subsidies. If this were the case, then the profit-maximisation motive would not be affected by the subsidisation, and enterprise incentives would not be affected. We also cannot exclude the possibility that subsidies are granted on the basis of, say, output sold. We saw in the previous chapter that a large part of the pattern of subsidisation can be explained by Polish pricing policy, in particular food pricing policy. If output prices are held artificially low by state regulations (which was often the case in Poland in this period), then a per unit subsidy would be a logical policy instrument to implement. If it is indeed the case that Polish industrial subsidies were per unit subsidies which did not depend on enterprise profitability per se, the absence of post-subsidy loss-makers would not necessarily indicate a policy of bailouts was in operation. We need therefore to investigate the data more closely.

An Econometric Investigation of Rescues

The Polish budget distinguishes between two types of subsidy. Some of the subsidies are product-specific (in Polish, dotacje przedmiotowe, "objective subsidies"); others are enterprise-specific (dotacje podmiotowe, "subjective subsidies"). The former are supposed to compensate enterprises for unfavourable output or input prices; for example, until August 1989 meat processing enterprises had to sell their output at state-set prices which were very low. The latter might be paid, for example, to old enterprises with high operating costs. According to Polish statistics, only a tiny fraction of subsidies are supposed to be enterprise-specific: in 1987, for example, total subsidies to enterprises amounted to 2527 billion złoty, of which only 0.1 billion were officially enterprise-specific.[3]

There is, however, anecdotal evidence that all these subsidies are allocated according to a number of informal, enterprise-specific criteria. An enterprise with a serious liquidity problem might, for example, be granted an extra subsidy which appears in the books as a product-specific subsidy. Unfortunately, the Lista 500 data gives only aggregate figures for subsidies received by each enterprise, rather than separate data on the two types of subsidies. Nevertheless, we can still try to discover from the Lista 500 data the apparent criteria by which subsidies are allocated.

I will be looking at the following questions. First, I will try to estimate a "state subsidisation function". That is, I will estimate a reduced form equation which gives the subsidy received by the enterprise as a function of a number of variables, most importantly enterprise sales and enterprise costs. Second, I will look for evidence that the subsidisation treatment of loss-makers is different from the subsidisation of profit-makers. That is, I will look for evidence that the state rescues loss-makers.

Notation is as follows:

i	Subscript identifying a specific enterprise
j	Subscript identifying a specific product
t	Subscript identifying the year
N	Total number of enterprises
D_{it}	Subsidy received by enterprise i in year t (from Polish <u>dotacje</u>, "subsidy")
S_{it}	Total sales of enterprise i in year t
S_{ijt}	Total sales of product j by enterprise i in year t
C_{it}	Total costs (materials, labour, etc)
MC_{it}	Material costs
NMC_{it}	Non-material costs ($\equiv$ C - MC)
C_{ijt}	Total costs of producing product j by enterprise i in year t
π_{it}	Original profit ("profit 1", $S_{it}-C_{it}$)
Z_{it}	Vector of other enterprise-specific variables
ϵ_{it}	Error term

Denote the enterprise-specific lump-sum subsidy as α_i, the product-specific subsidy rate in year t on sales S as β_t, the product-specific subsidy rate on material costs MC as τ_t, and the product-specific subsidy rate on non-material costs NMC as δ_t. By assumption the enterprise-specific lump-sum subsidy does not vary systematically over time. The allocation of the subsidy may also depend on other enterprise-specific variables Z. Our initial equation in levels thus looks like

$$D_{it} = \alpha_i + \beta_t S_{it} + \tau_t MC_{it} + \delta_t NMC_{it} + Z_{it}\Gamma + u_{it} \qquad (1)$$

We can also write equation (1) in terms of profit, sales and costs, e.g.:

$$D_{it} = \alpha_i + (\beta+\tau)S_{it} + (\delta-\tau)NMC_{it} - \tau\pi_{it} + Z_{it}\Gamma + u_{it} \tag{1'}$$

If the enterprise-specific lump-sum subsidy α_i is small (or, what is less likely, the same for all enterprises) and there are no other enterprise-specific fixed effects, then estimation of (1) in level form is straightforward.[4] If, however, we suspect the presence of such fixed effects, we must eliminate α_i by differencing (1) before estimating. I therefore estimate

$$(D_{it}-D_{it-1}) = \beta_t S_{it} - \beta_{t-1}S_{it-1} + \tau_t MC_{it} - \tau_{t-1}MC_{it-1} + \delta_t NMC_{it} - \delta_{t-1}NMC_{it-1} + Z_{it}\Gamma_t - Z_{it-1}\Gamma_{t-1} + \epsilon \tag{2}$$

where $\epsilon \equiv u_{it}-u_{it-1}$.

Interpretation of the regression coefficients is straightforward. If the coefficients on sales and costs are all insignificant then subsidies are lump-sum and/or arbitrary in the sense of being unrelated to sales or costs. A coefficient on sales which is greater than zero indicates a proportional subsidy on sales; positive coefficients on costs indicate proportional subsidies on inputs. If the coefficient on sales is negative, the coefficients on costs positive, and all of the same absolute value, then the subsidy is essentially a profit/loss subsidy: negative profits are subsidised, positive profits are taxed. Similarly, if the coefficient on sales is negative, the coefficient on material costs positive and of the same absolute value, and the coefficient on non-material costs small and/or insignificant, then the subsidy is essentially a value-added subsidy.

In Poland, different products attract (in theory) different subsidy rates. We can get around this problem to some extent as follows. First, we can run separate regressions for groups of enterprises producing specific products. In practice this is a reasonable procedure only for meat-processing firms (of which there are over 20).

Second, the Polish Statistical Yearbook (Rocznik Statystyczny) lists the products which attract subsidies for domestic sales (as well as aggregate figures for the size of the subsidy on each product). The Lista 500 data unfortunately does not give data for sales and costs by product; however, it does give for each enterprise a 3-digit industrial classification. We can therefore group enterprises according to the subsidised product in which they appear to specialise. This means I can try to estimate the subsidy rate specific to product j by using the 3-digit industrial classification as a proxy for a single product, and assuming that every enterprise produces only one such product. That is, I use the enterprise industrial classification combined with enterprise sales as a proxy for sales of specific products.

Denote the subsidy rate in year t on sales S of product j as β_{jt}, the subsidy rate on material costs MC of product j as τ_{jt}, and the subsidy rate on non-material costs NMC of product j as δ_{jt}. The equation in levels looks like

$$
\begin{aligned}
D_{it} = \; & \alpha_i + \beta_{1t}S_{i1t} + \tau_{1t}MC_{i1t} + \delta_{1t}NMC_{i1t} + \ldots \\
& + \beta_{jt}S_{ijt} + \tau_{jt}MC_{ijt} + \delta_{jt}NMC_{ijt} + \ldots \\
& + Z_{it}\Gamma + u_{it} \qquad (3)
\end{aligned}
$$

where

$S_{ijt} = 0$, $MC_{ijt} = 0$, $NMC_{ijt} = 0$	if firm i is not classified as a manufacturer of product j
$S_{ijt} = S_{it}$, $MC_{ijt} = MC_{it}$, $NMC_{ijt} = NMC_{it}$	if firm i is classified as a manufacturer of product j

To eliminate the enterprise-specific subsidy α_i I again estimate the equation in difference form.

To learn if loss-makers are subsidised differently from profit-makers, I will use the switching regressions technique (Quandt 1958, 1960). We hypothesise that there is an observable variable X_{it} with a critical value X^*. Firms with $X_{it} \leq X^*$ are subsidised according to one set of rules, and firms with $X_{it} > X^*$ are subsidised according to another set of rules. If all firms were the same size (with respect to both capital and labour), the natural choice for the switching variable X would be profit 2, original profit minus turnover tax, because subsidies are added to profit 2 to yield profit 3. We would hypothesise that enterprises with a profit 2 lower than a critical value X^* may be subsidised on more generous terms than enterprises with a profit 2 higher than X^*. There is considerable heterogeneity in firm size, however, and so we have to normalise. I will use for X the value of profit 2 per worker. This seems reasonable given the then Polish government's well known fear of worker unrest. A portion of retained profit is used by enterprises for worker bonuses. For a given subsidy, an enterprise with a low profit 2 per worker is less likely to have cash left over for bonuses than an enterprise with a high profit 2 per worker. When I estimate the model in difference form, the switching variable is the average profit 2 per worker over the two years.

The technique works as follows. Take for example equation (1), suppressing the time subscript and using superscripts 1 and 2 to denote the two different subsidy regimes. I postulate that subsidisation takes two different forms:

$$D_i = \alpha_i + \beta^1 S_i + \tau^1 MC_i + \delta^1 NMC_i + Z_i\Gamma^1 + u^1{}_i \qquad \text{for } X_i \leq X^* \qquad (4a)$$

$$D_i = \alpha_i + \beta^2 S_i + \tau^2 MC_i + \delta^2 NMC_i + Z_i\Gamma^2 + u^2{}_i \qquad \text{for } X_i > X^* \qquad (4b)$$

where u^1 and u^2 are normally distributed with mean zero and standard deviations σ_1 and σ_2. The critical value of

X^* is unknown and is to be estimated along with the other parameters in the equations.

The log of the likelihood function for the breakpoint X^* occurring between X_i and X_{i+1} is given by

$$L(i) = -N \ln(\mathrm{sqrt}(2\pi)) - N/2 - \frac{i}{2} \ln(RSS^1/i) - \frac{(N-i)}{2} \ln(RSS^2/(N-i)) \qquad (5)$$

where RSS^1 and RSS^2 are the residual sums of squares of maximum likelihood estimates done separately on the two samples of firms, (4a) and (4b) (see Quandt 1958). The maximum likelihood estimates of the other parameters in (4a) and (4b) are also given by separate maximum likelihood estimation of the two equations.

In practice, I first rank the sample of firms according to X_{it}; I will use the convention of ranking from lowest to highest. I then conduct a global search over all i for the breakpoint which maximises the log-likelihood function in (5). A breakpoint according to profit 2 per worker, X^*, which maximises (5) corresponds to a breakpoint according to the ranking by profit 2 per worker, i^*.

Since the MLE residual sums of squares and the MLE parameter estimates are also the OLS sums of squares and parameter estimates, this means to obtain all the parameter estimates I need only obtain, for every possible breakpoint i, OLS estimates for the two portions of the sample (low X and high X) separately, and choose the breakpoint i^* which maximises (5). For a sample of N firms, this means I have to obtain slightly less than 2N sets of OLS estimates.[5] Given the number of observations (500 firms in each of 5 years), this is a practical procedure, and has the distinct advantage of guaranteeing a global maximum; we shall see later that local maxima tend to be common.

The advantage of using the switching regressions technique is that our hypothesis may be more general; I ask if low profitability firms are treated differently from high profitability firms, and what is the value of the cut-off point between low and high profitability. That is, I do not have to being with the hypothesis that loss-makers are treated differently from profit-makers, i.e. that 0 is the critical X^*. (If we knew X^* a priori, we could use a Chow test to test its significance.)

To test the significance of X^* I use a likelihood ratio test; the test statistic is $LR = -2\ln(\lambda)$, where the likelihood ratio λ is given by $(RSS^1/i^*)^{i*}(RSS^2/(N-i^*))^{N-i*}$ $/(RSS^U/N)^N$, and RSS^U is the unrestricted sum of squares of an MLE/OLS regression over the entire sample. The χ^2 with r+2 degrees of freedom would normally be used as an approximation to the distribution of LR, where r is the number of regressors (including the constant) in equation 4a (or of course 4b). There is a problem here, however, since the conditions under which the χ^2 distribution is an acceptable approximation to the distribution of LR are not fulfilled here (Quandt 1958, p. 876; Mood 1950, pp. 211, 259). The test statistic LR is still useful, however. The reasons for the violation of these conditions are less serious in this cross-section application than in the usual time series analysis application of the technique;[6] Quandt (1960) has calculated some observed distributions for LR; it has also been reported that in some applications a χ^2 distribution with 3 degrees of freedom may give an acceptable approximation to LR (Goldfeld and Quandt 1976, p. 8). Farley, Hinich and McGuire (1975) present evidence that application of a Chow test at the estimated breakpoint, used as if i^* were known a priori, may give satisfactory results.[7]

An additional useful test is the Farley-Hinich (F-H) test (Farley, Hinich and McGuire, 1975). The F-H test is for the presence of two separate regimes (vs. the null hypothesis that the data is produced by one regression). Unlike the Quandt switching regressions procedure, the F-H test is only a test for the existence of two regimes; it does not tell us the dividing point between the two regimes. It is, however, a useful further test statistic.[8]

Before moving on to discussing in detail the methodology used and the results obtained, I should return briefly to the observation problems mentioned in Chapter 2. The first problem arose because of randomness in the environment; if an enterprise that would otherwise run into difficulties is lucky, it won't need to be rescued. This is not a problem here, however, since we have a large number of enterprises and a substantial number of observations on each, and the enterprises are unlikely to all always be lucky. The second problem arose because although a rescue policy might be in place and influence enterprise behaviour, the result may be to make rescues unnecessary. This problem is also alleviated to some extent by the number of observations we have; with a large number of enterprises and a reasonably long period, we would expect some enterprises to get into difficulties sometimes. The problem is also a problem only if we don't find evidence that a rescue policy is in place, but it isn't a problem if we do find positive evidence that a rescue policy is in fact in place. That is, the problem is that we can't 'prove' a rescue policy doesn't exist; but we can still 'prove' it does exist, and in fact this is what we find below.

Notes on the Data and the Variables Used

The discussion above assumes the data is in real terms. In fact, the data is in nominal terms, and furthermore Poland experienced an acceleration in inflation during this period. For our purposes this is only a problem when I difference to eliminate the firm-specific fixed effect

α_i, since by assumption α_i doesn't vary over time. I therefore deflate all the nominal variables into 1984 złoty using the implicit deflator for sales in socialised industry as reported in the Rocznik Statystyczny. The exception is the switching variable profit 2 per worker. Since the rationale for normalising by the number of workers is workers' welfare, in this case I deflate by the implicit deflator for consumption goods.[9]

All available enterprise observations are used, but (as in the previous chapter) with the two exceptions of Polmos and (in 1985 and 1987) the fertiliser producer Azoty Włocławek.

The size of the subsidy granted to an enterprise may well be influenced by variables besides the product produced and the costs incurred. Not all are observable; for example, an enterprise manager with good political connections should be better at squeezing extra subsidies out of the centre than a manager without such connections. We have, however, some other possibilities for which data is available and which can be included in the regressions: (1) Turnover tax: some subsidised enterprises have to pay turnover tax (essentially a sales tax paid by producers). It may be the case that a loss-making enterprise which has to pay a large turnover tax bill will receive a subsidy in order to meet its turnover tax obligations. (2) The size of the firm: a large enterprise may be better at bargaining with the centre. I cannot use the enterprise's sales as a measure of size/bargaining power, since I am using sales to capture sales subsidies. I use instead the enterprise's employment level. (3) The monopoly power of the firm: an enterprise which accounts for most of the national output of a category of product may have extra bargaining power. I measure monopoly power by first dividing the enterprise's sales by national output of all products within the enterprise's 3-digit industrial classification number, and then subtracting 0.2, the average for the Lista 500 for enterprise sales/national output. The result is a measure of monopoly power which is positive if above average and negative if below average. (4) The wages paid by the enterprise: an enterprise may be able to convince the centre to pay a larger subsidy if it can show that it needs the cash to pay its workers a decent bonus. More specifically, it may be successful in lobbying for a subsidy if it can show its workers are underpaid relative to all industrial workers, or if they are underpaid relative to all workers in their industrial sector. I calculate these two "wage gap" variables as the difference between the actual wage bill of the enterprise (wL) and the enterprise's wage bill if the relevant benchmark wage was paid (w^*L). Unfortunately, the data present a bit of a problem in the use of these wage gap variables. Data on wages include the bonus which is paid out of final profits. The subsidy, our dependent variable, contributes to final profits and thus to bonuses. For this reason I use a lagged wage gap variable in the equation.

As mentioned earlier, we have a largish number of observations for only one category of output (meat products, 22-24 enterprises). This means when I use industry-specific sales/costs variables (e.g. equation 4), I will be relying on relatively few degrees of freedom to estimate our coefficients. For such situations caution is called for, and I will often estimate equations with as few explanatory variables (as many degrees of freedom) as possible.

A word of caution is also in order regarding the data on material and non-material costs. These are not given directly in the data; rather, material costs are calculated using a peculiar measure of labour productivity which is supplied in the Lista 500 data, and non-material costs are simply total costs minus material costs. Unfortunately, the exact definition of the labour productivity measure (and thus material costs) is slightly unclear. (NB: data on material and non-material costs is unavailable for 1983.)

Empirical Results

Discussion of the results is organised into four parts: (1) OLS estimates of equations (1) and (2) for meat processing enterprises alone; (2) OLS estimates for enterprises making the products which attract the largest product-specific subsidies; (3) switching regressions analysis for enterprises producing these subsidised products; (4) switching regressions analysis for enterprises that receive any significant sum from the state in the form of subsidy 1.

Definitions of the variables presented in the tables can be found in Table 6.1, "Regression Variables: Symbols Used".

OLS Results: Meat Enterprises Only

Table 6.2 presents the basic OLS statistics for the final forms of the regressions with meat enterprises only. Heteroscedasticity was suspected on a priori grounds, and Goldfeld-Quandt tests on equations (1) and (2) often indicated its presence. For this reason equations (1) and (2) were estimated using weighted least squares, the weight being enterprise sales. The Goldfeld-Quandt test applied to the WLS estimates showed no clear pattern of heteroscedasticity (Table 6.2, column 5). (All the results discussed below in sections 2-4 also used WLS; again, the WLS estimates show no clear pattern of heteroscedasticity.)

The R^2 in these regressions was quite high for a cross-section sample; even in the regression in differences, the $\bar{R}^2$ varied from 0.55 to 0.85. The Farley-Hinich statistic was significant in only one regression (1985-86), suggesting that meat enterprises are not subsidised differently depending on their profit 2 per worker. Note, however, that these meat enterprises were nearly always loss-makers. The insignificance of the F-H statistic here means only that subsidy rates for this group of loss-makers do not seem to vary with profitability.

Table 6.3 summarises the coefficient estimates for the final specification of all the regressions. Only the coefficients on sales, material costs, and nonmaterial costs were consistently significant. The constant term for the levels regression was always insignificant and is not reported. Each coefficient is estimated either two or three times: once in the levels regression (subscripted t in equation 1), once as the lead variable in the difference regression (subscripted t in equation 2), and once as the lag variable in the difference regression (subscripted t-1 in equation 2). These three estimates correspond to the three columns in Table 6.3.

The results of the various regressions follow a clear and consistent pattern. The coefficient on sales is negative; the coefficients on material and nonmaterial costs are positive; the magnitudes of all the coefficients are similar, especially in any given year; the magnitudes are typically 0.6-0.9, i.e. not far from unity; and the coefficients are typically very significant. In short, <u>subsidy 1 is allocated as a profit/loss subsidy, with</u>

adjustment for changes in enterprise losses near (but not at) 100% (recall that meat processors are nearly always loss-makers). When a meat processing enterprise's losses increase, then, roughly speaking, the enterprise's subsidy 1 increases to compensate for 60%-90% of the increase in losses. When the enterprise's losses decrease, again its subsidy 1 decreases by a nearly matching amount. Note that the response of subsidy 1 to changes in sales is especially perverse; if sales go up without a corresponding increase in costs, the enterprise's subsidy 1, far from going up, actually declines.

Three other points are worth noting. First, the coefficients in the difference regressions are typically lower than the coefficients in the levels regression, though usually not significantly. This can be interpreted as weak evidence for the existence of enterprise-specific fixed effects. Second, the lowest estimated magnitudes for the coefficients was for the 1984 parameters. In fact, in 1984 three meat processing enterprises had a positive pre-subsidy profit 2; in all other years all meat-enterprises were loss-makers. We will return to this point later when we examine the evidence that profit-making enterprises are subsidised at a much lower rate. Third, although all the coefficients in a given year are typically similar in magnitude, this does not always stand up to rigorous statistical testing. That is, we sometimes reject the hypothesis that the coefficients have the same magnitude.

OLS Results: Major Product-Specific Subsidies

Here WLS was applied to equation (3). The major subsidy categories were fertiliser, meat, poultry, grain, and sugar. Different products were allowed to have different subsidy rates, but the variance of the error and the coefficients on the variables besides sales and costs were assumed to be the same for all products. Since none of these other variables was consistently significant and were therefore left out of the final specification of the regressions, the estimation procedure for the final reported results was in fact the SURE technique. The number of observations was small for enterprises in some product categories, and to preserve degrees of freedom a single coefficient was used for all costs (in place of two coefficients for material and nonmaterial costs).

Basic regression statistics are reported in Table 6.4. Unfortunately, the lack of degrees of freedom for some products meant the Goldfeld-Quandt and Farley-Hinich statistics could often not be calculated. The available F-H results do, however, strongly indicate the existence of a regime shift according to pre-subsidy profit per worker.

Table 6.5 presents the estimated coefficients, organised by product category. This time the results are somewhat mixed. Fertiliser enterprises, in the levels regressions, appear to have a roughly 100% profit/loss subsidy: the sales coefficients are about -1, the costs coefficients are about +1, all very significant. The differences regressions, however, are rather different. The coefficients vary a lot and often are insignificant. I suspect in this case misspecification, perhaps because of the presence of enterprise-specific fixed effects and perhaps because we are estimating a single equation when in fact we have two separate subsidy regimes operating (see below).

Results for meat processing enterprises are again as described above. Poultry enterprises have a similar pattern in levels, but with (significant) coefficients of a smaller magnitude, typically 0.3-0.5. In differences, the coefficients are even smaller and not statistically significant. Grain processing enterprises show the same pattern as the meat processing enterprises. Finally, the results for sugar enterprises are inconsistent and vary over time. Sometimes (e.g. 1985) the pattern resembles that of the meat and grain enterprises (significant coefficients in levels and differences, with magnitudes not far from 1); other times (e.g. 1987) the pattern resembles that of the poultry enterprises (significant but small coefficients in levels, insignificant in differences).

The significant Farley-Hinich statistic suggests I may be estimating a misspecified equation; and in fact the inconsistent results by product may be explained by patterns of profitability in the different product groups. Table 6.6 shows, for each of the product categories, the total number of enterprises, and the number of loss-makers according to the different profit definitions, for each year. Note that the two product groups which gave a consistent picture of a high rate profit/loss subsidy - meat and grain - are also the two groups whose enterprises nearly always made pre-subsidy losses (i.e. losses according to profit 2). Note also that the product group which gave a consistent picture of a low rate profit/loss subsidy - poultry - is also the group whose enterprises nearly always made pre-subsidy profits. Finally, note that the remaining two product groups - fertiliser and sugar - had both inconsistent regression results and a mixture of profit-making and loss-making enterprises.

The hypothesis which emerges from the foregoing is that the losses of loss-makers are positively subsidised at a high rate and the profits of profit-makers are negatively subsidised (i.e. taxed) at a low rate. A more general hypothesis is to say that there is a cut-off point in profitability, not necessarily zero; I can then use the switching regressions technique to estimate the cut-off point and the tax/subsidy rates for the two groups of enterprises. Ideally I would simply apply the switching regressions technique to the regressions just described, but unfortunately this is not possible. The problem is that, when we divide the sample in two as we look for the best cut-off point, we often don't have sufficient degrees of freedom for a successful regression on one of the two halves. Say, for example, that in one product group there is a single enterprise whose profitability is much higher than the rest in that group (e.g. poultry or sugar in 1987). When we divide the sample in two, in one part we will have all but one of these enterprises, and in the other other part, just the one very profitable enterprise representing that product group. We cannot estimate two coefficients (the product-specific sales and costs rates) in levels, let alone four coefficients (the same, for two years) in differences, in that part of the sample, and so the technique fails.

To apply the switching regressions technique, we must therefore make a leap of faith, and pool the data. I abandon the use of product-specific subsidy rates, and assume that subsidy rates vary only with profit 2 per worker. Above the critical value of profit 2 per worker, subsidisation by sales, material costs, and nonmaterial costs takes place at rates which are the same for all enterprises and products, and below this critical value, at different rates which are the same for all enterprises and products. This leap of faith is justified to some extent by the regression results just described. The estimates for grain and meat enterprises, for example, were very similar, because, the argument goes, they had similar loss-making patterns.

Switching Technique Results: Major Product-Specific Subsidies

Because I am pooling data and do not need to worry about guaranteeing sufficient degrees of freedom to estimate product-specific coefficients, I can now expand the sample to include product-specific subsidies for which I have only a few observations: fish products and fodder production. Again WLS is used. Results are presented here only for estimation of the differences regression, because of the suspected presence of enterprise-specific fixed effects.

The results of the estimation are presented in Table 6.7. The pattern is clear and statistically very significant: there is a regime shift according to profit 2 per worker, and the critical value of profit 2 per worker is about zero. For example, in the 1986-87 regression, profit 2 per worker ranged from -2.142 to 0.491 million złoty per worker. The breakpoint was found to be between observations 43 and 44 out of a total of 66, i.e. not too close to either of the endpoints. The critical value was between 0.092 and 0.103 million złoty per worker, i.e. not far from zero. It is statistically very significant: the test statistic LR is 73.33, which is very large indeed. By comparison, the critical level for a χ^2 statistic with 3 degrees of freedom at the 1% confidence level is 11.341.

The estimated statistic also appears very significant when we use Quandt's Monte Carlo estimates as a rough guide. For a switching regression with an intercept and one independent variable, Quandt estimates at about 99% the probability that LR < 42 (Quandt 1960, Table 3).[10]

Figure 6.1a plots the likelihood function according to the value of profit 2 per worker; figure 6.1b, according to observation number. In both figures is it clear that the likelihood function is well-behaved, and the estimated maximum is a clear global maximum. The pattern for the other regressions is similar. Note, by the way, the presence of a number of local maxima, suggesting that the use of numerical methods to find the breakpoint could be dangerous.

Chow statistics for the entire sample (testing at the estimated breakpoint), and Farley-Hinich statistics for both the entire sample and for the two portions separately, are also presented in Table 6.7. Both the Chow and Farley-Hinich statistics indicate the presence of a change in regime, which adds to our confidence that the critical values estimated are not spurious. The F-H statistics applied to the two portions of the samples separately suggest that there is no further nonlinearity in the upper portions; that is, profit-makers are not differentiated by profit 2 per worker in how they are subsidised. The results for the loss-maker portion are less clear; in two of the four regressions (1984-85 and

1986-87) there may be further such nonlinearities. I will return to this point later.

Table 6.8 reports the regression results in detail. For each estimation, results for both the pooled data and for the lower and upper portions separately, are reported. As before, the only significant variables were sales, material costs, and nonmaterial costs. The pattern for the loss-making portions is very similar to that for the meat enterprises: the coefficient on sales is negative, the coefficients on costs positive; the magnitudes are all about the same, between 0.75 and 1.0; and all the coefficients are very significant. Again, roughly speaking, loss-makers have their losses subsidised at a marginal rate approaching 100%. The pattern for the profit-making portion is similar, but the subsidy rate is much lower, between 0 and 50%. And again, this description is, statistically speaking, only approximate, since I sometimes reject the hypothesis that the coefficients on sales and costs have the same absolute magnitude (but again the difference is small even when significant).

Switching Technique Results: Major Subsidy Recipients

Our final set of results applies to all enterprises that received a "significant" subsidy 1, here defined as at least 10 million złoty (in the second year). Typically, nearly half the Lista 500 enterprises receive a subsidy 1 on this scale. Note that for the estimation here to be unbiased we need to assume that the combined error term ϵ ($\equiv u_{it}-u_{it-1}$) is independent of the level of subsidy 1.[11]

Table 6.9 presents the switching technique results. The numbers are very similar to those for the major product-specific subsidies discussed above, with the following differences: the sample size is now considerably larger, and the range of observed profit 2 per worker is also larger; the estimated critical value of profit 2 per worker is now consistently very close indeed to zero; and its statistical significance, as measured by 2 * the log likelihood, is huge. Figures 2a and 2b show the log of the likelihood function for the 1986-87 regression; again, the maximum is clearly global (and again, local maxima are common). The results for the other regressions are similar.

Table 6.10 presents the regression results in detail. Again the numbers are very similar to those for the major product-specific subsidies. The main difference here is that in addition to the sales and costs variables, turnover tax and our measure of market power (MONOP) are also statistically significant.[12] The fact that turnover tax is now significant and wasn't previously is due simply to the fact that for the first time I have included in our sample a large number of enterprises that actually pay this tax. The coefficient on turnover tax is very much like the coefficients on costs: positive and near unity for the loss-makers, positive but small for the profit-makers. In other words, enterprises are compensated for changes in turnover tax by corresponding changes in subsidy 1; loss-makers are compensated at nearly a 100% rate, profit-makers at a much lower rate.

The coefficient on MONOP is negative and significant but usually only in the profit-making portion of the sample. Exactly why an increase in market share should lead to a decrease in subsidy 1 is not clear. One possibility is that an increase in market share means the enterprise need be less reliant on the centre for subsidies. More work is needed here.

Summary of Results

Subsidy 1 responds to changes in pre-subsidy enterprise profit. For loss-makers, a change in subsidy 1 is explained almost completely by a change in pre-subsidy profits, and is nearly one-to-one - i.e. an increase in pre-subsidy losses is very predictably matched by a 60-90% increase in subsidy 1. Profit-makers that receive subsidy 1 are also compensated in this way, but on a much smaller scale, i.e. about 15-30% of a decrease in profit 1 would be covered by an increase in subsidy 1. For loss-makers that must pay turnover tax, changes in this tax are compensated by changes in subsidy 1; if e.g. an enterprises has to pay more turnover tax for some reason, it is likely to receive an increase in subsidy 1 in compensation. Again, profit-makers are also compensated in this way for turnover tax changes, but to a much lesser degree. The only other variable which seems to affect the allocation of subsidy 1 is market share, which has a small but significantly negative impact for profit-making enterprises. No other variables displayed a significant and consistent effect on subsidy 1. In short, a state policy of bailouts in in operation.

Possible lines to follow in future work are as follows. To begin with, one can argue that the estimated model in differences is in fact misspecified. The switching variable for the differences formulation is average profit 2 per worker over the two years. This means that all enterprises are in one regime for both years, or in the other regime for both years. Better would be to allow enterprises to move from one regime to the other over the two years. A change in the estimation procedure along these lines would probably not, however, lead to significant differences in the results because of the relatively small number of enterprises that actually move from one regime to the other. Incidentally, recall that the F-H statistic for lower portion of the switching regimes sample sometimes showed the continued presence of nonlinearity. The above misspecification may be its source.

A second possibility worth investigating relates to the nature of the switching variable. Above I simply assumed a priori that it was profit 2 per worker. Naturally, it would be better to allow for a number of different switching variables, and let the data tell us which switching variables if any are significant. Goldfeld and Quandt (1972, chapter 9) discuss a generalised switching regimes method which allows precisely this type of analysis. Unfortunately it requires the use of numerical methods, but it may be worth exploring nonetheless.

The policy implications of the analysis in this chapter are quite clear. The effects of the Polish subsidy system on enterprise incentives during this period were of course serious. A loss-making enterprise had little reason to try to cut costs or increase sales if these gains would largely disappear in the form of a decrease in subsidy. Competition among all firms is blunted when it is common knowledge that the ultimate punishment for inefficiency - bankruptcy - does not exist. A major challenge facing the Polish reformers today is to implement a tax/subsidy system which is clearly outlined and consistently applied, and which is not arbitrarily adjusted to suit the needs of individual enterprises. In short, what is needed is the introduction of the rule of law, in particular the rule of economic law. The methodology outlined in this chapter should allow us to measure the success of the Polish reformers in introducing the rule of economic law, once the necessary data becomes available.

Table 6.1: Symbols Used in Regression Results

VARXXXYY

VAR = Variable used

SALE	=	Value of total enterprise sales (incl. exports)
S	=	Same as SALE
COST	=	Value of all costs of production
C	=	Same as COST
MCOST	=	Materials costs
NMC	=	Non-materials costs
TTAX	=	Turnover tax
SUB1	=	Subsidy 1
MONOP	=	Market share
WGAP	=	Wage gap relative to the average industrial wage
BWGAP	=	Wage gap relative to the average for that 3-digit industrial branch

XXX = Industrial classification (if relevant)

123	=	artificial fertilizer
231	=	meat products
233	=	poultry products
234	=	fish products
241	=	grain products
243	=	sugar
261	=	fodder

YY = Year or Years

87 = Value of Variable in 1987
86 = Value in 1986
... etc.

76 = Value in 1987 - Value in 1986
= Growth 1986-7

65 = Value in 1986 - Value in 1985
= Growth 1985-6

54 = Value in 1985 - Value in 1984
= Growth 1984-5
... etc.

EXAMPLES

SALE86	=	Value of total sales in 1986
SUB176	=	Change in Subsidy 1, 1986-7
S23176	=	Change in sales of meat, 1986-7

Table 6.2: Regression Results, Meat Products Enterprises

Basic (OLS) regression statistics

Dep Var	Obs/DoF	R^2 / $Rbar^2$	G-Q (p-value)	F-H (p-value)
Levels				
SUB187	22/18	0.911 / 0.897	0.904 (0.538)	0.425 (0.788)
SUB186	24/20	0.959 / 0.952	1.806 (0.245)	0.660 (0.629)
SUB185	24/20	0.918 / 0.906	0.721 (0.649)	0.891 (0.492)
SUB184	23/19	0.898 / 0.881	0.160 (0.967)	0.998 (0.439)
SUB183	24/21	0.937 / 0.931	0.108 (0.996)	1.963 (0.156)
First Differences				
SUB176	22/16	0.673 / 0.570	0.902 (0.526)	1.135 (0.409)
SUB165	24/18	0.824 / 0.775	3.341 (0.135)	7.779 (0.001)
SUB154	23/17	0.648 / 0.545	0.178 (0.905)	1.619 (0.231)
SUB143	23/18	0.877 / 0.850	0.166 (0.945)	1.007 (0.452)

G-Q = Goldfeld-Quandt test for heteroskedasticity
F-H = Farley-Hinich statistic

Table 6.3: Regression Results, Meat Products Enterprises

OLS coefficients (standard errors in parentheses)

	Levels	First Differences t	First Differences t-1
SALE87	-0.883748 (0.085066)	-0.769912 (0.191751)	
MCOST87	0.946250 (0.077887)	0.792776 (0.191985)	
NMC87	0.918790 (0.074313)	0.644251 (0.326768)	
SALE86	-0.882983 (0.052947)	-0.898787 (0.120940)	-0.826741 (0.183351)
MCOST86	0.933282 (0.049453)	0.878725 (0.111513)	0.833504 (0.190112)
NMC86	0.954156 (0.054017)	0.705181 (0.166321)	0.717477 (0.320344)
SALE85	-0.637593 (0.059825)	-0.520606 (0.154356)	-0.676424 (0.134619)
MCOST85	0.710088 (0.057739)	0.595592 (0.145555)	0.676903 (0.132130)
NMC85	0.779133 (0.062127)	0.595954 (0.171196)	0.447055 (0.200305)
SALE84	-0.504185 (0.068826)	-0.509778 (0.108496)	-0.491488 (0.181881)
MCOST84	0.564215 (0.069791)	0.532958 (0.112220)	0.555542 (0.171504)
NMC84	0.639735 (0.058859)	0.600171 (0.098659)	0.524824 (0.175357)
SALE83	-0.902612 (0.058837)		-0.904694 (0.105147)
COST83	0.934607 (0.053125)		0.904355 (0.086830)

Note: The constant term for the levels regressions is not reported, as it was always insignificant.

Table 6.4: Regression Results, Major Subsidised Industries
(fertiliser, meat, poultry, grain, sugar)

Basic (OLS) regression statistics

Coefficients on sales and costs are industry-specific.

Dep Var	Obs/DoF	R^2 / $\bar{R}^2$	G-Q (p-value)	F-H (p-value)
Levels				
SUB187	52/43	0.992 / 0.990	3.421 (0.026)	1.651 (0.140)
SUB186	64/53	0.990 / 0.988	0.934 (0.552)	2.557 (0.014)
SUB185	66/55	0.985 / 0.983	0.855 (0.617)	2.347 (0.022)
SUB184	65/54	0.988 / 0.986	n.a.	3.454 (0.002)
SUB183	69/58	0.994 / 0.993	0.346 (0.979)	4.540 (0.000)
First Differences				
SUB176	51/35	0.809 / 0.727	n.a.	n.a.
SUB165	63/43	0.955 / 0.935	n.a.	n.a.
SUB154	63/43	0.964 / 0.949	n.a.	n.a.
SUB143	63/43	0.943 / 0.918	n.a.	n.a.

n.a. = not available

Table 6.5: Regression Results, Major Subsidised Industries

OLS coefficients (standard errors in parentheses)

	Levels	First Differences t	t-1
Industry 123: Fertiliser			
S12387	-1.143051	-1.064490	
	(0.024913)	(0.301123)	
C12387	1.266468	1.305857	
	(0.022107)	(0.204113)	
S12386	-1.049312	0.238367	-0.994239
	(0.040224)	(0.377518)	(0.334781)
C12386	1.121368	0.011653	1.209464
	(0.032313)	(0.248377)	(0.202441)
S12385	-1.051215	-0.696075	0.956583
	(0.053364)	(0.104445)	(0.520280)
C12385	1.113854	0.939361	-0.688062
	(0.045679)	(0.176098)	(0.371603)
S12384	-0.908411	-0.386605	-0.595748
	(0.049070)	(0.091221)	(0.134425)
C12384	0.994412	0.478153	0.845612
	(0.043619)	(0.055597)	(0.236243)
S12383	-0.950960		-0.261714
	(0.052238)		(0.097917)
C12383	1.030578		0.326071
	(0.049615)		(0.072865)

Table 6.5: Regression Results, Major Subsidised Industries (continued)

OLS coefficients (standard errors in parentheses)

	Levels	First Differences t	t-1
Industry 231 - Meat products			
S23187	-0.852490	-0.825207	
	(0.078784)	(0.185493)	
C23187	0.913968	0.840842	
	(0.070234)	(0.188764)	
S23186	-0.881881	-0.956606	-0.904688
	(0.108930)	(0.135032)	(0.166013)
C23186	0.932876	0.914067	0.907781
	(0.099057)	(0.127436)	(0.174900)
S23185	-0.653057	-0.558895	-0.729397
	(0.118540)	(0.167622)	(0.148546)
C23185	0.727526	0.633809	0.706265
	(0.111028)	(0.157296)	(0.150520)
S23184	-0.588514	-0.586885	-0.491103
	(0.142556)	(0.090624)	(0.207159)
C23184	0.656626	0.603004	0.552216
	(0.137546)	(0.098112)	(0.194611)
S23183	-0.897619		-0.883302
	(0.116595)		(0.103318)
C23183	0.934546		0.869167
	(0.105427)		(0.082126)

Table 6.5: Regression Results, Major Subsidised Industries (continued)

OLS coefficients (standard errors in parentheses)

	Levels	First Differences t	t-1
Industry 233 - Poultry products			
S23387	-0.595872	-0.279958	
	(0.128280)	(0.159080)	
C23387	0.675168	0.348733	
	(0.134768)	(0.182271)	
S23386	-0.392194	-0.322249	-0.366414
	(0.249161)	(0.294764)	(0.295649)
C23386	0.461545	0.333468	0.433384
	(0.254422)	(0.296207)	(0.269378)
S23385	-0.407767	-0.075052	-0.313258
	(0.174114)	(0.116620)	(0.239885)
C23385	0.464974	0.095535	0.319475
	(0.179952)	(0.123471)	(0.223556)
S23384	-0.221495	0.147605	0.068031
	(0.239134)	(0.212560)	(0.171250)
C23384	0.280329	-0.048504	-0.061773
	(0.253524)	(0.230550)	(0.168168)
S23383	-0.267657		-0.035964
	(0.153053)		(0.169979)
C23383	0.319926		0.069377
	(0.161556)		(0.185996)

Table 6.5: Regression Results, Major Subsidised Industries (continued)

OLS coefficients (standard errors in parentheses)

Industry 241 - Grain products

(Insufficient observations for 1987)

	Levels	First Differences t	First Differences t-1
S24186	-0.877455	-0.637747	
	(0.102579)	(0.216196)	
C24186	1.019729	0.567887	
	(0.071913)	(0.233884)	
S24185	-0.818081	-0.743858	-0.882477
	(0.067664)	(0.102827)	(0.171415)
C24185	0.954873	0.836043	0.721016
	(0.048479)	(0.083336)	(0.122159)
S24184	-0.859068	-0.612461	-0.757183
	(0.120065)	(0.108843)	(0.163010)
C24184	1.002113	0.827306	0.865357
	(0.083693)	(0.083722)	(0.134606)
S24183	-0.992663		-0.515956
	(0.092608)		(0.122504)
C24183	1.053619		0.757224
	(0.057646)		(0.072523)

Table 6.5: Regression Results, Major Subsidised Industries
(continued)

OLS coefficients (standard errors in parentheses)

	Levels	First Differences t	First Differences t-1
Industry 243 - Sugar			
S24387	-0.360255	-0.108109	
	(0.085413)	(0.134969)	
C24387	0.422267	0.161784	
	(0.092601)	(0.185113)	
S24386	-0.545723	-0.625023	-0.299099
	(0.151601)	(0.179332)	(0.137168)
C24386	0.635871	0.734850	0.359184
	(0.176397)	(0.200900)	(0.196495)
S24385	-0.841917	-0.611089	-0.838237
	(0.107541)	(0.129703)	(0.118347)
C24385	0.906771	0.649954	0.917373
	(0.111536)	(0.168823)	(0.123697)
S24384	-0.502766	-0.288701	-0.339735
	(0.230576)	(0.169047)	(0.200670)
C24384	0.548793	0.302193	0.371429
	(0.227142)	(0.189585)	(0.220430)
S24383	-0.928999		-0.443944
	(0.079659)		(0.139680)
C24383	1.058340		0.502611
	(0.083973)		(0.149029)

Table 6.6: Loss-Makers and Profit-Makers, Major Subsidised Industries 1983-7

Year	Total no. of enterprises	of which, lossmakers according to: Profit 1	2	3	4
	Fertiliser enterprises - industry 123				
1983	7	2	2	0	0
1984	7	3	3	0	0
1985	6	3	3	0	0
1986	7	4	4	0	0
1987	7	2	2	0	0
	Meat enterprises - industry 231				
1983	24	24	24	0	0
1984	23	19	20	1	2
1985	24	24	24	0	0
1986	24	24	24	0	0
1987	22	22	22	0	0
	Poultry enterprises - industry 233				
1983	13	1	1	0	0
1984	14	0	0	0	0
1985	15	2	2	0	0
1986	15	0	0	0	0
1987	12	1	1	0	0
	Grain enterprises - industry 241				
1983	13	13	13	0	0
1984	11	11	11	0	0
1985	10	10	10	0	0
1986	7	7	7	0	0
1987	5	5	5	0	0
	Sugar enterprises - industry 243				
1983	12	3	3	0	0
1984	10	5	5	0	0
1985	11	3	3	0	0
1986	11	0	0	0	0
1987	11	1	1	0	0

Table 6.7: Switching Regressions,
Major Subsidised Industries
(fertiliser, meat, poultry, fish, grain, sugar, fodder)

Switching variable is P2LRT, profit 2 per worker in 1984 złoty.

Coefficients on independent variables (sales, material costs, non-material costs) are assumed not to vary by industry.

Results are for the model in first differences only.

Switching Regressions: Basic Results

Eqn	Search grid boundaries Lower	Search grid boundaries Upper	Breakpt/ Sample Size	Lower Bound P2LRT	Upper Bound P2LRT	LR
86-87	-2.142	0.491	43/66	0.092	0.103	73.33
85-86	-1.908	0.442	45/73	-0.011	-0.003	73.83
84-85	-1.650	0.260	40/73	-0.181	-0.169	56.35
83-84	-2.060	0.246	44/73	-0.213	-0.181	63.77

LR = likelihood ratio test statistic

Switching Regressions: Farley-Hinich and Chow Statistics
(P-values in parentheses)

Eqn	Farley-Hinich Statistic Entire sample	Farley-Hinich Statistic Lower portion	Farley-Hinich Statistic Upper portion	Chow Statistic
86-87	3.08	3.53	0.58	11.28
	(0.011)	(0.009)	(0.742)	(0.000)
85-86	7.90	1.39	1.68	10.33
	(0.000)	(0.249)	(0.191)	(0.000)
84-85	6.60	2.68	1.75	9.91
	(0.000)	0.035)	(0.158)	(0.000)
83-84	3.86	1.65	1.43	17.56
	(0.004)	(0.174)	(0.258)	(0.000)

Figure 6.1a: Log of the Likelihood Function According to Value of Switching Variable, Major Subsidised Industries

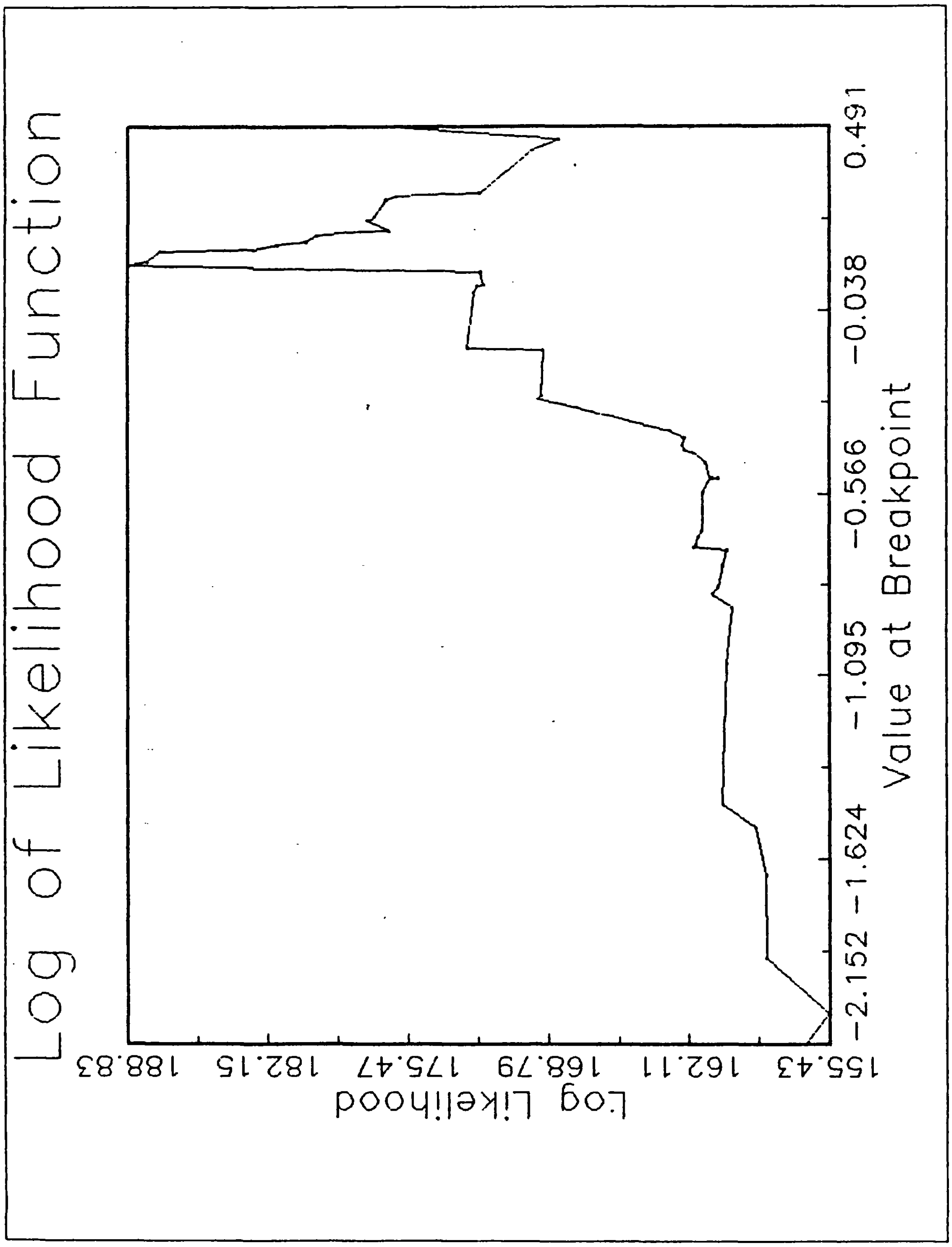


Figure 6.1b: Log of the Likelihood Function According to Observation Number, Major Subsidised Industries

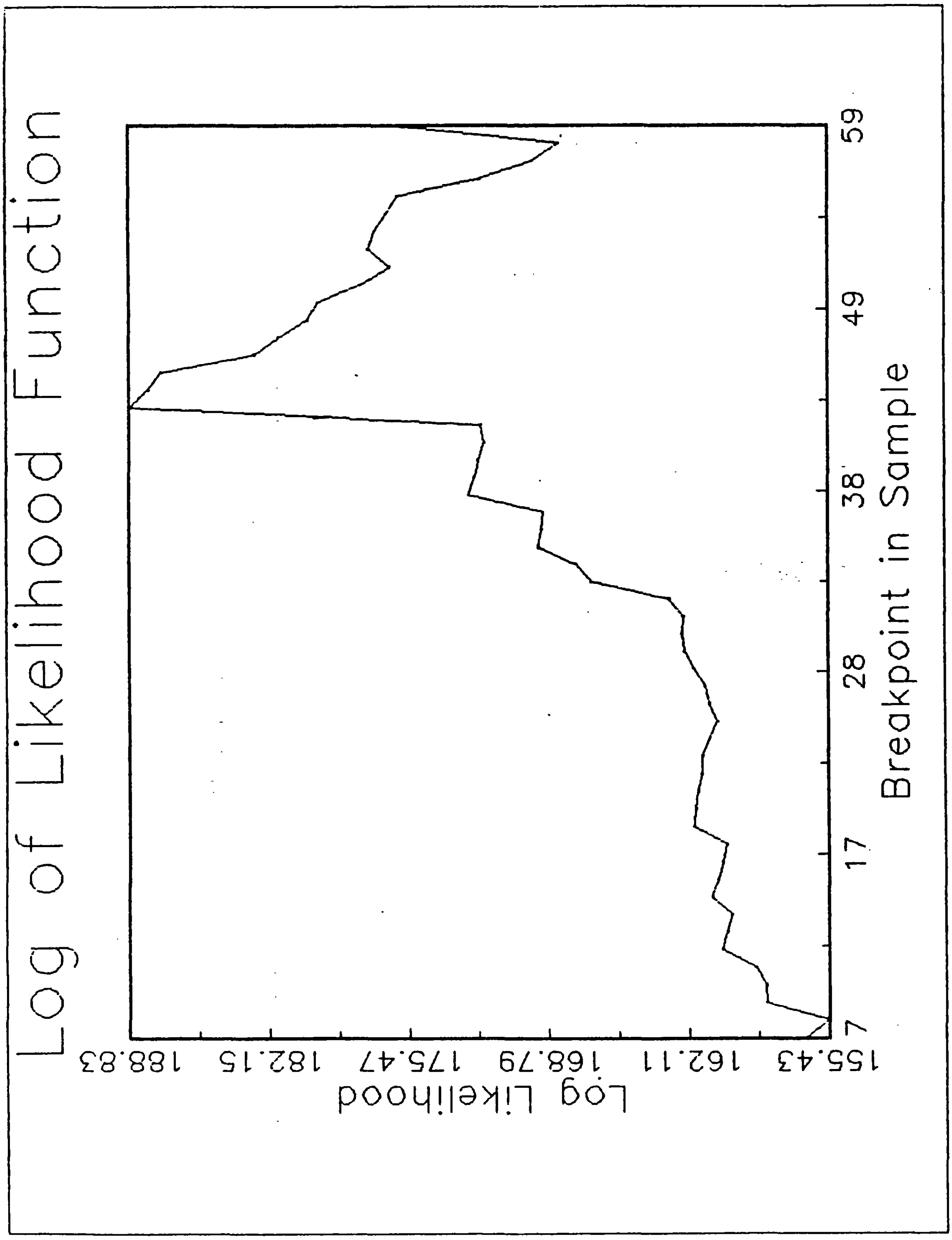


Table 6.8: Switching Regressions, Major Subsidised Industries

Regression Results in Detail

1. 1986-1987

OLS RESULTS: Entire Sample

Dep variable:	SUB176	Mean :	0.026
Minimum :	-0.120	Maximum :	0.255
Observations:	66	Degrees of freedom:	60
Weighted LS :	Weight is inverse of sale87		
R-squared :	0.857	Rbar-squared :	0.845
Residual SS :	0.038	Std error of est :	0.025
Total SS :	0.269	Log like :	152.1711

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE87	1.000000	-0.621157	0.050154	-12.385	0.000
SALE86	1.013131	0.536576	0.060621	8.851	0.000
MCOST87	0.968960	0.668210	0.067420	9.911	0.000
MCOST86	0.999440	-0.581262	0.075041	-7.746	0.000
NMC87	0.140704	0.744959	0.063367	11.756	0.000
NMC86	0.104065	-0.649256	0.077518	-8.376	0.000

OLS RESULTS: 1st Portion

Dep variable:	SUB176	Mean :	0.032
Minimum :	-0.120	Maximum :	0.255
Observations:	43	Degrees of freedom:	37
Weighted LS :	Weight is inverse of sale87		
R-squared :	0.938	Rbar-squared :	0.930
Residual SS :	0.016	Std error of est :	0.021
Total SS :	0.255	Log like :	109.1174

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE87	1.000000	-0.745871	0.060229	-12.384	0.000
SALE86	1.047640	0.637461	0.080727	7.896	0.000
MCOST87	1.042866	0.765736	0.086789	8.823	0.000
MCOST86	1.096818	-0.654788	0.106165	-6.168	0.000
NMC87	0.163684	0.841038	0.088700	9.482	0.000
NMC86	0.134529	-0.805627	0.120303	-6.697	0.000

OLS RESULTS: 2nd Portion

Dep variable:	SUB176	Mean :	0.016
Minimum :	-0.026	Maximum :	0.054
Observations:	23	Degrees of freedom:	17
Weighted LS :	Weight is inverse of sale87		
R-squared :	0.871	Rbar-squared :	0.833
Residual SS :	0.001	Std error of est :	0.009
Total SS :	0.010	Log like :	79.7162

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE87	1.000000	-0.151656	0.053364	-2.842	0.011
SALE86	0.948614	0.352869	0.042127	8.376	0.000
MCOST87	0.830788	0.206287	0.072348	2.851	0.011
MCOST86	0.817385	-0.437857	0.049939	-8.768	0.000
NMC87	0.097741	0.393692	0.088790	4.434	0.000
NMC86	0.047112	-0.399782	0.046232	-8.647	0.000

Table 6.8: Switching Regressions, Major Subsidised Industries (continued)

Regression Results in Detail

2. 1985-1986

OLS RESULTS: Entire Sample

Dep variable:	SUB165	Mean :	0.033
Minimum :	-0.131	Maximum :	0.345
Observations:	73	Degrees of freedom:	67
Weighted LS :	Weight is inverse of sale86		
R-squared :	0.805	Rbar-squared :	0.790
Residual SS :	0.067	Std error of est :	0.032
Total SS :	0.343	Log like :	151.6646

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE86	1.000000	-0.697732	0.070287	-9.927	0.000
SALE85	0.926255	0.622611	0.095717	6.505	0.000
MCOST86	0.990052	0.836537	0.073609	11.365	0.000
MCOST85	0.881228	-0.748577	0.101366	-7.385	0.000
NMC86	0.104230	0.668574	0.079380	8.422	0.000
NMC85	0.121782	-0.689779	0.064280	-10.731	0.000

OLS RESULTS: 1st Portion

Dep variable:	SUB165	Mean :	0.055
Minimum :	-0.131	Maximum :	0.345
Observations:	45	Degrees of freedom:	39
Weighted LS :	Weight is inverse of sale86		
R-squared :	0.888	Rbar-squared :	0.874
Residual SS :	0.030	Std error of est :	0.028
Total SS :	0.271	Log like :	100.5495

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE86	1.000000	-0.879897	0.095766	-9.188	0.000
SALE85	0.934223	0.672891	0.127877	5.262	0.000
MCOST86	1.066481	0.955398	0.082266	11.613	0.000
MCOST85	0.937042	-0.760471	0.121632	-6.252	0.000
NMC86	0.134236	1.017137	0.102354	9.937	0.000
NMC85	0.151324	-0.900520	0.074822	-12.035	0.000

OLS RESULTS: 2nd Portion

Dep variable:	SUB165	Mean :	-0.002
Minimum :	-0.059	Maximum :	0.029
Observations:	28	Degrees of freedom:	22
Weighted LS :	Weight is inverse of sale86		
R-squared :	0.794	Rbar-squared :	0.748
Residual SS :	0.003	Std error of est :	0.012
Total SS :	0.015	Log like :	88.0313

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE86	1.000000	-0.325966	0.048010	-6.790	0.000
SALE85	0.913449	0.470066	0.060774	7.735	0.000
MCOST86	0.867219	0.327143	0.060722	5.388	0.000
MCOST85	0.791525	-0.473344	0.067504	-7.012	0.000
NMC86	0.056005	0.298114	0.049459	6.027	0.000
NMC85	0.074304	-0.424083	0.077851	-5.447	0.000

Table 6.8: Switching Regressions, Major Subsidised Industries (continued)

Regression Results in Detail

3. 1984-1985

OLS RESULTS: Entire Sample

Dep variable:	SUB154	Mean :	0.005
Minimum :	-0.222	Maximum :	0.153
Observations:	73	Degrees of freedom:	67
Weighted LS :	Weight is inverse of sale85		
R-squared :	0.854	Rbar-squared :	0.843
Residual SS :	0.036	Std error of est :	0.023
Total SS :	0.245	Log like :	174.4427

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE85	1.000000	-0.712012	0.051419	-13.847	0.000
SALE84	1.018648	0.622379	0.071516	8.703	0.000
MCOST85	0.954681	0.807189	0.048699	16.575	0.000
MCOST84	0.790433	-0.695989	0.075761	-9.187	0.000
NMC85	0.136414	0.732995	0.061763	11.868	0.000
NMC84	0.312203	-0.761058	0.048019	-15.849	0.000

OLS RESULTS: 1st Portion

Dep variable:	SUB154	Mean :	0.009
Minimum :	-0.222	Maximum :	0.153
Observations:	40	Degrees of freedom:	34
Weighted LS :	Weight is inverse of sale85		
R-squared :	0.937	Rbar-squared :	0.928
Residual SS :	0.014	Std error of est :	0.020
Total SS :	0.217	Log like :	103.0153

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE85	1.000000	-0.830718	0.064469	-12.886	0.000
SALE84	1.031915	0.825732	0.105216	7.848	0.000
MCOST85	1.016153	0.948287	0.056915	16.661	0.000
MCOST84	0.774518	-0.928350	0.106803	-8.692	0.000
NMC85	0.183390	0.838050	0.069864	11.995	0.000
NMC84	0.443286	-0.926915	0.054415	-17.034	0.000

OLS RESULTS: 2nd Portion

Dep variable:	SUB154	Mean :	0.00008899
Minimum :	-0.082	Maximum :	0.047
Observations:	33	Degrees of freedom:	27
Weighted LS :	Weight is inverse of sale85		
R-squared :	0.831	Rbar-squared :	0.800
Residual SS :	0.005	Std error of est :	0.013
Total SS :	0.027	Log like :	99.6020

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE85	1.000000	-0.531234	0.056308	-9.434	0.000
SALE84	1.002567	0.264556	0.058878	4.493	0.000
MCOST85	0.880168	0.634402	0.056721	11.185	0.000
MCOST84	0.809723	-0.364858	0.067167	-5.432	0.000
NMC85	0.079475	0.456062	0.071902	6.343	0.000
NMC84	0.153314	-0.215922	0.061446	-3.514	0.002

Table 6.8: Switching Regressions, Major Subsidised Industries (continued)

Regression Results in Detail

4. 1983-1984

OLS RESULTS: Entire Sample

Dep variable:	SUB143	Mean :	-0.006
Minimum :	-0.188	Maximum :	0.168
Observations:	73	Degrees of freedom:	68
Weighted LS :	Weight is inverse of sale84		
R-squared :	0.809	Rbar-squared :	0.798
Residual SS :	0.064	Std error of est :	0.031
Total SS :	0.336	Log like :	153.3128

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE84	1.000000	-0.464800	0.074514	-6.238	0.000
SALE83	0.955110	0.431716	0.054561	7.913	0.000
MCOST84	0.772569	0.696891	0.066856	10.424	0.000
NMC84	0.320753	0.694194	0.049824	13.933	0.000
COST83	1.063447	-0.671715	0.043450	-15.459	0.000

OLS RESULTS: 1st Portion

Dep variable:	SUB143	Mean :	-0.010
Minimum :	-0.188	Maximum :	0.168
Observations:	44	Degrees of freedom:	39
Weighted LS :	Weight is inverse of sale84		
R-squared :	0.947	Rbar-squared :	0.942
Residual SS :	0.017	Std error of est :	0.021
Total SS :	0.315	Log like :	110.9282

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE84	1.000000	-0.763339	0.074177	-10.291	0.000
SALE83	0.937872	0.757346	0.062999	12.022	0.000
MCOST84	0.752872	0.835750	0.060410	13.835	0.000
NMC84	0.424092	0.843824	0.040173	21.005	0.000
COST83	1.153532	-0.818721	0.037030	-22.109	0.000

OLS RESULTS: 2nd Portion

Dep variable:	SUB143	Mean :	0.001
Minimum :	-0.043	Maximum :	0.091
Observations:	29	Degrees of freedom:	24
Weighted LS :	Weight is inverse of sale84		
R-squared :	0.461	Rbar-squared :	0.371
Residual SS :	0.010	Std error of est :	0.021
Total SS :	0.019	Log like :	74.2704

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE84	1.000000	0.102753	0.085081	1.208	0.239
SALE83	0.981264	0.244545	0.088649	2.759	0.011
MCOST84	0.802454	0.007010	0.102605	0.068	0.946
NMC84	0.163963	0.218508	0.103450	2.112	0.045
COST83	0.926766	-0.413091	0.108996	-3.790	0.001

Table 6.9: Switching Regressions, Major Subsidy Recipients

Major subsidy recipients are defined as all enterprises whose subsidy 1 equals or exceeds 10 million złoty (in the second year).

Switching variable is P2LRT, profit 2 per worker in 1984 złoty.

Coefficients on independent variables are assumed not to vary by industry.

Results are for the model in first differences only.

Switching Regressions: Basic Results

Eqn	Search grid boundaries Lower	Search grid boundaries Upper	Breakpt/ Sample Size	Lower Bound P2LRT	Upper Bound P2LRT	LR
86-87	-0.941	0.974	76/242	0.092	0.103	232.4
85-86	-0.820	0.763	88/245	0.080	0.081	220.7
84-85	-0.883	0.682	79/240	0.044	0.048	194.3
83-84	-0.618	0.549	76/223	0.039	0.042	133.3

LR = likelihood ratio test statistic

Switching Regressions: Farley-Hinich and Chow Statistics
(P-values in parentheses)

Eqn	Farley-Hinich Statistic Entire sample	Farley-Hinich Statistic Lower portion	Farley-Hinich Statistic Upper portion	Chow Statistic
86-87	15.88	3.15	0.75	25.38
	(0.000)	(0.003)	(0.678)	(0.000)
85-86	10.06	1.09	1.07	23.50
	(0.000)	(0.384)	(0.387)	(0.000)
84-85	19.41	3.53	0.42	21.89
	(0.000)	(0.001)	(0.934)	(0.000)
83-84	5.92	1.64	2.02	16.09
	(0.000)	(0.124)	(0.042)	(0.000)

<u>Figure 6.2a: Log of the Likelihood Function According to Value of Switching Variable, Major Subsidy Recipients</u>

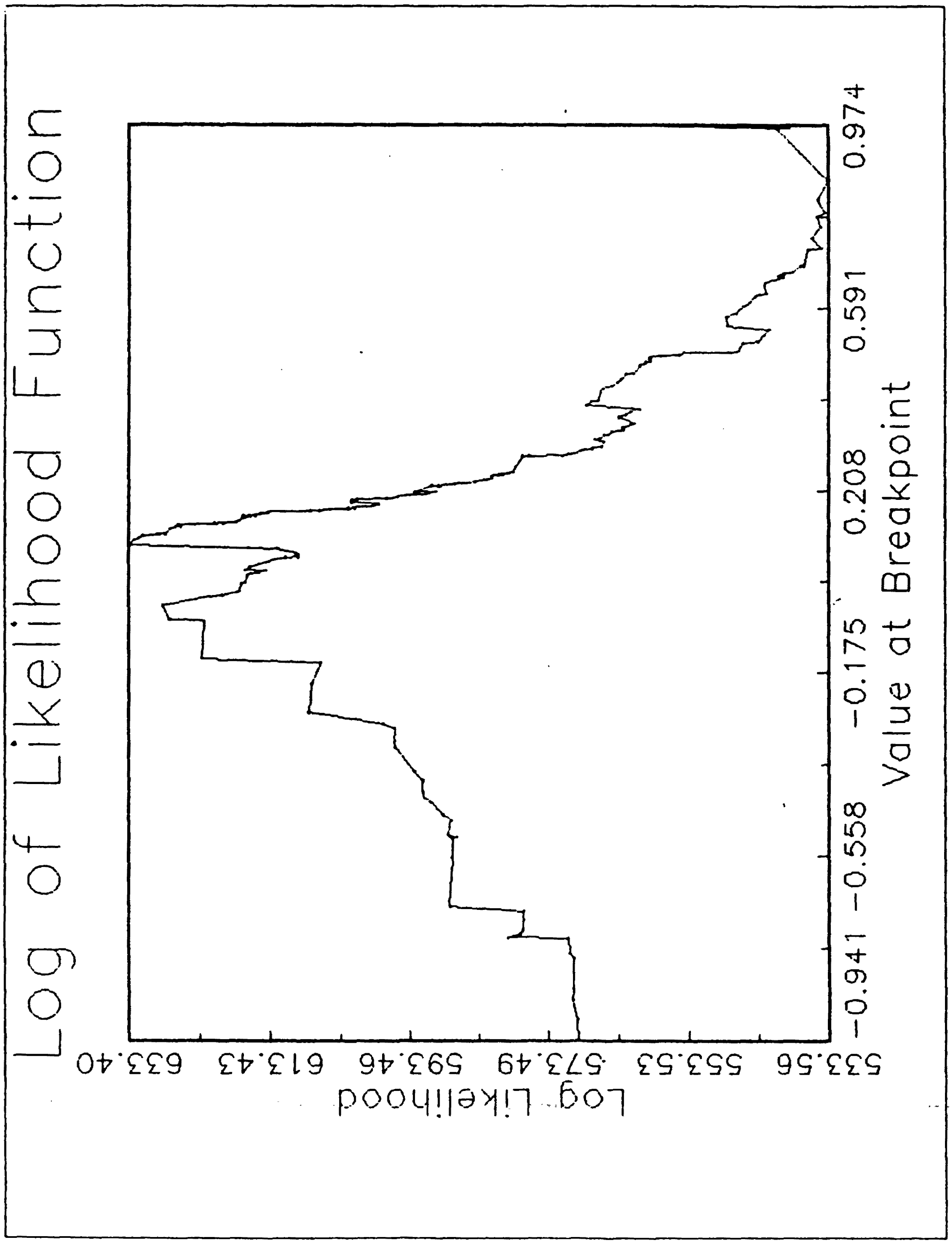


Figure 6.2b: Log of the Likelihood Function According to Observation Number, Major Subsidy Recipients

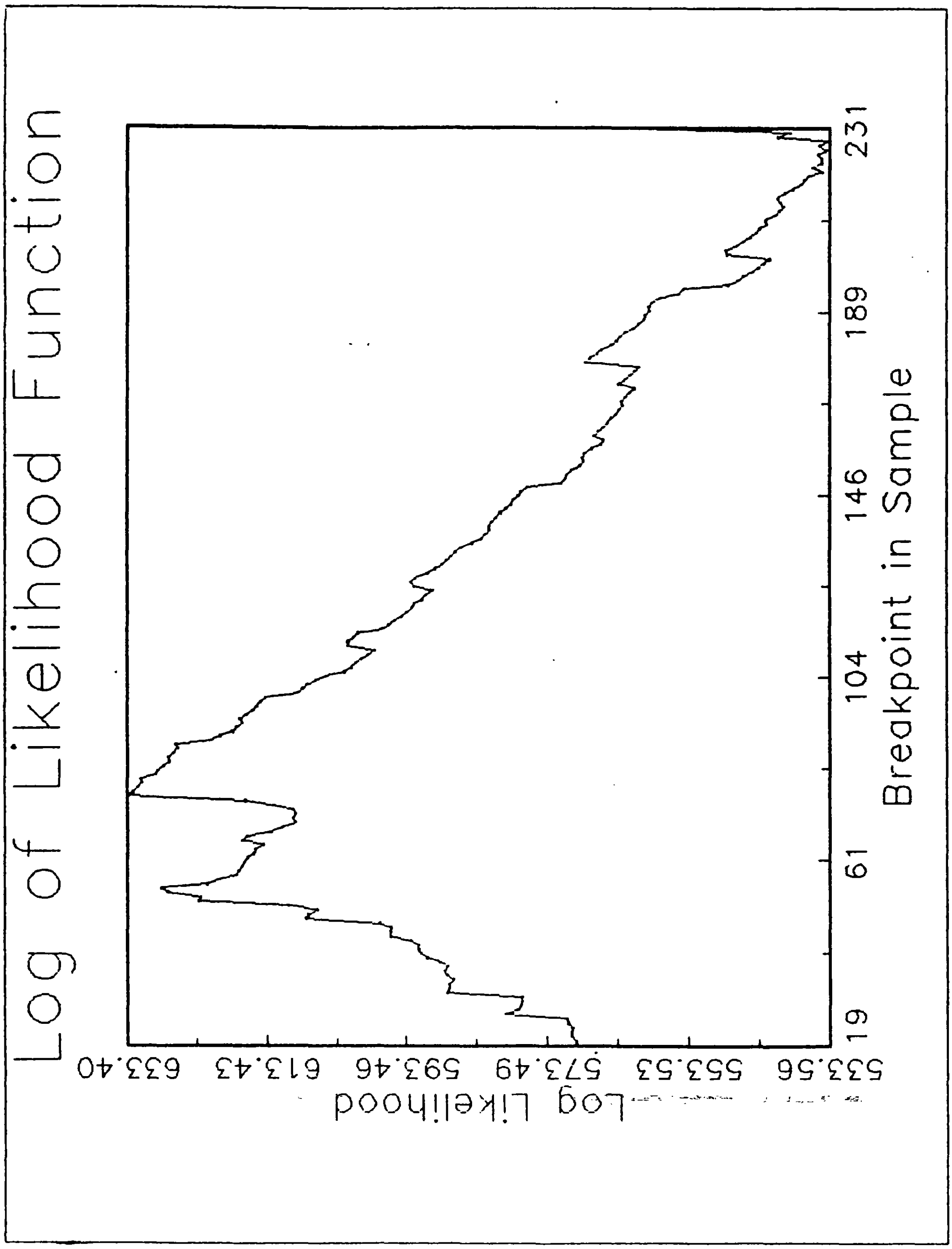


Table 6.10: Switching Regressions, Major Subsidy Recipients

Regression Results in Detail

1. 1986-1987

OLS RESULTS: Entire Sample

Dep variable:	SUB176	Mean :	0.006
Minimum :	-0.178	Maximum :	0.255
Observations:	242	Degrees of freedom:	232
Weighted LS :	Weight is inverse of sale87		
R-squared :	0.585	Rbar-squared :	0.569
Residual SS :	0.197	Std error of est :	0.029
Total SS :	0.475	Log likelihood :	517.1765

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE87	1.000000	-0.519297	0.036203	-14.344	0.000
SALE86	0.973937	0.506516	0.040021	12.656	0.000
TTAX87	0.042202	0.526896	0.105714	4.984	0.000
TTAX86	0.046440	-0.547213	0.095742	-5.715	0.000
MCOST87	0.751479	0.590712	0.046616	12.672	0.000
MCOST86	0.742859	-0.565927	0.048402	-11.692	0.000
NMC87	0.155230	0.563660	0.051900	10.860	0.000
NMC86	0.151615	-0.518139	0.055598	-9.319	0.000
MONOP87	0.115792	-0.094307	0.080438	-1.172	0.241
MONOP86	0.118484	0.114097	0.081433	1.401	0.161

OLS RESULTS: 1st Portion

Dep variable:	SUB176	Mean :	0.017
Minimum :	-0.178	Maximum :	0.255
Observations:	76	Degrees of freedom:	66
Weighted LS :	Weight is inverse of sale87		
R-squared :	0.857	Rbar-squared :	0.837
Residual SS :	0.058	Std error of est :	0.030
Total SS :	0.402	Log likelihood :	165.2399

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE87	1.000000	-0.805842	0.059571	-13.527	0.000
SALE86	1.021419	0.780046	0.070450	11.072	0.000
TTAX87	0.016895	1.841471	0.451787	4.076	0.000
TTAX86	0.019988	-1.483673	0.370794	-4.001	0.000
MCOST87	0.963957	0.960044	0.071345	13.456	0.000
MCOST86	0.998165	-0.905137	0.083433	-10.849	0.000
NMC87	0.164492	0.825547	0.098004	8.424	0.000
NMC86	0.145491	-0.846155	0.123581	-6.847	0.000
MONOP87	0.094329	-0.250232	0.170394	-1.469	0.147
MONOP86	0.098264	0.134564	0.161032	0.836	0.406

OLS RESULTS: 2nd Portion

Dep variable:	SUB176	Mean :	0.001
Minimum :	-0.061	Maximum :	0.090
Observations:	166	Degrees of freedom:	156
Weighted LS :	Weight is inverse of sale87		
R-squared :	0.431	Rbar-squared :	0.398
Residual SS :	0.035	Std error of est :	0.015
Total SS :	0.061	Log likelihood :	468.1580

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE87	1.000000	-0.165233	0.027122	-6.092	0.000
SALE86	0.952198	0.209944	0.028064	7.481	0.000
TTAX87	0.053789	0.129147	0.059753	2.161	0.032
TTAX86	0.058551	-0.206930	0.054737	-3.780	0.000
MCOST87	0.654200	0.234194	0.035642	6.571	0.000
MCOST86	0.625972	-0.277533	0.036279	-7.650	0.000
NMC87	0.150989	0.269540	0.041024	6.570	0.000
NMC86	0.154419	-0.330579	0.036847	-8.972	0.000
MONOP87	0.125619	-0.181511	0.048053	-3.777	0.000
MONOP86	0.127742	0.196658	0.049062	4.008	0.000

Table 6.10: Switching Regressions, Major Subsidy Recipients (continued)

Regression Results in Detail

2. 1985-1986

OLS RESULTS: Entire Sample

Dep variable:	SUB165	Mean :	0.018
Minimum :	-0.131	Maximum :	0.577
Observations:	245	Degrees of freedom:	235
Weighted LS :	Weight is inverse of sale86		
R-squared :	0.808	Rbar-squared :	0.801
Residual SS :	0.157	Std error of est :	0.026
Total SS :	0.817	Log likelihood :	553.2646

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE86	1.000000	-0.558166	0.033273	-16.775	0.000
SALE85	0.917299	0.473310	0.038784	12.204	0.000
TTAX86	0.045974	0.780252	0.093430	8.351	0.000
TTAX85	0.046784	-0.717425	0.094829	-7.565	0.000
MCOST86	0.762505	0.696577	0.037265	18.692	0.000
MCOST85	0.684690	-0.603211	0.042986	-14.033	0.000
NMC86	0.162579	0.801576	0.032771	24.460	0.000
NMC85	0.153653	-0.716022	0.033008	-21.692	0.000
MONOP86	0.115791	0.161436	0.113754	1.419	0.156
MONOP85	0.113494	-0.151157	0.111870	-1.351	0.177

OLS RESULTS: 1st Portion

Dep variable:	SUB165	Mean :	0.044
Minimum :	-0.131	Maximum :	0.577
Observations:	88	Degrees of freedom:	78
Weighted LS :	Weight is inverse of sale86		
R-squared :	0.927	Rbar-squared :	0.918
Residual SS :	0.051	Std error of est :	0.025
Total SS :	0.690	Log likelihood :	203.5064

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE86	1.000000	-0.736506	0.051305	-14.356	0.000
SALE85	0.924999	0.587275	0.064636	9.086	0.000
TTAX86	0.020092	1.156052	0.226246	5.110	0.000
TTAX85	0.025265	-1.045630	0.208658	-5.011	0.000
MCOST86	0.963036	0.873530	0.049324	17.710	0.000
MCOST85	0.866985	-0.718248	0.061656	-11.649	0.000
NMC86	0.152013	0.926621	0.047011	19.711	0.000
NMC85	0.141441	-0.862531	0.043947	-19.627	0.000
MONOP86	0.098148	0.079833	0.228766	0.349	0.728
MONOP85	0.089610	-0.049296	0.225412	-0.219	0.827

OLS RESULTS: 2nd Portion

Dep variable:	SUB165	Mean :	0.004
Minimum :	-0.056	Maximum :	0.058
Observations:	157	Degrees of freedom:	147
Weighted LS :	Weight is inverse of sale86		
R-squared :	0.206	Rbar-squared :	0.157
Residual SS :	0.026	Std error of est :	0.013
Total SS :	0.033	Log likelihood :	460.1176

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE86	1.000000	-0.124278	0.029941	-4.151	0.000
SALE85	0.912983	0.096569	0.029628	3.259	0.001
TTAX86	0.060481	0.215348	0.060914	3.535	0.001
TTAX85	0.058846	-0.187222	0.060799	-3.079	0.002
MCOST86	0.650105	0.171502	0.037792	4.538	0.000
MCOST85	0.582512	-0.142260	0.036530	-3.894	0.000
NMC86	0.168501	0.207309	0.041481	4.998	0.000
NMC85	0.160498	-0.164612	0.042760	-3.850	0.000
MONOP86	0.125680	-0.137414	0.070916	-1.938	0.055
MONOP85	0.126882	0.141096	0.069814	2.021	0.045

Table 6.10: Switching Regressions, Major Subsidy Recipients (continued)

Regression Results in Detail

3. 1984-1985

OLS RESULTS: Entire Sample

Dep variable:	SUB154	Mean :	0.008
Minimum :	-0.411	Maximum :	0.225
Observations:	240	Degrees of freedom:	230
Weighted LS :	Weight is inverse of sale85		
R-squared :	0.709	Rbar-squared :	0.697
Residual SS :	0.200	Std error of est :	0.029
Total SS :	0.686	Log likelihood :	510.3740

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE85	1.000000	-0.503115	0.035838	-14.039	0.000
SALE84	0.964893	0.457261	0.043636	10.479	0.000
TTAX85	0.045765	0.647059	0.090664	7.137	0.000
TTAX84	0.041296	-0.612461	0.107495	-5.698	0.000
MCOST85	0.755593	0.611744	0.037576	16.280	0.000
MCOST84	0.626841	-0.545279	0.047703	-11.431	0.000
NMC85	0.168526	0.666504	0.033755	19.745	0.000
NMC84	0.263076	-0.643257	0.034566	-18.609	0.000
MONOP85	0.110842	-0.183650	0.178048	-1.031	0.302
MONOP84	0.110113	0.199596	0.176758	1.129	0.259

OLS RESULTS: 1st Portion

Dep variable:	SUB154	Mean :	0.015
Minimum :	-0.411	Maximum :	0.225
Observations:	79	Degrees of freedom:	69
Weighted LS :	Weight is inverse of sale85		
R-squared :	0.907	Rbar-squared :	0.895
Residual SS :	0.057	Std error of est :	0.029
Total SS :	0.615	Log likelihood :	173.4766

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE85	1.000000	-0.808374	0.067514	-11.973	0.000
SALE84	1.015500	0.634174	0.083694	7.577	0.000
TTAX85	0.020857	1.101091	0.221320	4.975	0.000
TTAX84	0.017986	-0.823262	0.320469	-2.569	0.012
MCOST85	0.971704	0.875008	0.054959	15.921	0.000
MCOST84	0.746267	-0.688075	0.077107	-8.924	0.000
NMC85	0.149207	0.840788	0.044815	18.761	0.000
NMC84	0.374895	-0.801772	0.054467	-14.720	0.000
MONOP85	0.085118	0.031407	0.353090	0.089	0.929
MONOP84	0.084642	0.075713	0.367732	0.206	0.837

OLS RESULTS: 2nd Portion

Dep variable:	SUB154	Mean :	0.004
Minimum :	-0.048	Maximum :	0.141
Observations:	161	Degrees of freedom:	151
Weighted LS :	Weight is inverse of sale85		
R-squared :	0.342	Rbar-squared :	0.303
Residual SS :	0.043	Std error of est :	0.017
Total SS :	0.065	Log likelihood :	434.0668

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE85	1.000000	-0.167647	0.029440	-5.695	0.000
SALE84	0.940061	0.195757	0.033058	5.922	0.000
TTAX85	0.057987	0.158343	0.063945	2.476	0.014
TTAX84	0.052734	-0.190259	0.074127	-2.567	0.011
MCOST85	0.649551	0.182248	0.036819	4.950	0.000
MCOST84	0.568241	-0.198862	0.041353	-4.809	0.000
NMC85	0.178005	0.261898	0.041951	6.243	0.000
NMC84	0.208208	-0.304709	0.038103	-7.997	0.000
MONOP85	0.123464	-0.100161	0.121795	-0.822	0.412
MONOP84	0.122611	0.101448	0.120469	0.842	0.401

Table 6.10: Switching Regressions, Major Subsidy Recipients (continued)

Regression Results in Detail

4. 1983-1984

OLS RESULTS: Entire Sample

Dep variable:	SUB143	Mean	:	0.006
Minimum :	-0.236	Maximum	:	0.236
Observations:	223	Degrees of freedom:		214
Weighted LS :	Weight is inverse of sale84			
R-squared :	0.747	Rbar-squared	:	0.738
Residual SS :	0.163	Std error of est	:	0.028
Total SS :	0.647	Log likelihood	:	488.4563

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE84	1.000000	-0.460778	0.034935	-13.190	0.000
SALE83	0.946630	0.490792	0.033659	14.582	0.000
TTAX84	0.046099	0.466093	0.086730	5.374	0.000
TTAX83	0.037305	-0.496899	0.096100	-5.171	0.000
MCOST84	0.658688	0.669802	0.031426	21.313	0.000
NMC84	0.272216	0.710319	0.033346	21.301	0.000
COST83	0.889445	-0.711524	0.029706	-23.952	0.000
MONOP84	0.107026	-0.400845	0.191888	-2.089	0.037
MONOP83	0.107571	0.378657	0.187606	2.018	0.044

OLS RESULTS: 1st Portion

Dep variable:	SUB143	Mean	:	0.004
Minimum :	-0.236	Maximum	:	0.236
Observations:	76	Degrees of freedom:		67
Weighted LS :	Weight is inverse of sale84			
R-squared :	0.916	Rbar-squared	:	0.906
Residual SS :	0.050	Std error of est	:	0.027
Total SS :	0.588	Log likelihood	:	170.9118

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE84	1.000000	-0.624774	0.060027	-10.408	0.000
SALE83	0.936145	0.688325	0.056001	12.291	0.000
TTAX84	0.016534	0.666618	0.156075	4.271	0.000
TTAX83	0.010757	-0.768675	0.173706	-4.425	0.000
MCOST84	0.735890	0.813341	0.050909	15.976	0.000
NMC84	0.383582	0.888238	0.043961	20.205	0.000
COST83	1.071476	-0.886246	0.041272	-21.473	0.000
MONOP84	0.072543	-1.052713	0.491166	-2.143	0.036
MONOP83	0.070963	0.957317	0.497514	1.924	0.059

OLS RESULTS: 2nd Portion

Dep variable:	SUB143	Mean	:	0.008
Minimum :	-0.041	Maximum	:	0.091
Observations:	147	Degrees of freedom:		138
Weighted LS :	Weight is inverse of sale84			
R-squared :	0.195	Rbar-squared	:	0.148
Residual SS :	0.046	Std error of est	:	0.018
Total SS :	0.057	Log likelihood	:	384.1802

Var	Weighted Mean	Coef	Std. Error	T-Stat	P-value
SALE84	1.000000	-0.131142	0.036349	-3.608	0.000
SALE83	0.952050	0.099314	0.038895	2.553	0.012
TTAX84	0.061384	0.101336	0.074109	1.367	0.174
TTAX83	0.051031	-0.058418	0.087344	-0.669	0.505
MCOST84	0.618774	0.210284	0.043390	4.846	0.000
NMC84	0.214638	0.269529	0.049760	5.417	0.000
COST83	0.795333	-0.182813	0.045646	-4.005	0.000
MONOP84	0.124853	-0.278679	0.145292	-1.918	0.057
MONOP83	0.126497	0.263020	0.141382	1.860	0.065

Notes to Chapter 6

1. This chapter arises from a project directed by Stanislaw Gomulka of the London School of Economics and funded by the Suntory-Toyota International Centre for Economics and Related Disciplines. The author held an IREX Developmental Fellowship while much of the analysis presented in this chapter was developed. The generous financial support of STICERD and IREX are gratefully acknowledged. I would also like to thank Staszek Gomulka, Mario Nuti, Saul Estrin, Richard Quandt, and seminar audiences at the London School of Economics and the School of Slavonic and East European Studies for suggestions, support and encouragement.

2. That is, I obtain the pre-subsidy categories by multiplying the original profitability categories by the aggregate rate of turnover tax.

3. Rocznik Statystyczny 1988, p. 99.

4. The very small figure for enterprise-specific subsidies given by the official Polish statistics suggests estimation in levels may be OK.

5. It is slightly less because I cannot conduct the global search too close to the endpoints. That is, I cannot begin by dividing our sample of N firms into 1 low X firm and N-1 high X firms, because I cannot run an OLS regression on the 1 low X firm alone.

6. Time series analysis is the more common application of the simple switching regressions; there the search is for the point in time when parameters shifted. Since sampling over time is usually discrete, the derivative of the likelihood function will not vanish at the maximum, violating one of the conditions making a χ^2 distribution acceptable. In our application, however, the switching variable X^* is continuous, making it more plausible to assert that the derivative will vanish. See Quandt (1958, p. 876n7).

7. Their evidence, based on Monte Carlo experiments, show that the likelihood ratio test has moderately more power than a Chow test in the middle of the sample, moderately less at the ends.

8. The F-H test is best interpreted as follows. The breakpoint between the two regression regimes is determined by the variable X. At the critical value X^*, there is a discrete shift in the regression coefficients. The F-H procedure approximates this discrete shift with a continuous shift in the (slope) coefficients based on X. In essence a single OLS regression is run where instead of estimating, say, βS_i, I estimate $(\beta+\phi X_i)S_i$ (there is a separate ϕ for each exogenous variable). The F-H test is basically a test of the joint significance of the

estimated ϕ's. It does not allow for shifts in the intercept, however. See Farley, Hinich and McGuire (1975).

9. In practice the two deflators differ only slightly.

10. Quandt presents Monte Carlo estimates of the distribution of LR based on sample sizes of 20, 40 and 60. The distribution of the right-hand tail was essentially independent of the sample size used. To be more precise, he estimates that [P(LR) < 42] = 0.987; the 95% confidence interval for this estimate is 0.96 to 0.996. (These numbers vary very slightly for the different sample sizes.)

11. This is clearly untrue for the individual error terms u_{it} and u_{it-1}, but is not an unreasonable assumption for their difference.

12. Note that because MONOP measures the market share of the enterprise, it is not weighted as part of the WLS procedure.

Chapter 7: Conclusion

Below I briefly summarise the main findings presented in this dissertation. The emphasis here is on the relationship of the dissertation with existing work, and on the directions for possible future research.

The first contribution of Chapter 2 was to suggest a single consistent interpretation of Kornai's notion of the "soft budget constraint", namely that socialist enterprises that are in difficulties are rescued by the centre. This idea of Kornai's has been criticised by some as a "soft concept", but I argued that this particular interpretation is consistent with most of his writings.[1] I was then able to relate this concept of Kornai's to previous work in the field, notably by Hayek and von Mises. The chapter then presented two formal models of enterprise behaviour when a state policy of bailouts exists, i.e. when budget constraints are soft. The two main contributions of these simple models were, first, to show that in principle the effects of such a policy on enterprise performance are ambiguous (others who have written on this subject have typically assumed that budget softness leads to poorer performance); and second, to show that, since rescue subsidies are conditional in nature, empirical studies of budget softness will face the problem that budgets may be soft and yet no subsidies observed.

The main contribution of Chapter 3 was to present a formal argument explaining why budget constraints may be soft. Previous authors have typically simply assumed the budget constraints of socialist enterprises are soft without explaining why. Kornai's explanation simply states that the socialist state is "paternalistic"; he does not say why the socialist state behaves differently from the state in a Western market economy. The argument of Chapter 3 is that the socialist state rescues enterprises in difficulties because it is unable to commit itself in advance to a policy of "no rescues". In this view, the state in a Western market economy behaves differently not because it is not "paternalistic" (it has roughly the same "tastes" as the socialist state), but because the institutional and legal systems of a Western democracy afford a measure of (credible) commitment to a policy of "no bailouts". The totalitarian socialist state, by building a "reputation for toughness", can obtain the benefits of commitment, but I argued that this reputation could not be maintained once the socialist state ceased to be totalitarian and Stalinist excesses moved further and further into the past.

The model of Chapter 3 illustrated a number of other features commonly observed in socialist economies. One such feature, to which I devoted some attention, is "storming" or rush-work to meet a deadline. The existing literature on storming typically blames storming in part on the presence of deadlines by which time output targets must be fulfilled. I was able to show, by use of the model in Chapter 3 and two models in an appendix, that this explanation is incorrect: deadlines do not necessarily lead to a storming work pattern. Indeed, they may just as easily lead to an "anti-storming" pattern.

Of the existing game-theoretic models of the centre-enterprise relationship, most have assumed that the centre lacks information about the enterprise (typically its productive capacity). The model of Chapter 3, in contrast, assumed that the centre was perfectly informed about the enterprise but that the enterprise lacked information about the centre (namely its preferences). A model incorporating both types of imperfect information would be a natural next step. Such a model would be particularly informative about the nature of state bailouts, since one explanation offered for these bailouts is that the centre is not sure if the enterprise really needs the bailout or not, and chooses to rescue rather than take the chance of failing to help an enterprise that really does need central assistance.

Chapters 2 and 3 examined some of the incentive aspects of state bailouts. There is as well an "economic natural selection" aspect of the subject: if the state bails out failing enterprises, then all enterprises survive, not just the "fittest". The study of "economic natural selection" is not yet well developed, however, and so rather than ask the question "what are the effects of suspending the process of economic natural selection via a bailout policy", I asked the question which logically precedes it, namely "what are the effects of the presence of economic natural selection". Chapter 4 presented a model based on the "evolutionarily stable strategy" concept used by biologists and game theorists. The main result of the model is a demonstration that only when firms lack strategic power is it generally true that profit-maximisers are the best survivors; when firms have strategic power the best survivors are those that engage in "over-competitive", "spiteful" behaviour (as defined by Hamilton). The implications of this for the bailout question are not clear, however. It is not necessarily the case that such "over-competitive" behaviour is a "bad thing" and that therefore suspending economic natural selection via a bailout policy would be a good thing. Recall, for example, the Nash quantity-setting oligopoly example from Chapter 4: the profit-maximising result is for firms to earn oligopoly profits by restricting output, but the economic natural selection result is the competitive result, i.e. price equals marginal cost. The "over-competitive" result is thus socially preferable to the profit-maximising result.

The analysis in Chapter 4 and the appendix could be extended in a number of ways. One possibility would be to develop a fuller dynamic version of the model of Chapter 4. As was pointed out there, a firm may be a good survivor relative to its competitors at any particular point in time, but to achieve this its behaviour may have to be so spiteful and self-damaging at times that it is infrequently observed. A second possibility, more relevant to the evolutionary game theory model presented in the appendix, is to recognise that typically (in both economics and in biology) a competitor in a population interacts with some individuals more than others.

Chapters 5 and 6 presented the results of an empirical investigation of bailouts of enterprises, using enterprise-level panel data for Polish industry 1983-88. In Chapter 6 I estimated a simple model designed to reveal whether low profitability enterprises were subsidised differently from high profitability enterprises, and if so, in what way. The results of the estimation were quite robust and can be summarised as follows: in Poland during this period, product subsidies were in fact used as profit subsidies, and while profit-makers had their profits subsidised at a low marginal rate (15-30%), loss-makers were in fact "bailed out" in the sense that their losses were subsidised at a high marginal rate (60-90%) and after the subsidy process loss-makers nearly always became profit-makers.

I should note here that because the data sample included a large number of loss-making enterprises, the observation problem described in Chapter 2 was not encountered. Loss-makers whose losses increased had to be rescued by the state or they would have become insolvent.

Very little previous empirical work on socialist enterprises exists; the only work comparable to that in Chapters 5 and 6 to my knowledge was that done by Kornai and Matits on Hungarian state-owned enterprises. They too looked for evidence that enterprise budget constraints were "soft", but in my view their evidence was not entirely convincing. The main problem was they did not demonstrate that taxes and subsidies were adjusted on an ad hoc, enterprise-specific, ex post basis. Their results could conceivably been generated by a highly complex tax/subsidy system, with many product-specific rates and fixed ex ante lump sum taxes. The motivation behind the method used in Chapter 6 was to test whether this could in fact be the case.

The model and estimation method in Chapter 6 could be developed further in a number of ways. One interesting possibility would be to use a technique developed by Goldfeld and Quandt to look for regimes switches based on more than one variable. It is probably simplistic to say that the only determinant of how an enterprise is subsidised is its pre-subsidy profit/loss per worker. Perhaps profit in absolute terms, rather than per worker, is more appropriate; perhaps the size of the labour force, or the nature of the enterprise's output, are also factors.

Finally, I should stress again the usefulness of the model for evaluating the success of enterprise reform. The revolutions in Eastern Europe have put in place new governments, most of which have stated their intention to move to a Western-type market economy. Just how successful they will be is not at all clear. With respect to the subject of this dissertation - bailouts of enterprises - it is very possible that this practice will continue (indeed, it is not uncommon in Western economies). The model presented in Chapter 6 will allow us to test the success of these new governments in abandoning the old habits and implementing a sensible tax/subsidy system that is implemented fairly and according to the rule of law.

Notes to Chapter 7

1. I can note here as well that Prof. Kornai has read the three chapters of this dissertation that make reference to the "soft budget constraint", and has not indicated to me that this interpretation is incorrect. (In fact, he rather liked all three papers.)

Bibliography

Armen Alchian (1950), "Uncertainty, Evolution and Economic Theory", Journal of Political Economy (Vol. 58, No. 3, June).

Michael Alexeev (1989), "The 'Storming' Pattern of Enterprise Behavior in a Centrally Planned Economy", mimeo, August.

Abram Bergson (1978) "Managerial Risks and Rewards in Public Enterprises", Journal of Comparative Economics (Vol. 2, No. 3).

Joseph S. Berliner (1956), "A Problem in Soviet Business Administration", Administrative Science Quarterly (Vol. 1, No. 1, June). Also in Joseph S. Berliner (1988), Soviet Industry from Stalin to Gorbachev (Aldershot: Edward Elgar Publishing).

Joseph S. Berliner (1957), Factory and Manager in the USSR (Cambridge, MA: Harvard University Press).

David Canning (1988), "Convergence to Equilibrium in a Sequence of Games with Learning", European University Institute Working Paper No. 88/331.

Martin Cave and Paul Hare (1981), Alternative Approaches to Economic Planning (London: Macmillan).

Kai Lai Chung (1979), Elementary Probability Theory with Stochastic Processes (New York: Springer-Verlag).

Eric van Damme (1987), Stability and Perfection of Nash Equilibria (Berlin: Springer-Verlag).

Maurice Dobb (1966), Soviet Economic Development Since 1917, 6th ed. (London: Routledge and Kegan Paul).

David Dyker (1976), The Soviet Economy (London: Crosby Lockwood Staples).

David Dyker (1985), The Future of the Soviet Economic Planning System (London: Croom Helm).

Stephen Enke (1951), "On Maximizing Profits: A Distinction Between Chamberlin and Robinson", American Economic Review (Vol. 41, No. 4, September).

John U. Farley, Melvin Hinich and Timothy W. McGuire (1975), "Some Comparisons of Tests for a Shift in the Slopes of A Multivariate Linear Time Series Model", Journal of Econometrics (Vol. 3, No. 3, August).

Xavier Freixas, Roger Guesnerie and Jean Tirole (1985), "Planning under Incomplete Information and the Ratchet Effect", Review of Economic Studies (Vol. 52, No. 2, April).

James W. Friedman and Robert W. Rosenthal (1986), "A Positive Approach to Non-Cooperative Games", Journal of Economic Behavior and Organization (Vol. 7, No. 3, September).

Milton Friedman (1953), "The Methodology of Positive Economics", in Milton Friedman, Essays in Positive Economics (Chicago, IL: University of Chicago Press).

Stephen M. Goldfeld and Richard E. Quandt (1972), Nonlinear Methods in Econometrics (Amsterdam, New York and Oxford: North-Holland).

Stephen M. Goldfeld and Richard E. Quandt (eds.) (1976), Studies in Nonlinear Estimation (Cambridge, MA: Ballinger)

Stephen Goldfeld and Richard E. Quandt (1988), "Budget Constraints, Bailouts, and the Firm under Central Planning", Journal of Comparative Economics (Vol. 12, No. 4, December).

Marshall I. Goldman (1968), The Soviet Economy: Myth and Reality (Englewood Cliffs, NJ: Prentice-Hall, Inc.).

Stanislaw Gomulka (1985a), "The Incompatibility of Socialism and Rapid Innovation", in Schaffer (1985). Also printed in Gomulka (1986). Page references are to the former source.

Stanislaw Gomulka (1985b), "Kornai's Soft Budget Constraint and the Shortage Phenomenon", Economics of Planning (Vol. 19, No. 1). Also printed in Gomulka (1986). Page references are to the latter source.

Stanislaw Gomulka (1986), Growth, Innovation and Reform in Eastern Europe (Brighton: Wheatsheaf Books and Madison, WI: University of Wisconsin Press).

Stanislaw Gomulka and Jacek Rostowski (1988), "An International Comparison of Material Intensity", Journal of Comparative Economics (Vol. 12, No. 4, December).

Paul R. Gregory and Robert C. Stuart (1986), Soviet Economic Structure and Performance, 3rd ed. (New York: Harper and Row).

William D. Hamilton (1970), "Selfish and Spiteful Behaviour in an Evolutionary Model", Nature (Vol. 228, 19 December).

William D. Hamilton (1971), "Selection of Selfish and Altruistic Behavior in Some Extreme Models", in J.F. Eisenberg and Wilton S. Dillon (eds.), Man and Beast: Comparative Social Behavior (Washington, DC: Smithsonian Institution).

Robert G. Hansen and William F. Samuelson (1988), "Evolution in Economic Games", Journal of Economic Behavior and Organization (Vol. 10, No. 3, October).

F.A. Hayek (1935), "The Present State of the Debate", in F.A. Hayek (ed.), Collectivist Economic Planning (London: Routledge).

Arye L. Hillman, Eliakim Katz and Jacob Rosenberg (1987), "Workers as Insurance: Anticipated Government Assistance and Factor Demand", Oxford Economic Papers (Vol. 39, No. 5).

Bengt Holmstrom (1982), "Moral Hazard in Teams", Bell Journal of Economics (Vol. 13, No. 2, Autumn).

Barry W. Ickes and Larry Samuelson (1987), "Job Transfers and Incentives in Complex Organizations: Thwarting the Ratchet Effect", Rand Journal of Economics (Vol. 18, No. 2, Summer).

V.P. Khaikin (1980), "Analiz Sostoyaniya Planovoi Distsipliny na Predpriyatiyakh", Ekonomika i matimaticheskie metody (Vol. 15, No. 5, September-October). Also in English translation as "An Analysis of the State of Plan Discipline in Enterprises", Matekon (Vol. 18, No. 2, Winter 1981-2).

N. Knowlton and G.A. Parker (1979), "An Evolutionarily Stable Strategy Approach to Indiscriminate Spite", Nature (Vol. 279, 31 May).

Janos Kornai (1980), Economics of Shortage (Amsterdam: North Holland).

Janos Kornai (1986a), "The Soft Budget Contraint", Kyklos (Vol. 39, No. 1).

Janos Kornai (1986b), "The Hungarian Reform Process: Visions, Hopes, and Reality", Journal of Economic Literature (Vol. 24, No. 4, December).

Janos Kornai (1987), "The Dual Dependence of the State-Owned Firm in Hungary", in Gene Tidrick and Chen Jiyuan (eds.), China's Industrial Reform (New York: Oxford University Press for the World Bank).

Janos Kornai and Agnes Matits (1984), "Softness of the Budget Constraint - An Analysis Relying on Data of Firms", Acta Oeconomica (Vol. 32, Nos. 3-4).

Janos Kornai and J.W. Weibull (1983), "Paternalism, Buyers' and Sellers' Market", Mathematical Social Sciences (Vol. 6, No. 2, November).

David M. Kreps and Robert Wilson (1982a), "Sequential Equilibria", Econometrica (Vol. 50, No. 4, July).

David M. Kreps and Robert Wilson (1982b), "Reputation and Imperfect Information", Journal of Economic Theory (Vol. 27, No. 2, August).

Jean-Jacques Laffont and Jean Tirole (1987), "Comparative Statics of the Optimal Dynamic Incentive Contract", European Economic Review (Vol. 31, No. 4, June).

Jean-Jacques Laffont and Jean Tirole (1988), "The Dynamics of Incentive Contracts", Econometrica (Vol. 56, No. 5, September).

M. Laki (1980), "End-Year Rush-Work in Hungarian Industry and Foreign Trade", Acta Oeconomica (Vol. 25, Nos. 1-2).

Edward P. Lazear and Sherwin Rosen (1981), "Rank-Order Tournaments as Optimum Labor Contracts", Journal of Political Economy (Vol. 89, No. 5, October).

Herbert S. Levine (1983), "On the Nature and Location of Entrepreneurial Activity in Centrally Planned Economies: The Soviet Case", in Joshua Ronen (ed.), Entrepreneurship (Lexington, MA: Lexington Books).

John M. Litwack (1987), "Coordination, Incentives, and the Ratchet Effect", mimeo, Stanford University.

John M. Litwack (1988), "Commitment, 'Ratcheting' and Economic Reform in the USSR", mimeo, Stanford University.

Michael Marrese and Janet L. Mitchell (1984), "Kornai's Resource-Constrained Economy: A Survey and an Appraisal", Journal of Comparative Economics (Vol. 8, No. 1, January).

Alastair McAuley (1985), "Central Planning, Market Socialism and Rapid Innovation", in Schaffer (1985).

A. Matits (n.d.), "Methodological Notes on Complex Measures of Impacts of Bureaucracy on Firms' Profit", mimeo.

R.O.C. Matthews (1984), "Darwinism and Economic Change", Oxford Economic Papers (New Series) (Vol. 36, Supplement, November).

John Maynard Smith (1974), "The Theory of Games and the Evolution of Animal Conflicts", Journal of Theoretical Biology (Vol. 47, No. 1, September).

John Maynard Smith (1982), Evolution and the Theory of Games (Cambridge: Cambridge University Press).

John Maynard Smith (1988), "Can a Mixed Strategy be Stable in a Finite Population?", Journal of Theoretical Biology (Vol. 130, No. 2, 21 January).

John Maynard Smith and G.R. Price (1973), "The Logic of Animal Conflict", Nature (Vol. 246, No. 5427, 2 November).

Paul Milgrom and John Roberts (1982), "Predation, Reputation, and Entry Deterrence", Journal of Economic Theory (Vol. 27, No. 2, August 1982).

von Mises, Ludwig (1920), "Economic Calculation in the Socialist Commonwealth", reprinted in Hayek (1935).

Alexander McFarlane Mood (1950), Introduction to the Theory of Statistics (New York: McGraw-Hill).

R.R. Nelson and S.G. Winter (1982), An Evolutionary Theory of Economic Change (Cambridge, MA, and London: Belknap Press).

Alec Nove (1968), The Soviet Economy: An Introduction, 3rd ed. (London: George Allen and Unwin).

Alec Nove (1977), The Soviet Economic System (London: George Allen and Unwin).

Richard E. Quandt (1958), "The Estimation of the Parameters of a Linear Regression System Obeying Two Separate Regimes", Journal of the American Statistical Association (Vol. 53, No. 284, December).

Richard E. Quandt (1960), "Tests of the Hypothesis that a Linear Regression System Obeys Two Separate Regimes", Journal of the American Statistical Association (Vol. 55, No. 290, June).

John G. Riley (1979), "Evolutionary Equilibrium Strategies", Journal of Theoretical Biology (Vol. 76, No. 2, 21 January).

Jacek Rostowski and Paul Auerbach (1986), "Storming Cycles and Economic Systems", Journal of Comparative Economics (Vol. 10, No. 3, September).

Jacek Rostowski and Paul Auerbach (1988), "Intra-year Fluctuations in Production and Sales: East and West", in Peter Wiles (ed.), The Soviet Economy on the Brink of Reform (London: Unwin Hyman).

Larry Samuelson (1987), "Evolutionary Foundations of Solution Concepts for Finite, Two-Player, Normal-Form Games", mimeo, Pennsylvania State University/University of Illinois.

Mark E. Schaffer (ed.) (1985), Technology Transfer and East-West Relations (London: Croom Helm and New York: St. Martin's Press).

R. Selten (1975), "Reexamination of the Perfectness Concept for Equilibrium Points in Extensive Games", International Journal Game Theory (Vol. 4, No. 1).

R. Selten (1978), "The Chain Store Paradox", Theory and Decision (Vol. 9, No. 2, April).

Reinhard Selten (1983), "Evolutionary Stability in Extensive Two-Person Games", Mathematical Social Sciences (Vol. 5, No. 3, June).

Martin Shubik (1954), "Does the Fittest Necessarily Survive?", in Martin Shubik (ed.), Readings in Game Theory and Political Behavior (Garden City, NY: Doubleday and Company, Inc.).

Martin Shubik and Richard Levitan (1980), Market Structure and Behavior (Cambridge, MA and London: Harvard University Press).

Lynn Turgeon, The Contrasting Economies: A Study of Modern Economic Systems, 2nd ed. (Boston, MA: Allyn and Bacon, Inc.).

Laura D'Andrea Tyson (1977), "Liquidity Crises in the Yugoslav Economy: An Alternative to Bankruptcy?", Soviet Studies (Vol. 29, No. 2, April).

William L. Vickery (1987), "How to Cheat Against a Simple Mixed Strategy ESS", Journal of Theoretical Biology (Vol. 127, No. 2, 21 July).

Sidney G. Winter, Jr. (1964), "Economic 'Natural Selection' and the Theory of the Firm", Yale Economic Essays (Vol. 4, No. 1, Spring).

Sidney G. Winter (1971), "Saticficing, Selection and the Innovating Remnant", Quarterly Journal of Economics (Vol. 85, No. 2, May).

Sidney G. Winter (1975), "Optimization and Evolution in the Theory of the Firm", in Richard H. Day and Theodore Groves (eds.), Adaptive Economic Models (New York: Academic Press).