Informational Rents and Discretionary Industrial Assistance

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Abstract

The paper analyses the existence and efficiency of discretionary industrial assistance schemes under asymmetric information between an uninformed government and a uniform distribution of firms with differing productivities. Discretionary assistance allows the government to scrutinise projects in an effort to learn the type, which can reduce the 'informational rents' of automatic assistance, where firms take up any contract on offer. Two discretionary grant schemes are analysed, which either exclude 'non-additional' projects or reduce the assistance to the minimum necessary for a project to proceed. The paper finds the conditions under which discretionary assistance exists and is more efficient than automatic assistance.

Key Words: subsidies, asymmetric information, discretionary assistance, investment grants.

JEL Classification: H2 (taxation and subsidies), D8 (information and uncertainty).

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1: Introduction

There have been fundamental changes in the nature of industrial subsidies over the last few decades (Schwartz and Clements, 1999). Not only have they become more narrowly focused on small-scale microeconomic interventions designed to improve allocative efficiency (see Wren and Storey, 2002), but there has been a shift from automatic to discretionary assistance in an effort to improve the performance of these measures. Automatic assistance is available at pre-determined rates to firms, whereas discretionary assistance is allocated on a case-by-case basis at the discretion of the policymaker, with the advantage that the assistance contract can be better tailored to the aims of the policymaker (Swales, 1997). In many countries discretionary assistance is now the mainstay of industrial support programmes (Holden and Swales, 1995).[1]

The difficulty with automatic assistance is that under asymmetric information over the nature of projects the firms are able to extract an "informational rent," which reduces the efficiency of these schemes (Picard, 2001). Discretionary assistance has the potential advantage that it gives the policymaker the opportunity to collect or verify information about each project, so that the terms of the assistance contract can be varied in the light of this information. This means assistance may be refused to projects that do not depend on assistance, while for other projects assistance may be reduced to the minimum necessary for it to proceed. It leads to a welfare gain in the form of a cost saving to the Exchequer from the reduced informational rents, but there are several factors that may reduce the attractiveness of discretionary schemes. One is the cost or difficulty of obtaining information on the nature of projects, and another is the welfare loss of any errors from incorrectly identifying the nature of projects. This might reduce the Exchequer cost saving or could mean that some investment projects do not go ahead at all. Further, discretion may open up the possibility of bargaining with firms over the terms of the assistance contract.

Despite the increased use of discretionary assistance, virtually all the research on industrial subsidies relates to automatic assistance. Under this, firms are free to take up any of the contracts on offer, and the analyses focus on incentive compatibility constraints (Picard, 2001; Wren, 2002a). It means that from a theoretical standpoint the efficiency of discretionary assistance is unexplored,[2] although there are a number of empirical studies.[3] The purpose of this paper is to examine the existence and efficiency of discretionary assistance relative to automatic assistance. Each scheme is considered in grant form, and two kinds of discretionary assistance scheme are analysed. The first is a 'Proof of Need' scheme in which discretion is exercised over the project 'additionality', so that the government seeks to exclude the projects that do not depend on assistance. The second is a 'Minimum Necessary' scheme in which the government seeks to reduce the grant to a minimum for each project in order to maximise the Exchequer cost saving. Under asymmetric information the government makes errors, but it is supposed that it can commit resources to scrutinise projects, and this increases the probability that it correctly allocates the assistance contracts.

The analysis is based on the model developed for automatic assistance in Wren (2002a). It has some similarities with models developed by Laffont and Tirole (1994) and Swales (1995b), but it is quite distinct. [4] The government designs assistance contracts to maximise social welfare under asymmetric information over a uniform distribution of firms with differing productivities. Firms are free to take up any of the contract on offer under automatic assistance, but under discretionary assistance the government allocates a separate contract to each firm, which may be a null contract with a zero grant rate. The paper finds circumstances in which discretionary assistance does not exist (in that welfare is higher in the without-subsidy position) and circumstances where automatic assistance is more efficient. However, while discretionary assistance can improve the performance of industrial subsidies, for existence the probability of identifying the project 'additionality' must be sufficiently high, and for efficiency the cost of scrutinising projects must be low.

Section 2 considers the nature of discretionary assistance, and the modelling framework is set out in section 3. Section 4 describes the first-best scheme under full information, including the implications of bargaining for the results, and section 5 analyses automatic assistance. Section 6 examines the two discretionary schemes, and section 7 discusses the results and concludes.

2: The Nature of Discretionary Assistance

Industrial assistance can be viewed as a principal-agent relationship in which the firm is contracted to carry out an investment project by the government in return for financial assistance. The parties have different objectives, which can give rise to adverse selection and moral hazard problems. Whereas automatic assistance sets the contract 'automatically' for each firm according to the conditions in the published eligibility criteria, discretionary assistance gives the government the opportunity to collect or verify information about each project, with the advantage that in the light of this information the government can exercise 'discretion' in setting the grant rate to better fulfil its objectives. This information cannot be determined from the published eligibility criteria alone, as there is an incentive for a firm to misrepresent its type.

There are several features of discretionary assistance (see Swales 1995a). First, discretion is not necessary under full information, as there is no new information for the government to learn about a project that cannot be written into the eligibility criteria, so that the distinction between discretionary and automatic assistance only exists in a second-best position. Second, the difference between automatic and discretionary assistance has nothing to do with whether the grant rate is varied, as an automatic scheme could involve a variable grant rate, while a discretionary scheme could involve a single grant rate that is refused to some firms (eg. under a 'Proof of Need' scheme). Finally, bargaining over the grant rate will tend to occur where the bargaining strength of the firm is greatest, eg. the investment scale is large and / or the number of projects is small. Bargaining is associated with discretionary assistance, and this is because these schemes operate where the firms have the greatest bargaining power, but it could occur with automatic assistance.

In practice, discretion may be exercised in many ways, depending both on the objectives of the government and on the way in which the assistance contract is varied. The UK experience suggests that discretion may be used as an attempt to mitigate adverse selection or moral hazard.[5] In this paper, discretion is considered in relation to adverse selection, which is the context in which discretionary assistance has been extended to many areas of industrial support. Under the 'Proof of Need' scheme the government's problem is to identify the project 'additionality', and hence the prospective counter-factual position, which depends on the project characteristics. The 'Minimum Necessary' scheme seeks to offer assistance as the minimum necessary for a project to proceed, and this is analogous to price discrimination, with the government seeking to determine the assistance contract for each project according to the firm's willingness to invest.

3: The Modelling Framework

The framework is based on a simplified version of the model developed in Wren (2002a). This is a highly stylised model, which was used to analyse automatic assistance, but it draws out the main features with great analytical power. The economy consists of a finite number n of profit-maximising firms, indexed by i, and a government that offers assistance contracts to firms in order to maximise social welfare. A firm's willingness to invest is determined by its productivity, and these are uniformly distributed across projects. The government has second-order knowledge of the productivities under asymmetric information, and it moves first in offering assistance contracts in grant form at a rate of g_i ($0 \leq g_i \leq 1$). The assistance is available towards investment (see Fuest and Huber, 2000), and it could be provided on an automatic or a discretionary basis. The nature of the firm and the government problems are now considered.

3.1 The Firms

Each firm has a single investment project I_i of the same fixed scale $I > 0$, so that the terms 'project' and 'firm' are used interchangeably. Only profitable projects are implemented, and these utilise labour E in a fixed proportion $\gamma > 0$. Project output q_i is a linear function of the inputs

$$q_i = \alpha_i I + \beta E \tag{1}$$

where α_i denotes the firm productivity and $\beta > 0$ is the productivity of labour. The linear production form has little significance given the assumption of a constant investment scale, while for simplicity labour is supplied at a constant productivity, which again has little significance as there are fixed factor proportions. The productivities or types α_i are uniformly distributed across firms with a lower limit 0 and an upper limit of α, so that there are $m = n / \alpha$ firms of each type.

The firms finance their investment from assistance of amount A_i and from private funds F_i ($A_i, F_i \geq 0$). The first of these is determined once the grant rate g_i is known, while it is assumed that the private funds are available at an opportunity cost of r ($1 \leq r < \alpha$). This may be thought of as the present value cost of bank loans. It is equal to unity when risk-neutral banks operate in competitive markets. The cost of private funds could potentially indicate a firm's type, but the parameterisation of r means that this signal is not available, while its relaxation is outside the paper's scope. Labour is paid out of revenue at a competitive market wage w that is equal to its marginal productivity β.

Given the above, a firm in receipt of assistance at a grant rate of g_i has profits π_i of

$$\pi_i = (\alpha_i I_i + \beta E) - r F_i - w E \tag{2}$$

$$\text{where } I_i = F_i + A_i \text{ and } A_i = g_i I_i \tag{3a, 3b}$$

The price of capital goods is set to unity and the output price is taken as numeraire. When the constraints in (3) are substituted into the objective function, profits simplify to

$$\pi_i = \{\alpha_i - (1 - g_i) r\} I_i \tag{4}$$

The firms that invest are those earning non-negative profits, so that $I_i = I$ when $\alpha_i \geq (1 - g_i) r$ (ie. $\pi_i \geq 0$), but $I_i = 0$ when $\alpha_i < (1 - g_i) r$. Hence, investment depends on the firm's productivity α_i relative to the terms on which the firm has access to public and private funds, ie. g_i and r.

3.2 The Government

The government is the only source of industrial subsidy. For each assistance scheme it sets the contracts to maximise social welfare W above the level that would occur in the without-subsidy position where no assistance is on offer, ie. ΔW. The welfare function W is specified to capture the main features of the problem (see Layard, 1979), and it is summed over the n firms as follows

$$W = \Sigma_i \gamma I_i + \Sigma_i \mu \pi_i - \Sigma_i \lambda A_i - \Sigma_i C_i \qquad (5)$$

The primary benefit arises from investment. In this case it is employment $E = \gamma I$, but under alternative interpretations γ could capture other benefits from the investment, so that for generality γ is referred to as the social value of investment, and the model has wide application.[6] The second right-hand side term is the social value of the private producer surplus, ie. firm profits. These have a weight of $\mu \geq 0$, which includes any flow-backs to the Exchequer from profits taxes. The third term is the social cost of assistance, which measures the alternative uses to which the assistance may be put. It is assumed that the scheme is funded from distortionary taxes at a shadow cost of $\lambda > 1$. The final right-hand side term is the scrutiny costs that are incurred by the government in attempting to learn a firm's type under discretionary assistance, on which more is said below. For simplicity, the firm compliance costs and other administration costs are set to zero.

The welfare function captures the direct effects only, but the indirect effects can potentially be parameterised in (5), while consumers pay a price for output equal to their marginal valuation. Further details are given in Wren (2002a). There are two constraints on the parameters

$$\lambda > \mu r \text{ and } \lambda > \gamma \qquad (6a, 6b)$$

The first of these ensures that 'deadweight spending' is welfare reducing. It means that the government never transfers funds to a firm without some increase in investment. A transfer of resources A_i has a value to the firm of $r A_i$ and a social value of $\mu r A_i$, but there is a resource cost of λA_i. Hence, the welfare change is $- (\lambda - \mu r) A$, which by (6a) is negative. If (6a) does not hold then there is no benefit from discretionary assistance and welfare is higher under an automatic scheme. The assumption is reasonable, as the funds for assistance could be raised by taxing firms' profits, which have a resource cost of μr, but in addition they incur an excess burden, so that $\lambda > \mu r$. Throughout, deadweight spending is denoted by $\eta \equiv \lambda - \mu r > 0$.

The second constraint means that under full information the government does not assist the whole economy of firms, so that the marginal grant rate is set to a value that is strictly less than unity.[7] It can be seen by noting that under full information $\pi_i = C_i = 0$ in (5) for the marginal firm. At the margin, $W = 0$, so that $\gamma I - \lambda g_i I = 0$, which gives a marginal grant rate of $\gamma / \lambda < 1$ by (6b).

3.3 The Equilibrium

An assistance scheme consists of contracts that are all either discretionary or automatic in nature. The government moves first in offering contracts that firms take up to maximise profits. Under automatic assistance a firm may take up any of the contracts that are on offer, but under discretionary assistance each firm is allocated a separate contract, which when the firm is refused assistance is a null contract with a zero grant rate. The government maximises social welfare W, where the equilibrium is when the firms take up contracts such that the welfare change ΔW from the without-subsidy position where no assistance contracts are on offer is non-negative (ie. $\Delta W \geq 0$). A scheme is said to have 'failed' if an equilibrium does not exist (ie. $\Delta W < 0$).

The outcome under full information is considered in the next section, which illustrates the general approach. The distinction between discretionary and automatic assistance does not exist in this position, but the first-best scheme is considered without and with bargaining. The former case is a special case of the latter, in which the firms have zero bargaining strength. A firm's bargaining strength is likely to be greater if the number of projects n is small or the investment scale I is large, but both of these are exogenous to the analysis.

The interest and focus of the paper is in the second-best position, where the government is uninformed about the firm productivities and hence the willingness to invest. As mentioned above, two kinds of discretionary scheme are considered, for which automatic assistance is the benchmark scheme. This analysis is conducted under several simplifying assumptions. The first is that there is no signalling on the part of firms, either intentionally or otherwise, so that the firm productivity is the only distinguishing characteristic of projects.[8] The second assumption is that projects can be costlessly monitored and a 'claw-back' condition is in place, so that there is no moral hazard. The final assumption is that in determining the welfare for each scheme there is no bargaining over the grant rate. Bargaining is usually associated with discretionary assistance, but in principle it could occur with an automatic scheme even though the formal grant rate is determined automatically by the published eligibility criteria. This issue is considered further below.

4: The First-Best Scheme

Under full information the government observes the firm productivities, and it sets the grant rate for each project according to its willingness to invest. When there is no bargaining, it is able to extract the full producer surplus as a welfare gain. It is analogous to first-degree or perfect price discrimination. By (4) with $\pi_i = 0$ the grant rate offered to each firm i is

$$g_i = (r - \alpha_i) / r \qquad (7)$$

To determine the welfare for the scheme it is necessary to optimally determine the highest grant rate g_m paid to the marginal projects, where $0 < g_i \leq g_m$. Figure 1 shows that the firms with productivities in the range $r \leq \alpha_i \leq \alpha$ are 'non-additional' projects. These go ahead in the absence of assistance and they are offered a grant rate of zero. Other projects are 'additional', in that they require public support to make them viable. There are two sub-groups. The first are 'target' firms ($g_m \leq \alpha_i < r$), which are offered assistance in the first-best position, and the second are 'non-target' firms ($0 \leq \alpha_i < g_m$), which are refused assistance. The participation constraint for an additional project is $\pi_i \geq 0$, where profits are given by (4), while a non-additional project will take up any offered assistance contract, as it does not change its behaviour and it is a pure windfall gain.

To derive the welfare expression, it can be noted that only the target firms receive support, so that the number of subsidised projects is $m\ \{r - (1 - g_m)r\}$. This equals $r\ g_m\ m$ and investment is $\Sigma_i\ I_i = r\ g_m\ m\ I$. By (7) the grant rate increases linearly from 0 to g_m, so that the average grant rate is $g_m / 2$ and total assistance is $\Sigma_i\ A_i = (r\ g_m\ m\ I)\ g_m / 2$. Profits and the scrutiny costs are zero, ie. $\Sigma_i\ \pi_i = \Sigma_i\ C_i = 0$. The non-additional projects are implemented exactly as in the without-subsidy position, and do not receive assistance, so that the welfare change for the first-best scheme ΔW_F is

$$\Delta W_F = r\ g_m\ m\ I\ [\gamma - \lambda\ g_m / 2] \qquad (8)$$

The term in front of the square brackets is the volume of investment, while the term inside the brackets is the average welfare effect per unit of investment. Both of these terms depend on the marginal grant rate. This can be found by partially differentiating (8) with respect to g_m and setting this equal to zero for a maximum. This gives $g_m^* = \gamma / \lambda < 1$ by (6b). Further, partial substitution of this into (8) gives the maximised change in welfare as

$$\Delta W_F^* = r\ g_m^*\ m\ I\ [\gamma / 2] \qquad (9)$$

It is positive, so that an equilibrium in assistance exists in the first-best position. Welfare increases with r, m, I and γ, but it decreases with λ, and each of these is plausible.

4.1 Bargaining

Where the number of projects is small or the investment scale is large the firm has some bargaining strength and it may be able to secure a higher grant rate in order to increase profits. This occurs, even though the government can observe the relevant firm characteristics. In this case the government enters into negotiation with the firm, and the grant rate is determined as a co-operative bargaining agreement. Let b denote the government bargaining power ($0 \leq b \leq 1$), and suppose the contracts are negotiated independently across projects, then the bargained grant rate g_{ib} for firm i is found by maximising the Nash bargain V_i as follows

$$V_i = (W_i - W_i^0)^b (\pi_i - \pi_i^0)^{1-b} \quad (10)$$

where W_i^0 and π_i^0 are the disagreement positions. This holds for the additional firms only, as the non-additional projects are offered a zero grant rate, so that there is nothing to bargain over. When agreement is not reached the additional firms undertake no investment, so that $W_i^0 = \pi_i^0 = 0$. W_i and π_i are given by (5) and (4), and substituting these into (10) gives

$$V_i = \{(\gamma + \mu(\alpha_i - (1 - g_{ib}) r) - \lambda g_{ib}) I\}^b \{(\alpha_i - (1 - g_{ib}) r) I\}^{1-b} \quad (11)$$

Differentiating this with respect to g_{ib} the optimal bargained grant rate for firm i is

$$g_{ib}^* = \{(1 - b) r \gamma + (r - \alpha_i)(b \lambda - \mu r)\} \;/\; \eta r \quad (12)$$

For the bargained contract to be offered the contribution to welfare must be non-negative, ie. $W_i \geq 0$, and profits must be non-negative for a firm to take it up, ie. $\pi_i \geq 0$. It is shown below that the first of these is satisfied, while substituting (12) into (4) gives $\pi_i \geq 0$ when

$$\gamma / \lambda \geq (r - \alpha_i) / r \quad (13)$$

Proposition 1: Bargaining does not affect the marginal grant rate under full information, and the volume of investment is unchanged.

Proof: The marginal productivity under bargaining is when (13) holds with equality, which gives $\alpha_{mb} = r(\lambda - \gamma) / \lambda$. Substituting this into (12) the marginal grant rate is $g_{mb}^* = \gamma / \lambda$, which is the same as before, ie. $g_m^* = g_{mb}^*$. The marginal productivity α_{mb} is independent of the bargaining strength b, and hence the same as in the first-best position, which is $b = 1$ in (11). This can be seen by substituting $g_m^* = \gamma / \lambda$ into (7), which gives $\alpha_m = r(\lambda - \gamma) / \lambda$, so that $\alpha_m = \alpha_{mb}$. It follows that the same number of projects is implemented and that investment is unchanged. *QED*

The intuition behind the result is straightforward. The non-target projects continue to be refused assistance under bargaining, as like before, the grant rate necessary to make these profitable means there is no welfare gain. However, all the target firms receive assistance, since the intra-marginal projects generate a positive welfare return, and the firms are able to bargain some of this away in return for greater profits. Since each contract is negotiated independently it is not in the firm's interest to bargain for too much profit, such that $W_i < 0$, as the contract will not be offered. It ensures that a contract is offered to each target firm.

The marginal grant rate is independent of b, as these projects generate a zero welfare gain, but the intra-marginal projects it can be shown $\partial g_{ib}^* / \partial b < 0$, so that these firms get a higher grant rate as their bargaining power increases. By (12) when they have no bargaining strength (ie. $b = 1$) they receive $g_{ib}^* = (r - \alpha_i) / r$, which is (7), but when they have maximum bargaining strength (ie. $b = 0$) they get $g_{ib}^* = \{\gamma - (r - \alpha_i) \mu\} / \eta$. This reaches a maximum of $\gamma / \lambda < 1$ for the marginal project, so that $0 \leq g_{ib}^* < 1$. Substituting g_{ib}^* into (4) with $b = 0$ gives $\pi_i^* = \{\gamma r - \lambda (r - \alpha_i)\} / \eta$, and putting this into the expression for welfare gives $W_i = 0$. Thus, when the firm has maximum bargaining strength it is able to fully appropriate the welfare gain as profit.

To obtain an expression for welfare it is assumed that the bargaining power b is invariant across firms. This is reasonable as each firm implements the same investment scale.[9] Let ΔW_B^* be the change in welfare for the optimal first-best bargained discretionary scheme.

Proposition 2: Under full information, $\Delta W_B^* = b \, \Delta W_F^*$, so that bargaining reduces social welfare in direct proportion to the bargaining strength of the firm.

Proof: By Proposition 1 bargaining does not affect the marginal grant rate, so that total investment is $\Sigma_i I_i = r \, g_m^* \, m \, I$, where $g_m^* = \gamma / \lambda$. To find the total firm profits, (4) is integrated across the target firms from $\alpha_{mb} = r (\lambda - \gamma) / \lambda$ to $\alpha_i = r$, where the grant rate is given by (12), to give

$$\Sigma_i \pi_i = r \, g_m^* \, m \, I \, [(1 - b) \, r \, \gamma / 2 \, \eta] \qquad (14)$$

Likewise, the total assistance can be found by integrating $m \, I \, g_{ib}^*$ across the same range of productivities, where g_{ib}^* is given by (12), to give

$$\Sigma_i A_i = r \, g_m^* \, m \, I \, [(2 - b - \mu \, r / \lambda) \, \gamma / 2 \, \eta] \qquad (15)$$

Substituting these into (5) with $\Sigma_i C_i = 0$, and after rearrangement, the change in welfare for the optimal first-best bargained discretionary scheme ΔW_B^* is

$$\Delta W_B^* = b \, r \, g_m^* \, m \, I \, [\gamma / 2] \qquad (16)$$

Comparison with (9) shows $\Delta W_B^* = b \, \Delta W_F^*$. *QED*

When the firms have no bargaining power, $\Delta W_B^* = \Delta W_F^*$, but when they have maximum bargaining strength then $\Delta W_B^* = 0$, so that the firms appropriate the welfare gain.

5: Automatic Assistance

Automatic assistance is when the firms are free to take-up any contract on offer according to the published eligibility criteria. The firm productivities are not observed under asymmetric information, so that the government sets the contracts based only on second-order knowledge of the overall distribution. A firm will take up assistance at the highest offered rate, and since there is no way of generating a separating equilibrium, the optimal scheme has a single pooling grant rate. The automatic assistance scheme is described more fully in Wren (2002a). Letting g_a denote the grant rate, the expression for the change in welfare ΔW_A can be derived as

$$\Delta W_A = r\, g_a\, m\, I\, [\gamma - g_a (\lambda + \eta) / 2] - (\alpha - r)\, m\, I\, [g_a\, \eta] \qquad (17)$$

The first right-hand side term is the welfare gain from the additional projects. By (4) the marginal productivity is $\alpha_i = (1 - g_a)\, r$, so that there are $r\, m\, g_a$ of these projects. The average social value of investment is γ and the average social value of profits is $\mu\, r\, g_a / 2$, while the average cost of assistance is $\lambda\, g_a$. The second right-hand side term is the welfare loss from the non-additional projects, which now cannot be excluded from assistance. There are $(\alpha - r)\, m$ of these projects that each receive assistance of $A_i = g_a I$, which is 'deadweight spending' and has a weight of η.

Differentiating (17) with respect to g_a the optimal grant rate is

$$g_a^* = (\gamma - \chi) / (\lambda + \eta) \qquad \text{where } \chi \equiv \eta\, (\alpha - r) / r > 0 \qquad (18a, 18b)$$

To ensure $g_a^* \leq 1$ then $\gamma \leq \lambda + \alpha\, \eta / r$, which is satisfied by (6). Partial substitution of (18a) into (17) gives the maximised welfare as

$$\Delta W_A^* = r\, g_a^*\, m\, I\, [\gamma - \chi] / 2 \qquad (19)$$

An equilibrium in automatic assistance exists only if $\gamma \geq \chi$, in which case $g_a^* \geq 0$ and $\Delta W_A^* \geq 0$. This means $r\, \gamma \geq (\alpha - r)\, \eta$, so that the benefit from giving assistance to the additional projects, ie. $r\, \gamma m\, g_a\, I$, is not less than the deadweight spending from giving assistance to the non-additional projects, ie. $(\alpha - r)\, \eta\, m\, g_a\, I$. By (9), there is a welfare loss relative to the first-best scheme.

6: Discretionary Assistance

Deadweight spending may occur in both 'non-additional' and 'additional' projects, giving rise to two kinds of discretionary assistance scheme. The first is a 'Proof of Need' scheme in which the government seeks to exclude the non-additional projects. The second is a 'Minimum Necessary' scheme in which the government seeks to reduce the grant to the minimum necessary for all projects. In the first scheme the government seeks information on the counter-factual position, ie. would the project go ahead without assistance or not, while in the second scheme it seeks information on the firm's productivity, which also it gives information on the counter-factual position. The advantage of the 'Proof of Need' scheme is that it has less exacting requirements, so that the scrutiny costs are lower, but the disadvantage is that the firm's willingness to invest is not observed, so that a single grant rate must be offered.

Discretionary assistance means that the government can scrutinise projects by committing resources or effort, which increases the probability that it correctly identifies the true nature of a project (ie. the counter-factual position or the productivity). It is only after all the contracts have been allocated that the government might learn which of the contracts has been allocated correctly, so that it acts in the belief that it knows the project's nature, but it may make errors. These either result in a windfall gain to the firm or to no investment at all. The scrutiny is costly, but it helps determine the welfare-maximising grant rate, which in the absence of bargaining is the same as the offered grant rate. For simplicity, the government does not announce the maximum grant rate, so that firms are not discouraged from applying.[10] This includes those firms whose productivity is so low that they would turn down the assistance if offered.

6.1 The 'Proof of Need' Scheme

Under the 'Proof of Need' scheme the government seeks information on the prospective counter-factual position to learn if in the absence of assistance a project will go ahead or not. The purpose of this is to withhold assistance from non-additional projects, while supporting only those projects that are additional. It differs from the automatic scheme where the non-additional projects cannot be excluded at all. Since it does not observe the firm productivities (but only if α_i is greater or less than r), the assistance is offered at a single grant rate g_s to any project that it believes to be additional, but only for a marginal project will this be the minimum necessary for it to proceed. If the government believes a project is non-additional it offers a null contract.

The government has second-order knowledge of the overall distribution of productivities, but in the absence of scrutiny it has no information on any given project at all. In the population as a whole the ratio of additional to non-additional projects is r / α, and in the absence of scrutiny it is assumed that with a probability r / α the government believes that the project is additional and it offers g_s, but with a probability $(\alpha - r) / \alpha$ it believes that it is non-additional and it offers a null contract. This means it makes two types of error

Type I: the government wrongly refuses a grant to an additional project
Type II: the government wrongly assists a non-additional project.

The government scrutinises a project by committing effort e ($e \geq 0$), and it is supposed that it learns the 'Proof of Need' with a probability $p = p(e)$, where $0 \leq p(e) \leq 1$ and $p'(e) > 0$. The cost to the government of this scrutiny is $C = C(e)$, where $C(0) = 0$ and $C'(e) \geq 0$. Both $p(e)$ and $C(e)$ are the same across projects, and are known by the government. The government fails to correctly identify the 'Proof of Need' with probability $1 - p$, so that it makes a Type I error with a probability $(1 - p) (\alpha - r) / \alpha$ and a Type II error with a probability $(1 - p)\, r / \alpha$, where $(1 - p) (\alpha - r) / \alpha + (1 - p)\, r / \alpha = 1 - p$. These errors may be reduced by greater scrutiny, but it may not be optimal to avoid them altogether, as scrutiny is costly. The expression for welfare ΔW_S is

$$\Delta W_S = p\, r\, g_s\, m\, I\, [\gamma - g_s (\lambda + \eta) / 2]$$

$$+ (1 - p) (r / \alpha) \{r\, g_s\, m\, I\, [\gamma - g_s (\lambda + \eta) / 2)] - (\alpha - r)\, m\, I\, [g_s\, \eta]\} - \alpha\, m\, I\, C \quad (20a)$$

The first right-hand side term is the welfare when the government learns the counter-factual position or 'Proof of Need' with a probability p. An additional project receives assistance at a grant rate of g_s and makes non-zero profits at an average rate of $g_s / 2$, while a non-additional project is offered a null contract. The second term is the welfare when the government does not learn the 'Proof of Need'. In this case, an additional project is offered g_s with a probability $(1 - p) (r / \alpha)$, but a non-additional project is also incorrectly offered g_s with the same probability, which is a windfall gain to the firm. The final term is the cost of scrutinising projects.

An additional project is assisted with a total probability of $p + (1 - p) (r / \alpha)$, which equals $\{r + p (\alpha - r)\} / \alpha$. It is easier to work with this rather than p, so let $P \equiv \{r + p (\alpha - r)\} / \alpha$, where $\partial P / \partial p = (\alpha - r) / \alpha > 0$. When $p = 0$ then $P = r / \alpha$ and when $p = 1$ then $P = 1$, so that $r / \alpha \leq P \leq 1$. Also, since $1 - P = (1 - p) (\alpha - r) / \alpha$, then (20a) can be written more simply as

$$\Delta W_S = P\, r\, g_s\, m\, I\, [\gamma - g_s (\lambda + \eta) / 2)] - (1 - P)\, r\, m\, I\, [g_s\, \eta] - \alpha\, m\, I\, C \quad (20b)$$

Differentiating this with respect to g_s gives

$$g_s = \{P\, \gamma - (1 - P)\, \eta\} / (\lambda + \eta)\, P \quad (21)$$

It is straightforward to show $g_s < g_m^*$, so that investment is always lower than in the first-best position, and comparison with that for the automatic scheme in (18a) tells us that $g_s > g_a^*$, but investment may be no greater because of the Type I errors. It can be shown that $g_s \leq 1$ when $P(\gamma - \lambda) \leq \eta$, and setting $P = 1$ a sufficient condition for this is $\gamma \leq \lambda + \eta$, which is satisfied by (6).

Proposition 3: The 'Proof of Need' scheme fails to exist when $P < \eta / (\eta + \gamma)$.

Proof: By (21), $g_s \geq 0$ if and only if $P\gamma - (1 - P)\eta \geq 0$, which rearranges to $P \geq \eta / (\eta + \gamma)$. *QED*

The probability of learning the 'Proof of Need' must be sufficiently large for a non-negative grant rate to be offered, and hence for the scheme to exist. Since $P \equiv \{r + p(\alpha - r)\} / \alpha$, this might happen with or without scrutiny (ie. $p > 0$ or $p = 0$ respectively). When $P < \eta / (\eta + \gamma)$ the scheme does not exist because the cost of the deadweight spending exceeds the social value of investment, which is independent of any scrutiny costs.[11] The critical value $\eta / (\eta + \gamma)$ is negatively related to γ and positively related to η, so that the greater is the welfare loss from deadweight spending η the greater must be the probability that the grants are correctly allocated. Of course, as η tends to zero then the condition is always satisfied.

Partial substitution of (21) into (20b) the welfare for the scheme is

$$\Delta W_S = W_S^B - W_S^C \qquad (22)$$

where $W_S^B = r\, g_s\, m\, I\, [P\gamma - (1 - P)\eta] / 2$ and $W_S^C = \alpha\, m\, I\, C$

W_S^B is the benefit function and W_S^C is the scrutiny cost. The benefit depends on $p = p(e)$ while the cost function depends on $C = C(e)$. In what follows it is supposed that these functions are linear in effort, so that $p(e) = e$ and $C(e) = c\, e$, where $0 \leq e \leq 1$ and $c > 0$. These lead to a corner solution in effort, but they are the simplest functional forms to work with. As we see, other forms can generate an interior solution, but they prove intractable.

Differentiating W_S^B in (22) with respect to P gives

$$\partial W_S^B / \partial P = r\, m\, I\, [(\eta + \gamma)^2 - (\eta / P)^2] / 2(\lambda + \eta) \qquad (23)$$

By Proposition 3, $g_s > 0$ when $P > \eta / (\eta + \gamma)$, and in this range it can be shown that $\partial W_S^B / \partial P > 0$ and $\partial^2 W_S^B / \partial P^2 > 0$, so that W_S^B is strictly convex in P. This schedule is sketched in Figure 2. Further, since $C = c\, e = c\, p$ and $P \equiv \{r + p(\alpha - r)\} / \alpha$, then $W_S^C = \alpha\, m\, I\, c\, (\alpha P - r) / (\alpha - r)$. This is linear in P, and $W_S^C = 0$ when $P = r / \alpha$, which is when effort is zero.

The existence and relative efficiency of the assistance schemes depends on two factors. The first is the sign on $\gamma - \chi$, which determines whether r / α is greater or less than $\eta / (\eta + \gamma)$, and hence where the W_S^C schedule cuts the P-axis relative to the W_S^B schedule in Figure 2. The second is the average scrutiny cost c in $C = c\, e$. This leads to the following set of results.

Proposition 4: When $\gamma < \chi$, the automatic assistance scheme does not exist, but the 'Proof of Need' discretionary scheme exists provided $c \leq \varphi \equiv r\, \gamma^2 / 2\, \alpha (\lambda + \eta)$.

Proof: When $\gamma < \chi$ then $\Delta W_A^* < 0$ by (19). Further, $\gamma < \chi$ rearranges to $r / \alpha < \eta / (\eta + \gamma)$, so that the W_S^C schedule cuts the P-axis to the left of the W_S^B schedule. Since the W_S^B schedule is strictly convex in P while the W_S^C schedule is linear, the 'Proof of Need' scheme exists only if $\Delta W_S \geq 0$ at $P = 1$ in (22). Making this substitution gives the result. *QED*

The interpretation of this result is as follows. When $\gamma < \chi$ the automatic scheme fails because the deadweight spending of the non-additional projects is too high relative to the benefit derived from the additional projects. However, the discretionary scheme exists provided effort is expended to learn the 'Proof of Need' but at a scrutiny cost that is not too high. When $c \leq \varphi$, the W_S^C schedule cuts the W_S^B schedule, but from above, so that welfare is maximised at $P = 1$. This is when maximum effort is supplied, so that $e = p = P = 1$. Substituting $P = 1$ into (22) welfare is

$$\Delta W_S^{e=1} = r\, m\, I\, [\alpha / r\, (\varphi - c)] \qquad (24)$$

so that $\Delta W_S^{e=1} \geq 0$ when $c \leq \varphi$. It increases with r and γ, but decreases with λ, η, α and c.

Proposition 5: When $\gamma \geq \chi$, both the automatic assistance and 'Proof of Need' schemes exist, but when $c > \phi \equiv (\alpha - r)\, \{r\, \gamma (\gamma + 2\, \eta) - (\alpha - r)\, \eta^2\} / 2\, \alpha^2\, (\lambda + \eta)$ it is optimal to supply zero effort and the discretionary scheme is less efficient than the automatic scheme, where $\phi \leq \varphi$.[12]

Proof: When $\gamma \geq \chi$ then $\Delta W_A^* \geq 0$ by (19). Further, $\gamma \geq \chi$ rearranges to $r / \alpha \geq \eta / (\eta + \gamma)$, so that the W_S^C schedule cuts the P-axis to the right of the W_S^B schedule. Since the W_S^B schedule is strictly convex, welfare is maximised at either $e = 0$ or $e = 1$, so that $P = r / \alpha$ or $P = 1$. Substituting $P = r / \alpha$ into (22) then welfare is

$$\Delta W_S^{e=0} = (r / \alpha)\, r\, m\, I\, [\gamma - \chi]^2 / 2\, (\lambda + \eta) \qquad (25)$$

By (24) and (25) it can be shown that $\Delta W_S^{e=0} > \Delta W_S^{e=1}$ when $c > \phi$, so that it is optimal to supply no effort and hence not to scrutinise projects. However, comparison of (25) with (19) shows that $\Delta W_S^{e=0} = (r / \alpha)\, \Delta W_A*$, so that welfare is lower than for the automatic scheme. *QED*

When the scrutiny costs are relatively high then no effort is expended, and in this case the discretionary scheme is inferior to automatic assistance. This is because the contracts are allocated between the additional and non-additional projects in the same proportion as the automatic scheme, but only a fraction of the additional projects receive a non-zero contract and welfare is lower. It is despite the grant rates being the same between the two schemes, as substituting $P = r / \alpha$ into (21) gives (18a). This case is sketched in Figure 2, which shows that welfare is maximised at $P = r / \alpha$.

Proposition 6: When $\gamma \geq \chi$ and $c \leq \phi$, the 'Proof of Need' scheme exists, but it is only more efficient than the automatic scheme when $c < \psi \equiv \chi (2\gamma - \chi)\, \varphi / \gamma^2$, where $\psi < \phi$.

Proof: Both schemes exist by Proposition 5. Since $c \leq \phi$, then it is optimal to supply maximum effort by Proposition 5 and welfare is given by (24). Comparison with (19) shows that $\Delta W_S^{e=1} > \Delta W_A*$ when $c < \psi$. *QED*

In summary, if the number of the non-additional projects is relatively high ($\gamma < \chi$) then the automatic scheme fails to exist, while the 'Proof of Need' discretionary scheme exists provided the average scrutiny cost is not too high, ie. $c \leq \varphi$. When the number of the non-additional projects is not high ($\gamma \geq \chi$), then it may be optimal not to scrutinise projects at all if the average scrutiny cost is relatively high, ie. $\phi \leq c \leq \varphi$, in which case the automatic scheme is preferred. In this latter case, scrutiny is worthwhile if $c < \phi$, but automatic assistance is more efficient when $\psi \leq c < \phi$, while the discretionary scheme is more efficient only when $c < \psi$. This is more likely the higher is γ, α or λ and the smaller is μ or r. It means that the W_S^C schedule has a relatively flat slope in Figure 2.

6.2 The 'Minimum Necessary' Scheme

Under the 'Minimum Necessary' discretionary scheme the government wishes to set the grant rate for each project as the minimum necessary for it to proceed. It has greater informational requirements than the 'Proof of Need' scheme, as information on the willingness to invest (ie. the absolute value of α_i) reveals the 'additionality' of each project (α_i relative to r), but not conversely. The government commits effort to scrutinise a project, and it learns the true productivity with a probability of $q = q(e)$, where $0 \leq q(e) \leq 1$ and $q'(e) > 0$. The greater informational requirements are now represented by $C = C(\sigma e)$, where $\sigma > 1$, $C(0) = 0$ and $C'(\sigma e) \geq 0$. Both $q(e)$ and $C(\sigma e)$ are the same across projects and are known by the government.

The government learns the productivity of a project with a true productivity of α_i with a probability q. In this case it offers a grant rate of $g_{it} = (r - \alpha_i) / r$ to an additional project, so that the firm makes zero profit, and a null contract to a non-additional project. However, with a probability $1 - q$ it does not learn the productivity, and in this case it is supposed that the government makes an error. With an equal probability it either over- or under-estimates the firm's true productivity by a constant amount $r\,\varepsilon$, where $\varepsilon > 0$. This means it believes a project with a true productivity of α_i has a productivity of $\alpha_i \pm r\,\varepsilon$, so that it commits two types of error[13]

Type III: the grant rate is lower than the minimum necessary.
Type IV: the grant rate is higher than the minimum necessary.

It is assumed that the error is relatively small, so that $\varepsilon \leq g_{mt}$, where g_{mt} is the highest grant rate that is offered to the lowest productivity α_{mt} that is correctly identified by the government. It means that when the government incorrectly identifies a firm as having a productivity of less than α_{mt} it offers a grant rate of $g_{it} = \varepsilon$, which the firm refuses, so that g_{mt} is the highest grant rate that is taken up by firms, and $0 \leq g_{it} \leq g_{mt}$. Using (27) below, $\varepsilon \leq g_{mt}$ implies $\varepsilon \leq \gamma / (\lambda + \eta)$.[14]

The Type III error is when the government believes that a project with productivity α_i has a higher productivity of $\alpha_i + r\,\varepsilon$. For an additional project it offers a lower grant rate of $g_{it} = (r - \alpha_i) / r - \varepsilon$, which the firm refuses, while for a non-additional project it offers a null contract. The Type IV error is when the government believes that the same project has a lower productivity of $\alpha_i - r\,\varepsilon$, and it offers a higher grant rate of $g_{it} = (r - \alpha_i) / r + \varepsilon$ to an additional project, which is deadweight spending. It also commits Type I and II errors, so that it believes that a project with a productivity in the range α_{mt} to $\alpha_{mt} + r\,\varepsilon$ has a productivity of less than α_{mt} and it refuses assistance (a Type I error), and it believes that a non-additional project with a productivity in the range r to $r + r\,\varepsilon$ is additional, and it offers a non-zero contract (a Type II error). Welfare ΔW_T is therefore:

$$\Delta W_T = q\, r\, g_{mt}\, m\, I\, [\gamma - \lambda\, g_{mt} / 2] + \{(1 - q) / 2\}\, r\, g_{mt}\, m\, I\, [\gamma - \lambda\, g_{mt} / 2 - \eta\, \varepsilon]$$

$$- \{(1 - q) / 2\}\, r\, \varepsilon\, m\, I\, [\gamma + \eta\, \varepsilon / 2] - \alpha\, m\, I\, C \qquad (26a)$$

The first right-hand side term is the welfare when the government correctly identifies the productivity with a probability of q. There are $r\, g_{mt}\, m$ additional projects, and on average they receive a grant at a rate of $g_{mt} / 2$. The second term is the welfare for the additional projects when the government offers a higher grant rate of $g_{it} = (r - \alpha_i) / r + \varepsilon$ with a probability of $(1 - q) / 2$, but in the absence of any Type I or II errors. The average benefit is smaller by $\eta\, \varepsilon$ because of the deadweight spending from the higher grant rate. The third right-hand side term captures the Type I and II errors.[15] The final term is the scrutiny cost.

In the absence of Type I and II errors, the probability that an additional project is assisted is $(1 + q) / 2$, and it is easier to work with $Q \equiv (1 + q) / 2$. When $q = 0$ then $Q = 1 / 2$ and when $q = 1$ then $Q = 1$, so that $1 / 2 \leq Q \leq 1$. Since $(1 - q) / 2$ is equal to $1 - Q$, (26a) can be rewritten as

$$\Delta W_T = Q\, r\, g_{mt}\, m\, I\, [\gamma - \lambda\, g_{mt} / 2] - (1 - Q)\, r\, \varepsilon\, m\, I\, [\gamma + \eta\, (g_{mt} + \varepsilon / 2)] - \alpha\, m\, I\, C \quad (26b)$$

and differentiating this with respect to g_{mt} the marginal grant rate is

$$g_{mt} = \{Q\, \gamma - (1 - Q)\, \eta\, \varepsilon\} / \lambda\, Q \quad (27)$$

If $Q = 1$ the government always correctly identifies the true productivity, and the grant rate is the same as in the first-best position, ie. $g_{mt} = \gamma / \lambda$. In this case, investment is also the same as in the first-best position, but welfare is lower because of the scrutiny costs, ie. $\Delta W_T = \Delta W_F - \alpha\, m\, I\, C$. Clearly, $g_{mt} < 1$ when $Q\, (\gamma - \lambda) - (1 - Q)\, \eta\, \varepsilon < 0$, and setting $Q = 1$ a sufficient condition for this is $\gamma < \lambda$, which is satisfied by (6b). Also, $g_s > 0$ when $Q > \eta\, \varepsilon / (\eta\, \varepsilon + \gamma)$, which is similar to Proposition 3. It means that the probability of assisting an additional project must be sufficiently large. In this case it is because of the deadweight spending that arises from an error, ie. $\eta\, \varepsilon$.[16]

Partial substitution of (27) into (26b) the welfare for the scheme is

$$\Delta W_T = W_T^B - W_T^C \quad (28)$$

where $W_T^B = r\, g_{mt}\, m\, I\, [Q\, \gamma - (1 - Q)\, \eta\, \varepsilon] / 2 - (1 - Q)\, r\, \varepsilon\, m\, I\, [\gamma + \eta\, \varepsilon / 2]$ and $W_T^C = \alpha\, m\, I\, C$.

and differentiating the benefit function gives

$$\partial W_T^B / \partial Q = r\, m\, I\, [(\eta\, \varepsilon + \gamma)^2 - (\eta\, \varepsilon / Q)^2] / 2\, \lambda + r\, \varepsilon\, m\, I\, [\gamma + \eta\, \varepsilon / 2] \quad (29)$$

By the above, $g_{mt} > 0$ when $Q > \eta\, \varepsilon / (\eta\, \varepsilon + \gamma)$, and in this range it can be shown that $\partial W_T^B / \partial Q > 0$, but also that $\partial^2 W_T^B / \partial Q^2 > 0$. Further, when $Q = \eta\, \varepsilon / (\eta\, \varepsilon + \gamma)$, then $W_T^B < 0$. Again, in what follows it is supposed that the relevant functions are linear in effort e, so that $q = q(e) = e$ and $C = C(\sigma\, e) = c\, \sigma\, e$, where $0 \leq e \leq 1$ and $c > 0$. Since $q = e$ and $Q \equiv (1 + q) / 2$, the cost function is $W_T^C = \alpha\, m\, I\, c\, \sigma\, (2\, Q - 1)$. This is linear in Q and it cuts the Q-axis at $Q = 1 / 2$, where $e = 0$. The benefit and cost functions are sketched in Figure 3.

Again, a key issue is where the W_T^C schedule cuts the Q-axis relative to the W_T^B schedule. The benefit function W_T^B is negatively related to ε, and when $Q = 1 / 2$ it can be shown that $W_T^B >$

$(\leq)$ 0 when $\varepsilon^2 \eta (\eta - \lambda) - 2 \gamma \varepsilon (\eta + \lambda) + \gamma^2 > (\leq) 0$, which is a quadratic in the error term. This has no simple solution, but as an approximation it can be shown that the W_T^C schedule cuts the Q-axis to the left of the W_T^B schedule if and only if $\varepsilon > \approx \gamma / 2 (\eta + \lambda)$.[17] The results relative to the automatic scheme follow in a similar way to before, so that the discussion focuses on the efficiency of the 'Minimum Necessary' scheme relative to the 'Proof of Need' scheme.

Proposition 7: When $\varepsilon > \approx \gamma / 2 (\eta + \lambda)$, the 'Minimum Necessary' discretionary assistance exists when $c\, \sigma < \varphi (\lambda + \eta) / \lambda$, but it is only more efficient than the 'Proof of Need' scheme when $\varphi \eta / \lambda > c (\sigma - 1)$, where φ is defined in Proposition 4.

Proof: When $\varepsilon > \approx \gamma / 2 (\eta + \lambda)$, the W_T^C schedule cuts the Q-axis to the left of the W_T^B schedule, and the only way the 'Minimum Necessary' scheme can exist is if $\Delta W_T > 0$ at $Q = 1$ (see Figure 3). Making this substitution in (28) gives the maximised welfare as

$$\Delta W_T^{e=1} = r\, m\, I\, [\alpha / r\, \{\varphi (\lambda + \eta) / \lambda \;-\; c\, \sigma\}] \qquad (30)$$

It is positive when $c\, \sigma < \varphi (\lambda + \eta) / \lambda$. By (24), welfare is greater than for the 'Proof of Need' scheme when $\varphi (\lambda + \eta) / \lambda - \sigma c > \varphi - c$, which rearranges to give the result. *QED*

It means that when the error ε is relatively large, the 'Minimum Necessary' scheme exists only if the government is prepared to commit effort to learn the productivities, but the scrutiny cost must not be too great. It is sketched in Figure 3. The scheme is more efficient than the 'Proof of Need' scheme only if $\varphi \eta / \lambda > c (\sigma - 1)$, which is more likely to hold the greater is r, γ and η and the smaller is α, λ, σ and c. These indicate the relative advantage of the 'Minimum Necessary' scheme. If the welfare effect of deadweight spending η is large, for example, the scheme is preferred as it is optimal to vary the grant rate in an attempt to allocate the assistance contracts as the minimum necessary. This is provided that extra scrutiny cost σ of the greater informational requirements of the 'Minimum Necessary' scheme is not too great. Indeed, when the scrutiny costs of the schemes are the same, ie. σ tends to unity, then it can be seen that the 'Minimum Necessary' scheme is always preferred, even though the error is relatively large.

Finally, when the error is relatively small, ie. $\varepsilon \leq \approx \gamma / 2 (\eta + \lambda)$, the W_T^C schedule cuts the Q-axis on or to the right of the W_T^B schedule, and the 'Minimum Necessary' scheme always exists. To save on space the conditions are not derived, but the reasoning is similar to Propositions 5 and 6. Broadly, when the scrutiny cost is high, it may be optimal not to scrutinise projects at all, and in this case welfare is given by (28) with $Q = 1 / 2$. However, when the scrutiny cost is relatively low it is optimal to scrutinise projects, and the condition for efficiency of the 'Minimum Necessary' scheme relative to the 'Proof of Need' scheme is the same as in Proposition 7.

7: Discussion and Concluding Remarks

Before concluding, it is worth briefly reviewing some of the key features and assumptions of the analysis of the two discretionary schemes. One important feature of both models is that the benefit function is zero over some initial range but then it has a strictly convex form. The first of these indicates that the probability with which the government correctly allocates the contracts to firms must exceed some threshold. This might be through the scrutiny of projects or by chance, but the critical probability is smaller the greater is the welfare consequences of deadweight spending. The second feature of the benefit function is that over the rest of its range it is strictly convex. This is because an increase in the probability of correctly allocating contracts between firm types has a dual effect: not only does it increase the investment level, but it increases the net benefit per unit of investment, so that the benefit increases at an increasing rate.

The analysis is conducted under the assumptions that the probability and scrutiny functions are linear in effort, which given the strictly convex benefit function, generates a corner solution in effort. To generate an interior solution in effort there are two possibilities. Since the models have a similar structure, these are considered in the case of the 'Proof of Need' scheme. One possibility is that $C = C(e)$ is strictly convex in effort, but even for the simplest quadratic form, the optimal value of P results from a cubic equation, which is difficult to solve. The other possibility is that $p = p(e)$ is strictly concave in effort, so that the benefit function W_S^B is also concave in effort. It can be shown that this requires that the degree of concavity satisfies[18]

$$- (\partial^2 p / \partial e^2)\, e / (\partial p / \partial e) \ > \ \{(\partial P / \partial e)\, e / P\}\ \{2\, \eta^2 / (P^2\, (\eta + \gamma)^2 - \eta^2)\} \qquad (31)$$

where $P \equiv \{r + p\,(\alpha - r)\} / \alpha$. The left hand-side is the elasticity of $\partial p / \partial e$ with respect to e, where $\partial p / \partial e > 0$ and $\partial^2 p / \partial e^2 < 0$, so that the proportionate reduction in $\partial p / \partial e$ as effort increases must exceed the right-hand side of (31), which increases with η and α and decreases with γ and r. To interpret this, it can be noted that the greater is the welfare loss from deadweight spending η, the greater is the benefit from scrutiny. In this case, to ensure that the benefit function W_S^B remains concave the elasticity must increase as η increases. As η tends to zero the right-hand side of (31) is zero, and any concave function for $p(e)$ will do. However, even simple concave forms for $p(e)$ will not satisfy (31), which points to the great difficulty of solving the model explicitly for an interior solution for effort. Nevertheless, it is believed that the results that have been derived for the linear probability and scrutiny functions indicate the general nature of the solution, and that the thrust of the results will carry over to more complex functional forms.[19]

A second feature of the analysis of discretionary assistance is that there is no bargaining over the grant rate. Bargaining is likely to occur where the investment scale is large and / or the number of projects is small, as this increases the bargaining strength of the firm, but it applies to both discretionary and automatic assistance schemes. Discretionary assistance is often associated with bargaining, as it affords the flexibility of a negotiable grant rate, so that it tends to operate in the circumstances in which the firms' bargaining strength is strongest, such as inward investment (see Haaparanta, 1996). However, discretionary assistance can apply in other circumstances, and a proper comparison between the schemes should be made under a constant level of firm bargaining strength. The paper assumes that firms have no bargaining power, but if bargaining is allowed it should apply to both discretionary and automatic schemes, in which case the analysis of bargaining in the first-best position suggests that the relative direction of the results may be little affected. In particular, not only is investment unaffected by bargaining, but welfare is lower in direct proportion to the bargaining strength of the firm. This suggests that the results will hold more generally, but an exception to this might be if a variable grant rate signals the preparedness of the government to negotiate and acts as an invitation to the firm to bargain. This might lessen the attractiveness of the 'Minimum Necessary' scheme relative to the 'Proof of Need' scheme.

In conclusion, the paper offers many interesting insights on discretionary assistance. While previous analyses point to the "informational rents" that firms can extract from industrial subsidy schemes under asymmetric information, resulting in deadweight spending, the paper indicates that there are two aspects to this, leading to two different kinds of discretionary scheme. The first is a scheme that seeks to exclude the 'non-additional' projects that do not depend on assistance, and the second is a scheme that also seeks to reduce to a minimum the assistance received by 'additional' projects. The paper derives results on the relative efficiency of these two schemes, and it makes comparison with automatic assistance, where the firms are free to take up any contract on offer. The automatic assistance fails to exist when the deadweight spending on non-additional projects is high relative to the benefit from additional projects, in which case discretionary assistance may be optimal. However, discretionary assistance also fails if the probability of identifying the additional projects is not sufficiently high, and it is less efficient than automatic assistance when the cost of scrutinising projects is not low enough. In these instances, automatic assistance is preferred. The implication of the paper is that the recent shift towards discretionary assistance may have improved the performance of industrial subsidies, but that this depends both on the overall characteristics of the firms and the cost of scrutiny. These are empirical matters, but the current paper helps provide a framework in which to investigate these issues.

Notes

1. It is difficult to find hard evidence to support this contention, but Grant (1983) detects an early shift to selective assistance in several European countries. Recent surveys of state aids, carried out by the OECD (2001) and by the European Union (CEC, 2001), ignore the method of aid disbursement, since the interest is in competition policy, so that they collect information on the purpose and form of the subsidies (eg. grant, loan, etc). In the UK there has been a strong move to discretionary assistance since the early 1980s, so that virtually all the subsidy is now in this form, requiring the firm to demonstrate a 'proof of need' (Wren, 1996). However, as elsewhere, there has been a reduction in expenditure on subsidies in recent decades, and these issues are considered in Besley and Seabright (1999) and in Collie (2000).

2. A notable exception to this is Swales (1995a, 19995b).

3. In the UK, these are government-funded evaluations of Regional Selective Assistance, the main discretionary instrument of regional policy. They find that around a fifth of the supported projects do not depend on assistance at all, while the full Exchequer cost saving is achieved in only about half the number of projects (Arup Economics and Planning, 2000). This is based on interview survey with successful applicants only, so that it is not possible to judge the extent to which the cost saving was achieved at the expense of reduced investment from grant offers that were too low. About thirty per cent of the applicants are refused assistance (Wren, 2002b).

4. Laffont and Tirole focus on moral hazard, and when effort is not relevant then the 'assistance' in their model reduces to a lump sum transfer that is unrelated to investment. Swales assumes that the government commits no errors, but this seems to be a crucial factor in determining the relative efficiency of discretionary assistance.

5. Moral hazard is when in receipt of assistance the firm behaves in a way that varies the terms of the assistance contract, eg. by implementing the without-subsidy project, so that the assistance acts as a lump sum subsidy. Murshed (1994) gives an analysis of assistance in this case. Under moral hazard, discretion may be used to test the firm's commitment to implement the project as contracted. This was the case for Regional Selective Assistance when introduced in the early 1970s. Discretion was exercised over the number of project jobs, the firm viability and the public sector contribution. In principle, each of these can be observed *ex-post* to the contract, but there was no 'claw-back' condition in the event of the firm failing to meet its obligations, so that discretion was to test the firm's commitment to fully implementing the project. A 'proof of need' condition was introduced in the early 1980s.

6. These could be improved technology, R&D, increased exports or other positive externalities to the national economy, so that the model is broader than just employment creation, and applies to investment grant schemes more generally.

7. This assumption is not strictly necessary and it is made to simplify the analysis. It differs from Wren (2002a), where it is assumed that $\gamma > \lambda$, but with no real implications for the analysis.

8. One possibility is that the firms have different access to private funds and that this acts as a signal to the government of a firm's willingness to invest, but this is outside the paper's scope.

9. A firm's bargaining power may increase with the investment scale or decrease with the number of projects. The first of these is the same for all projects, while the latter does not explain differences in bargaining power between firms. The firm productivity might account for these

differences, as high-productivity firms require a smaller grant and make a greater contribution to welfare, but this is outside the paper's scope.

10. The model has been worked through for the case where the maximum grant rate is announced, in which case the number of scrutinised projects is $\{\alpha - r\,(1 - g_s)\}\, m$. Letting C denote the scrutiny costs then the grant rate for the 'Proof of Need' scheme is given by $g_s = \{P\,\gamma - (1 - P)\,\eta - C\} / (\lambda + \eta)\, P$. A positive grant rate exists only if $C > \gamma$, so that the cost of scrutinising each project cannot exceed its social value. However, it means that the benefit function W_S^B in (22) depends on C, while the total scrutiny costs are $\{\alpha - r\,(1 - g_s)\}\, m\, I\, C$, so that W_S^C depends on g_s. It greatly complicates the analysis, so that it is necessary to simplify by assuming that the grant rate is not announced. This is in the government's interest when there is bargaining

11. Substituting for $P \equiv \{r + p\,(\alpha - r)\} / \alpha$, the condition $P > \eta / (\eta + \gamma)$ becomes $p > \{\eta - r\,\gamma / (\alpha - r)\} / (\eta + \gamma)$. It always holds when $\eta < r\,\gamma / (\alpha - r)$, which is when $\gamma > \chi$, and it is an issue which is returned to below.

12. The inequality $\phi \leq \varphi$ can be shown to hold, as can the other inequality $\psi < \phi$ in Proposition 6.

13. There are other ways to model the government's behaviour in this case, but this is the easiest to work with. One alternative, like before, is to assume that in the absence of scrutiny the government randomly assigns the available contracts across firms. However, this means that the null contract is allocated with a probability of $1 - g_{mt}\, r / \alpha$, where g_{mt} is the maximum grant rate, while the rest of the time it allocates grant rates of between zero and g_{mt} with an equal probability. In this case, investment by the additional projects is $m\, I\, (g_{mt}\, r / \alpha)\, (g_{mt}\, r / 2)$, where $g_{mt}\, r / \alpha$ is the probability that a contract is offered and $g_{mt}\, r / 2$ is the overall probability that a firm makes a profit and takes up a contract. This greatly complicates the analysis as investment now depends on g_{mt}^2, while it can be shown that total profits depend on g_{mt}^4, so that the optimal grant rate is determined by a cubic equation in g_{mt}.

14. Although not strictly necessary, the welfare expression is derived by supposing that $\varepsilon \leq (\alpha - r) / r$, so that not all of the non-additional projects are offered a non-zero grant rate in error. This has no real significance for the results that are derived.

15. The Type I error means that $r\,\varepsilon\, m$ additional projects do not undertake investment, but while these also do not receive assistance the Type II error means that there is an equal number of non-additional projects that do receive assistance. On average, the net effect of this is $\eta\,\varepsilon / 2$.

16. Since $Q \geq 1 / 2$ and $\varepsilon \leq \gamma / (\lambda + \eta)$, it can be shown that $g_{mt} > g_s$ in (21) and $g_{mt} > g_a{}^*$ in (18a).

17. Since ε^2 is small, the approximation is derived by setting ε^2 to zero in the quadratic equation for ε. This gives a critical value, $\varepsilon = \gamma / 2\,(\eta + \lambda)$, and since $\varepsilon \leq \min\,\{\gamma / (\lambda + \eta), (\alpha - r) / r\}$, then it is supposed that $\gamma / 2\,(\eta + \lambda) < (\alpha - r) / r$, in which case the automatic scheme may or may not exist, as it requires $\gamma - \eta\,(\alpha - r) / r > 0$.

18. If $C = C(e)$ is linear, then W_S^C is also linear in e, so that the only way that an interior solution for effort can be generated is if W_S^B is strictly concave in e. By (23), $\partial W_S^B / \partial e = r\, m\, I\, [(\eta + \gamma)^2 - (\eta / P)^2] / 2\,(\lambda + \eta)\, \partial P / \partial e$, where $P > \eta / (\eta + \gamma)$. Differentiating this, $\partial^2 W_S^B / \partial e^2 < 0$ if and only if $-(\partial^2 P / \partial e^2)\, e / (\partial P / \partial e) > \{(\partial P / \partial e)\, e / P\}\, \{2\,\eta^2 / (P^2\,(\eta + \gamma)^2 - \eta^2)\}$. Since $P \equiv \{r + p\,(\alpha - r)\} / \alpha$, then $-(\partial^2 P / \partial e^2)\, e / (\partial P / \partial e) = -(\partial^2 p / \partial e^2)\, e / (\partial p / \partial e)$.

19. In the case of Proposition 5, for example, when the benefit function has a concave form there will exist a range for the average scrutiny cost over which scrutiny is not worthwhile.

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Figure 1: 'Additional' and 'Non-Additional' Projects

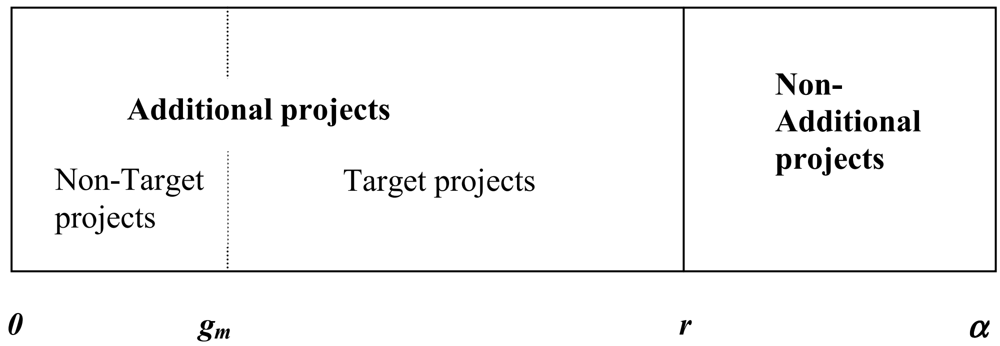
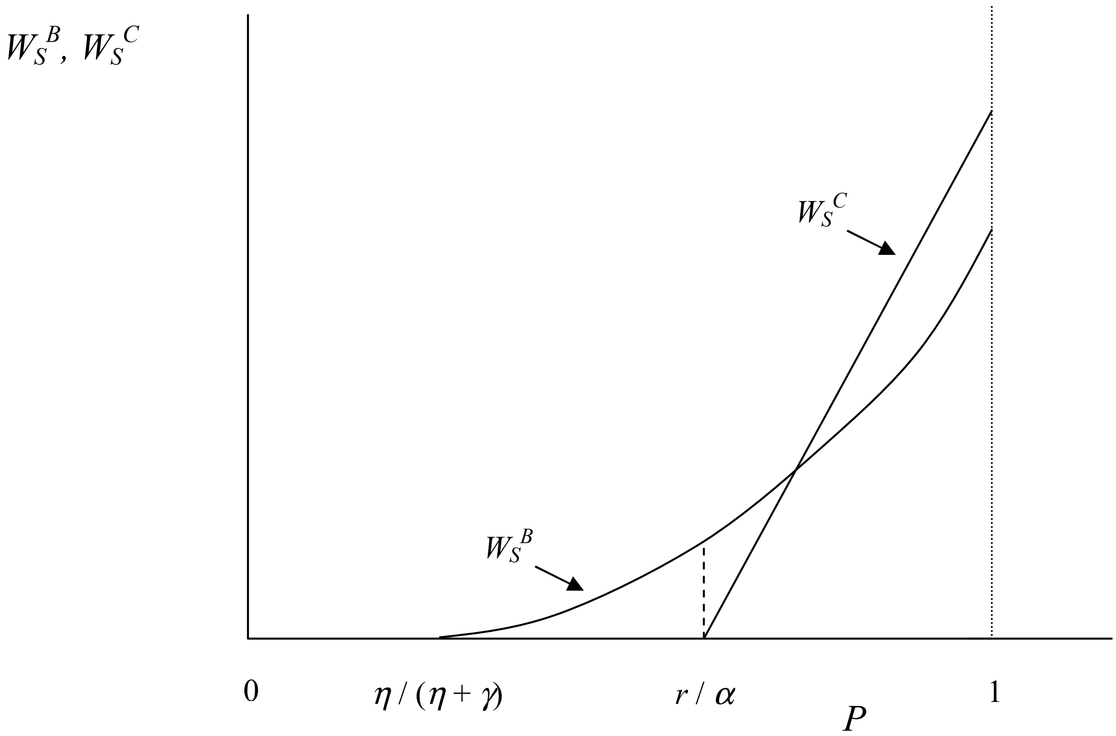
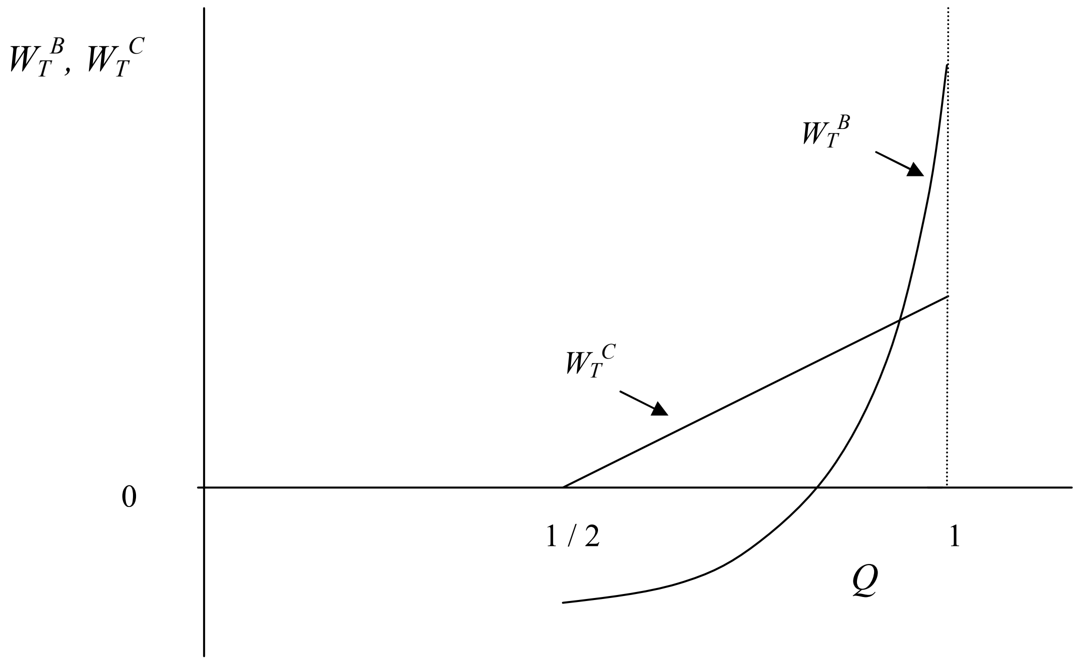


Figure 2: Benefit and Cost Function for 'Proof of Need' Scheme



Note: The figure shows the case $\gamma > \chi$, so that $r / \alpha > \eta / (\eta + \gamma)$, and the W_S^C schedule cuts the P-axis to the right of the W_S^B schedule. The optimum occurs at $P = r / \alpha$ where effort e is zero.

Figure 3: Benefit and Cost Function for 'Minimum Necessary' Scheme



Note: The figure shows the case $\varepsilon >\approx \gamma / 2\ (\eta + \lambda)$, so that the W_T^C schedule cuts the Q-axis to the left of the W_T^B schedule. The optimum occurs at $Q = 1$ where maximum effort e is expended.