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GOVERNMENT INTERVENTION IN THE PROVISION OF ON-THE-JOB TRAINING

Bruce J. Chapman and Peter J. Stemp

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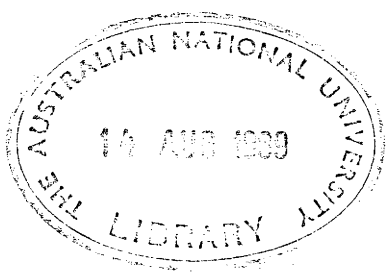
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Executive Summary

An important current Australian economic policy debate concerns the rationale, or otherwise, for an industry training levy. The analysis of this paper promotes the view that intervention by government in the provision of industry training could be welfare-improving even where there are no recognisable institutional rigidities in the labour market. This suggests that increasing the Australian training effort may require more than reform or removal of wage regulation and occupationally-based unionism.

The basic reasons offered for this perspective derive from the argument that externalities result from training. The propositions necessary for our conclusion are two-fold: that the training of its workforce increases a firm's ability to develop, adapt and implement new technology; and that the innovations associated with this process are diffused relatively easily to the firm's competitors. Empirical evidence is presented which supports both conjectures.

An economic modelling framework is used to examine parameters of interest in determining whether intervention is appropriate. It is demonstrated that market structure and the interaction of production technologies with the relevant externalities are fundamental to the case for and nature of intervention.

It is argued that the framework adopted does not constitute a general case for government intervention in the form of a uniform levy imposed on all industries. As well, if the value of the externalities associated with training are exaggerated, intervention could decrease social welfare. On the other hand, market economies with non-colluding firms potentially generating significant training externalities could well deliver welfare improvements given circumspect government intervention in training arrangements.

INTRODUCTION

One of the most important current Australian economic policy debates concerns the rationale, or otherwise, for an industry training levy. The Minister for Employment, Education and Training, the Honourable J.S. Dawkins, released a discussion paper on the issue in December 1988, which presents a case for the imposition of a levy, with the major unresolved question of the authors being its form. On the other hand, Edwards (1988) argues that barriers to training exist because of institutional rigidities in the labour market that arise from wage regulation and the nature of occupationally-based unionism. In his framework the appropriate policy response is the removal of these rigidities, after which it is presumed that no important impediments will exist in the training market.

The analysis of this paper challenges the view that training under-provision results *only* from the nature of our labour market regulation. It is argued that even regulation-free market economies may provide less than desirable amounts of on-the-job training, so long as firms do not collude. The basic reasons offered are that training leads to technological change, the advances of which are diffused relatively easily between the firms of an industry. Our case is that this possibility constitutes a classic example of an industry-specific externality, which takes the form of the inability of firms or workers to internalise all the benefits from training, leading to its under-provision.

Empirical support for the existence of externalities associated with training in specific industries is presented in section 2. This evidence provides an intuitive basis for collective action or government intervention in the provision of training. A formal modelling approach is then used to highlight crucial issues evolving from potential government intervention. The framework demonstrates that, without collusion or intervention, training provision may be less than is desirable. As well, the implications of alternative approaches to intervention and the consequences of misdirected government action are considered.

2. AN EMPIRICAL JUSTIFICATION FOR TRAINING INTERVENTION

There are two crucial assertions pertinent to the case that, left to themselves, market economies may under-provide training. The first is that a highly skilled workforce is able to initiate, develop and adapt technological innovation, a perspective implying that training provides benefits throughout the industry and the economy. The second contention is that those firms or workers financing the training investments leading to technological advancement are not able to completely internalize the concomitant benefits, implying that competitors will experience windfall gains. To the extent that technological change is industry-specific, all producers and consumers of the industry's product may be advantaged, as well as the firm originally providing the training. In this view, the firm originally providing the training will be unable to capture all the rents from training, implying that firms will invest less in such an environment than if they could be assumed to have internalised the benefits.

The above arguments are still relevant in a world in which wages are free to adjust to reflect agreements between firms and workers as to the distribution of training investment costs, so long as the following proposition is true. This is that workers as well as firms would choose to invest less in training if innovations following from increased skill acquisition are relatively easily diffused throughout the industry. Our principal assertion, then, is that if the benefits of technological progress cannot be fully captured by those financing the training investments that influence this progress, then left to itself the market may provide less training than if training rents were protected.

It is important to stress that the above argument does not lead unambiguously to a specific recommendation concerning government intervention. In some cases, industrial organisation may mean that adopting a changed market structure (eg from collusion) will lead to an appropriate level of training. In other cases, a market solution will not be possible at all. Then the benefits of intervention designed to improve training incentives

have to be weighed against the costs of such intervention. This is a balancing act varying in degree of difficulty according to parameters defining production technologies of particular firms as well as the market structure of the economy.

Justification for the view that government intervention in training may be appropriate requires empirical support in (at least) two obvious and distinct areas: the relevance of training to technological change, and the ease of diffusion of technological advances. These are discussed below.

2.1 THE RELEVANCE OF TRAINING TO TECHNOLOGICAL CHANGE

The first question concerns whether or not more skilled/trained workers facilitate the discovery, adaptation and implementation of innovations. A useful way of initiating such an inquiry is to examine the characteristics of technological advancement.

A concensus from the literature is that most new technologies are initially very crude, badly adapted to ultimate uses, and usually offer only few and small advantages over existing processes. Typically it is argued that they acquire economic significance only through a period of experimentation and redesign (Nelson, Peck and Kalachek, 1969; Johnson, 1975). The subsequent process of adaptation and modification is seen to be cumulatively responsible for the larger part of measured productivity growth. Here, there is a large body of evidence about learning curves (cost reductions with experience) with fixed plant and equipment, which suggest important learning-by-doing effects of training. This is apparently true in the US regarding cotton textiles (David, 1975) and aircraft production (Rapping, 1965). For the petroleum refining industry, Enos (1962) finds that the initial introduction of four new process technologies yielded cost reductions of 1.5 percent per annum, while subsequent modification and adaptation of these processes yielded cost reductions in excess of 4.5 percent per annum. Hollander (1965) finds similar qualitative results for the chemical industry.

The significant point from the above is that the progression from an idea to its full integration into production is an iterative, complex and fundamental aspect of technological advancement. Crucial to our case is the proposition that if more skilled workers facilitate this integration they will be adding to that broad range of processes which contribute to technological change. Consequently, a matter of considerable relevance here is whether or not additional training improves this integration process.

There is, in fact, persuasive theoretical evidence that more *educated* managers and personnel are more adept at the adoption of new technologies (Schultz, 1975). Empirical tests of the hypothesis are available only for agricultural innovations, presumably because it is much more difficult to identify those responsible for adoption in a multi-employee firm. But at least in this context the evidence for a link between the efficiency of adoption of innovation and formal measures of worker skills is difficult to refute (Welch, 1970; Fane, 1975; Huffman, 1974; Quek, 1980; Wozniak, 1984).

Going beyond adoption to encompass implementation and adaptation of new technology, the case for a critical role of a highly skilled workforce becomes more convincing. In this context Hirsch (1952) attributes production learning effects to the role played by personnel in the implementation of new innovations. He argues that in a more trained environment managers develop more effective modes of organisation, engineers are more likely to successfully redesign products, and the potential for the introduction of labour saving production devices is greater. It is important to stress that these benefits are apparently not just the domain of the upper echelons of a firm's workforce; for example, there is clear evidence of a link between training and technological change for Japanese production workers (Tan, 1980).

Further evidence for the nexus between innovation implementation and skills comes from the initally high and subsequent declining demand for skilled workers over the life of a technology, which implies that skill requirements decline over time as the

technology becomes better understood and routinized. Setzer (1974) cites evidence for this in the decreasing inputs of educated and technical personnel per unit of output for several innovations traced over their product cycle. Support also comes from Bartel and Lichtenberg (1987), who report compelling empirical evidence for the view that highly educated workers have a comparative advantage in adjusting to and implementing new technologies. Their estimation of variants of a labour demand equation for 61 manufacturing industries in the U.S. in 1950, 1960, and 1970, found that the relative demand for educated workers declines with the age of the capital stock, a proxy for the age of technology. In other words, the derived demand for skilled workers falls as technologies become older, and their characteristics better known.

To be useful for the main argument, the cited evidence must rely on the assumption that education includes both formal schooling processes and skills enhancement learned on-the-job. If this is the case, the conclusion of Bartel and Lichtenberg (1987, p.10) is particularly pertinent: "...government subsidies and other policies which tend to encourage the acquisition of education and increase the relative supply of highly educated workers, will be expected to accelerate the rate of diffusion of new industrial technologies by lowering the costs of adjustment to and implementation [of new technologies]..." (our brackets).

As noted, but worth stressing, is that the above discussion relates in general to the effect of formal education on technological innovation and diffusion, and not necessarily to the effects of training . Even though it is plausible to argue that acts of learning have similar implications for individual skill development irrespective of the environment in which they take place, more direct evidence on the alleged connection is desirable. Two avenues are worth exploring here.

The first avenue relates to a possibly important measurement problem hidden in the research reported above. In no case does the empirical work examined control for the

possibility that the technological advances seemingly associated with formal education could be reflecting, in part, elements of on-the-job training. This is important since there is little doubt that more highly educated workers receive more on-the-job training (Lillard and Tan, 1986; Miller, 1987).[1] It follows that some of the measured benefits of education could be more properly considered as having captured the total effect of schooling and training. Thus, until proper controls are included in empirical tests, it is arguable that the conclusions reported above are entirely consistent with the proposition that on-the-job training effects contribute to the identified relationship between formal education and technological change.

Secondly, it is intriguing to note the analysis reported by Acs and Audretsch (1988) since for their analysis they employed more direct measures of both technological change and training. In a multiple regression framework, they examined the determinants of 8074 technical innovations recorded in US industry in 1982, finding that "the total number of innovations is ... positively related to R&D, skilled labor, and the degree to which large firms comprise the industry" (p.678). The measure of skilled labour used was the proportion of four-digit SIC industry employment consisting of professional and kindred workers plus managers and administrators, plus craftsmen and kindred workers. Again, so long as these relatively (formally) skilled personnel also have relatively large amounts of on-the-job training, these data constitute a case for our proposition.

In summary, the evidence reported above is strongly supportive of the notion that skills enhancement increases the likelihood and efficiency of the development, adaptation

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[1] This conclusion, derived using direct tests, is supported strongly in an indirect way by the slopes of the experience-earning profiles reported in Beggs and Chapman (1988). More schooling apparently leads to steeper slopes, and this can be interpreted from theory to represent greater on-the-job training.

and implementation of new technology. But much of the data referred to relate to the effect of schooling, and it is necessary to presume that on-the-job training is functionally similar to the more formal education process to allow a strong version of the conclusion. The positive correlation between education and training is consistent with our case, and throws important doubt on empirical work ascribing increased efficiency in the adoption of new technologies to the role of formal schooling only. Moreover, the test of Acs and Audretsch (1988) suggests that the hypothesised nexus has some direct statistical support. Nevertheless, our proposition remains conjectural and awaits completely suitable empirical work.

2.2 THE DIFFUSION OF TECHNOLOGICAL ADVANCES

That more training leads to technological advancement is irrelevant to the main issue if innovating firms or workers are able to fully internalise the benefits. In this situation there is no market failure, no industry-specific externalities, and no case for collusion or intervention. But if complete internalisation is not the case, the parties will not be willing to underwrite all training costs, leading to less training than would otherwise be the case. The second question requiring empirical support, then, is: are technological improvements diffused easily throughout the industry, or do other firms and workers have to go through the learning, training and other innovative activities completely by themselves, with no benefits flowing from the successful completion of the process by competitors?

This question may be addressed by identifying the avenues of diffusion of technology from one organisation to another. There are numerous ways in which this occurs: through what is revealed in the product, as determined by reverse engineering (a process whereby a firm takes apart a good in order to ascertain how it was produced); through the written word, as in technical journals and papers; by licensing or cross-licensing of technology (to increase returns to investments in innovative activities and

training or in exchange for other firms' technology); by interaction between users and producers of intermediate goods (new machinery), which results in the incorporation (embodiment) of users' learning in subsequent improved vintages of capital; through the mobility of informed personnel; and through spill-overs of R&D from other firms and industries (Scherer, 1982; Griliches and Lichtenberg, 1985).

Empirical evidence in this area is limited because of the difficulty in measuring relevant variables, but some useful material is available. For example, Johnson (1975) found that of the most important ideas leading to the 51 innovations receiving the Queen's Award to Industry in the UK in the 1960s, two-thirds come from outside the innovating firm. Sources included reverse engineering, technical papers, and the inter-firm mobility of technical personnel, the last potential avenue requiring a careful analysis in the context of the broader issue. Importantly, 60 per cent of diffused innovations occurred through informal networks or via third parties, implying strongly that it is very difficult for firms to protect their innovations.

The mobility of trained personnel (or "technology on the hoof") is pertinent to the question of who should pay for training leading to innovation. Human capital theory (Becker, 1964) suggests that transferable skills acquired on-the-job will be financed by workers since they can receive full returns to such investments in alternative employment. This does not compromise the externalities analysis *so long as there are sources of technological diffusion not embodied in workers.* There would still be an argument supporting the existence of benefits from externalities if skilled workers' discoveries are easily adopted by competing firms or workers, irrespective of who finances the training.

Two further points on the financing of training are worth making. One is that when technological change starts in one firm and slowly diffuses through the industry, the training related to it is initially firm-specific and must be paid for in part by the

employer. Additionally, there is the possibility that if workers are significantly more risk-averse than firms then much of the financing of (even general) training potentially leading to technological change may need to be undertaken by firms.[2] This is because of the relatively high likelihood of the skills not being embodied in the worker. Thus diffusion of technological advances affects the incidence of training investments, as well as the stock of training undertaken.

To get back to the main point, there are many illustrations of the spread of innovations across firms, with such spread not obviously related to labour mobility. One of the best known of these is that of the development and eventual dominance of the so-called QWERTY[3] keyboard in typewriters (David, 1985; Dosi, 1988). Nabseth and Ray (1974) document several rapidly diffused process innovations, including numerically controlled machine tools, tunnel kilns in brick-making and the basic oxygen steel process. It is clear from these studies that there are considerable difficulties in limiting the diffusion of technological change. Such will be the case so long as firms cannot completely stop the flow of ideas, the obvious conclusion in this situation being that it is not possible to fully internalise the benefits of shop-floor and management innovation.

In summary, there are only two issues to be resolved in terms of establishing the case that, left alone, non-colluding firms may provide less training than is desirable for reasons other than labour market arrangements. The first is whether or not training facilitates technological advancement, through the discovery of innovations and in the

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2 There are several other reasons firms might pay for investments in general human capital: the moral hazard of firms paying low wages but not providing training (Hermalin, 1987); binding wealth constraints of workers; excessive costs of bargaining over the financing arrangements in the context of the difficulties of distinguishing general and firm-specific training; and informational asymmetries between the employing firm and other potential employers (Chiang and Chiang, 1988).

3 QWERTY refers to the first top letters in the standard typewriter keyboard.

adaptation and implementation of reform. A moderately strong case can be made that this is so. The second issue concerns whether or not firms and workers are able to fully internalise the benefits of such progress or, in other words, to easily erect complete barriers to the dissemination of knowledge. While there may be a short-run capturing of rents, the many possible avenues of diffusion of information imply that the protection of technological advances over time is highly unlikely, a conclusion reinforced by many case studies.

It is important to reiterate that these arguments do not by themselves constitute a case for government intervention or, more specifically, the imposition of industry training levies. Collusion between competitors may resolve the training underprovision, but in the absence of voluntary collective action more direct government involvement may be desirable, so long as the costs of so doing are not prohibitive. These issues are now explored more formally.

3. THE CASE FOR INTERVENTION

In this section of the paper it is assumed that the two major propositions argued in section 2 of the paper are satisfied, so that training leads to technological advance and it is not possible for innovating firms and workers to internalise the rents from the process. If these conjectures matter empirically, it is useful to highlight the relevant issues for policy through a formal modelling approach.

To motivate the exercise an example is chosen where the externalities from training enter into firms' production technologies in a specific manner. By making very strong assumptions about the production technology and the structure of the market facing the industry the example demonstrates that government intervention can lead to increased profitability for all firms in the industry. This specific example is argued to be a special case of the more general proposition that when there are externalities derived from

government intervention in on-the-job training, its provision can lead to economy-wide welfare improvements. It is demonstrated that the ultimate benefits from training externalities in a particular industry can be distributed throughout the economy with their incidence being strongly dependent on the market structure facing the industry.

3.1 AN EXAMPLE WHERE INTERVENTION IS JUSTIFIED

It is useful to consider the relationship between corporate training and the production decision of the firm in an example of an industry in which firms are price-takers in all markets. Assume further that there are barriers to entry, and training provided by one firm in the industry generates externalities for other firms in the same industry. In this context it can be demonstrated that if firms chose levels of training to maximise their *own* profits then training and output is less than if the level of training in each firm was chosen so as to maximise *industry-wide* profits. Establishment of this proposition suggests that, for such an industry, collusion or some form of government intervention to encourage collusion-like behaviour will lead to increased training.

In the model, the firm is assumed to have one input, raw labour, L, and the output per unit of labour can be increased by the provision of training courses, T, within the firm. In addition to its influence on the output per unit of labour within the firm, some training financed by the firm[4] is assumed to provide an externality to the industry by increasing the output per unit of input of other firms in the same industry. Benefits to the rest of the industry resulting from training provision by one firm occurs, for example, if that training results in modifications of new equipment or adaptations which

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4 As noted earlier, there may be important reasons for the financing of risky training to be mainly underwritten by firms, not workers. As well, training leading to innovation is initially firm-specific and theory suggests that firms must finance part of this training. The essence of the analysis is not compromised if workers contribute to the financing.

eventually become the industry standard.

To explain the model further assume that there are a total of m (>1) firms in the industry, each of which is assumed to have the same technology (identical production functions). Firms finance the training provided to their own staff so that training can be funded without calling on resources from elsewhere in the economy. As noted the industry is assumed small in the national economy so that it is a price-taker in the market for labour and training resources. In addition, it is assumed that the national output by the industry is small in a world market, so that the domestic industry is a price-taker on the product market. These last assumptions allow prices, wages and the cost of training to be treated as exogenous to the decision of the firm. The model is long-run and abstracts from the dynamics associated with the time-stream of costs and benefits associated with training.

Using subscripts to denote each of the m different firms, a model of the ith firm is given by:

$$\Pi_i = pY_i - wL_i - cT_i \qquad c > w \qquad (1a)$$

$$Y_i = F(L_i, T_i, X_i) = [a + bX_i^{\alpha}] (L_i + T_i)^{\beta}$$

$$a > 0, b > 0, \alpha > 0, \beta > 0, \alpha + \beta < 1 \qquad (1b)$$

$$X_i = \sum_{j \neq i} T_j \qquad (1c)$$

where,

Π_i = nominal profits of ith firm

Y_i = units of output by ith firm

L_i = raw labour units demanded by ith firm

T_i = units of training provided within ith firm[5]

X_i = units of training provided by all firms within the industry other than the ith firm

p = price of unit of output (assumed exogenous)

w = nominal wage per unit of raw labour (assumed exogenous)

c = nominal cost per unit of training (assumed exogenous)

Equation (1a) defines nominal profits as equal to income derived from sales of output less wage costs and the cost of training within the firm. Equation (1b) defines the technology facing the producer, represented by a production function defining output of the firm. Provision of training increases the output of the industry in two ways. The first is that the provision of training within the firm increases output within the firm, so that even if no firms in the industry other than the ith firm provide training ($X_i = 0$), aggregate production can be represented in the form:

$$Y_i = a\,(L_i + T_i)^{\beta} \qquad (2a)$$

Thus, increases in training will increase aggregate ouput even in the absence of any externalities.

The second way training provision increases output in this model is that when other firms in the industry also provide training (represented by $X_i > 0$, so that the externalities are positive) then the externality generated by such training will result in increased output even if inputs within the firm remain the same. With the addition of benefits generated from training provided elsewhere in the industry, output is given by:

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5 A unit of training is implicitly defined here as that amount of training that, in the absence of externalities, will increase output by the same amount as will one unit of raw labour.

$$Y_i = [a + bX_i^{\alpha}] (L_i + T_i)^{\beta} > a (L_i + T_i)^{\beta} \qquad (2b)$$

Clearly, output is greater as a consequence of benefits generated from the externalities.

Equation (1c) defines training provided by all firms other than the ith firm. In the model benefits accrue to individual firms as a result of training provided by other firms in the same industry; accordingly, it is possible for an individual firm to 'free-ride' on its competitors by not providing an appropriate share of training to its own employees. Such free-riding behaviour can lead to less than desirable provision of training throughout the industry, a point demonstrated below by considering alternative profit maximising scenarios.

If each firm in the industry made its production decision so as to maximise profits throughout the industry then, since each firm faces the same production technology and the same cost structure, each firm will choose the same level of production, labour and training. As prices, wages and the cost of training are assumed exogenous to the industry, these will be unaffected by the decisions of the firm and the decision to maximise profits over the whole industry will be accompanied by increased profits for firms within the industry.

In the case when each firm decides to maximise profits over the whole industry, if each firm has perfect knowledge about the production technology and cost structure of its competitors, then it will know that the level of training provided by its competitors will be the same as its own level of training provision. The solution resulting when each firm makes its training and production decisions so as to maximize overall profits within the industry is henceforth referred to as the solution under industry-wide collusion. In this case, the aggregate level of training provided by all firms other than the ith firm is given by:

$$X_i = (m - 1)T_i \qquad (3)$$

It is demonstrated in the Appendix that the level of training, T_i, under this scenario will be positive.

The case of the free-riding firm occurs when an individual firm knows nothing about the optimisation decision of other firms in the industry, but simply assumes that aggregate training provision by such firms is fixed. In the model presented here the free-riding firm will provide no training. If each firm in the industry adopts the same approach of maximising its own profits taking training by the rest of the industry as given, then no firms in the industry will provide training. It is also possible to choose other technologies where free-riding firms do train, the crucial issue being that free-riding firms will always provide less training than would be the situation under industry-wide collusion.

Levels of training, output and profits over the industry will always be greater under industry-wide collusion than when some (or all) firms choose to free-ride. Hence, under collusion, all firms have higher profits and are better off. All firms would also be better off if the incentive for any firm to attempt to free-ride on its competitors was removed.

One way in which the incentive for firms to free-ride could be eliminated would be by a mandatory requirement that all firms provide a minimum level of training to their staff, or a minimum training expenditure to an industry training board. If each firm were required to provide and fund the level of training that would be forthcoming from industry-wide collusion this would generate similar improvements in industry-wide training, employment and profit scenarios as would have been achieved under a profit-maximising solution based on industry-wide collusion. By removing the incentive to free-ride, the profit position of the industry can be improved.

3.2 THE GENERAL CASE FOR INTERVENTION

The example presented above shows that there are situations in which the profits of an industry will be higher under industry-wide collusion, voluntarily reached or government induced. Essentially, such improvement in profitability can be achieved because it is possible to spend resources on additional industry-wide training to achieve an increase in output throughout the industry which is greater than the additional resources needed to provide this additional training.

Of course, there is no reason why the government should intervene just because profits in a particular industry will be higher. The economic outcomes under different criteria need to be ranked by more appropriate means according to some welfare criteria. Two types are:

. equity criteria, which attempt to assess whether resources are distributed fairly throughout the economy;

. aggregate welfare criteria, which assess whether resources can be used more effectively so as to increase economy-wide benefits. This approach does not take account of how resources are distributed.

It is useful to keep in mind that, by making use of lump-sum transfers, any policy which satisfies a particular aggregate welfare criterion can also be made to satisfy given equity criteria. One aggregate welfare criterion uses a money metric approach to measuring welfare (Boadway and Bruce, 1984), identifying aggregate welfare improvements in the economy as follows:

change in aggregate welfare = change in consumer surplus + change in producer surplus (4)

Under this criterion any process which increases profits of firms within an industry, thus increasing producer surplus, while at the same time not reducing consumer surplus, will lead to an aggregate welfare improvement. Similarly, a process which reduces the price of output, thus increasing consumer surplus, while at the same time not reducing producer surplus, will result in a welfare improvement.

The example in section 3.1 presented a scenario under which government intervention will lead to an increase in profits for a particular industry without any reduction of benefits to other sectors of the economy. In the money-metric approach to welfare discussed above, an increase in industry profits is equivalent to an increase in producer surplus and hence, under the criterion summarised in equation (4), such intervention leads to a welfare improvement.

In the model it is assumed that prices, wages and the cost of training are exogenous. In this case, an equivalent outcome to that achieved under the government intervention scenario could also be achieved by a change in market structure. For example, if all firms in the domestic industry combined to form a monopoly then, under the assumptions outlined above, the solution derived from industry-wide collusion or equivalent market intervention would be achieved.

In many circumstances the industry will not be a price-taker in all markets and barriers to entry will not exist. In such cases, if training externalities exist, government intervention may still lead to a welfare improvement, but the extent to which it is distributed between increases in producer surplus and increases in consumer surplus will depend on the particular structure of the market. This point is pertinent to the determination of the most desirable form of intervention.

Under market structures which differ from that presented in the model, a welfare improving outcome may yet require an interventionist solution. For example, where an

industry is not a price taker in the market for output and there are no barriers to entry, if perfect competition prevails then market intervention designed to lead to an appropriate level of training results in a decline in output prices with no long-run change in profits. The benefits will then be realised through an increase in consumer surplus leading to corresponding welfare improvements. But if the firms combined to form an industry-wide monopoly this would lead to a pricing distortion, implying that increases in output and corresponding welfare improvements would be less than could be achieved by government intervention requiring specified levels of training in the perfectly competitive industry.

Other scenarios where increased levels of training lead to changes in the level or structure of wages or the cost of training can also be considered. Complex and relevant situations where changes to profits, prices and the returns to other factors of production all occur simultaneously can also be considered. Clearly, different scenarios can result in different distributions of welfare improvements between increases in consumer surplus and increases in producer surplus. In particular, benefits from market intervention may not accrue within the specific industry but may be distributed throughout the economy. From this discussion it is clear that if there are externalities from on-the job training then government intervention can lead to welfare improvements, with the ultimate incidence of benefits differing depending on the market structure facing the industry.

4. METHODS OF GOVERNMENT INTERVENTION

The government may determine that there are benefits to be gained from training externalities and that these benefits are not being delivered by the market. If the benefits are assessed to be large enough a case can be made for government intervention in the industry. One way the government can intervene is by choosing a mandatory requirement that all firms in the industry provide a minimum level of expenditure on training. If this happens then there are two important questions to be addressed: how

should the mandatory training requirement be distributed between firms?; and, how should the required levels of training be financed? The answer to both questions will depend to some extent on the production technologies of different firms within the industry.

The most desirable distribution of training requirements between firms depends crucially on the way in which the externalities associated with training interact with production technologies. It is useful to assume that different firms within the industry possess different technologies so that, in the absence of intervention, profit-maximising firms vary in levels of employment, output, training and profits. In the model, such an outcome can be illustrated by assuming that different firms within the industry have unequal values for the parameters α and β in their respective production functions. Allowing the α and β parameters to differ, the best level of government intervention in training provision would involve a higher mandatory training requirement for those firms which obtain a smaller externality from industry-wide training, a result following from the specification of the production function. Modified to allow for different values of α and β across firms the production function is given by:

$$Y_i = F_i(L_i, T_i, X_i) = [a + bX_i^{\alpha i}] (L_i + T_i)^{\beta i} \qquad (5a)$$

where

$$X_i = \sum_{j \neq i} T_j \qquad (5b)$$

Under this specification, the externalities from training for the ith firm enter through the variable, X_i, which takes no account of training provided within the ith firm. Accordingly, if the α_is and β_is are allowed to vary so that different firms possess different technologies, then industry-wide externalities generated by additional training

will differ according to which firm provides the training.

An alternative production technology can be represented by:

$$Y_i = F_i(L_i, T_i, Z) = [a + bZ^{\alpha i}] (L_i + T_i)^{\beta i} \qquad (6a)$$

where

$$Z = \sum_j T_j \qquad (6b)$$

For this specification, the externalities from training enter through the variable, Z. This variable does take account of training within the ith firm and additional training generates the same externalities throughout the industry, no matter which firm provides the training. Under this specification, a given training requirement funded at a given lump-sum cost to the industry will have the same impact on output and profit levels for the industry overall irrespective of how that mandatory training requirement is distributed across firms within the industry.[6]

Even if the government has determined that training externalities exist within an industry, it is unlikely to be aware of the precise manner in which such training externalities interact with the production technologies. The understanding of how this interaction operates will be crucial in the determination of the allocation of mandatory training requirements across firms, with the nature of this interaction being best understood by industry members. Accordingly, the distribution of mandatory training requirements can probably be best determined by an industry board with appropriate

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6 Since the demand for raw labour must always be positive, this assertion assumes that no firm provides 'too much' training.

representation by all firms within the industry.

Once appropriate mandatory levels of training across firms within the industry have been decided, it will be necessary to determine how such training requirements should be financed. This decision will depend on a combination of aggregate welfare and equity considerations.

For a given level of training intervention in each firm there will be a corresponding level of benefits from training externalities across the whole industry. When evaluating the aggregate welfare gains from such intervention these benefits must be offset against the welfare losses associated with the distortions introduced by alternative financing proposals.[7]

As noted in section 3, the principal benefits of any externalities arising from mandatory training requirements may not be realised as additional profits within the industry at all. For example, if the externalities lead to a change in product prices then the externalities may be realised as an increase in consumer surplus only. The benefits from externalities may also accrue to factors of production such as wages and the costs of training. This would be represented as an increase in producer surplus. In general, benefits may be realised as an increase in consumer surplus, as an increase in producer surplus or as a combination of both. Equity considerations lead to the conclusion that it would be desirable for the costs of mandatory training to be borne by those sectors of the

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7 Fred Gruen has raised the interesting possibility that Australian government financing of formal training - such as in the case of TAFE or higher education- already corrects some of the distortions arising from industry training under-provision. The point has some relevance where training externalities deliver economy-wide benefits but cannot be used to justify the *status quo* if specific industry producers are the beneficiaries. In such a situation a levy imposed on particular industries to finance the specific formal training would be desirable. In the case where the externalities are generated from on-the-job training the financing of formal skills enhancement programmes is not obviously relevant to the intervention issue.

economy that are the ultimate beneficiaries of training intervention. To identify those beneficiaries would require, for each industry, a detailed study of market structure and distributions of consumer surplus and producer surplus. Such an analysis is beyond the scope of this paper. Suffice it to say that larger benefits could accrue to those sectors that possessed some degree of monopoly power.

It is also important to note that different methods of financing will result in varying levels of market distortion and in corresponding welfare losses. The example presented in section 3 assumed that each firm financed its own training requirements; this is equivalent to financing by a lump-sum tax and introduces no distortion to the profit-maximising decision of the firm. Other financing options will typically involve the introduction of distortions somewhere in the economy thus to some extent reducing aggregate welfare. For example, any method of financing that involves some form of marginal taxation will introduce distortions which will tend to offset the benefits derived from the training externalities. The cost of additional training could be financed by slightly raising marginal tax rates across the economy or by a levy on firms within the industry. If such a levy were to be based on some form of marginal taxation then it would introduce greater distortions than would be the case with funding through economy-wide taxation.

To further develop the methods by which the distribution of a levy across firms within the industry could be determined it is useful to distinguish the following three possibilities:[8]

(a) each firm finances the training provided to its own staff;

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8 A fourth option would be a profits tax. There is a problem with how profits should be defined, and for certain technologies, such as when the production function is homogeneous of degree 1, firm profits will be driven to zero (which is also the case in a perfectly competitive industry).

(b) training is financed by a sales-tax levied on firms within the industry;

(c) training is financed by a payroll tax levied on firms within the industry.

If a mandatory training requirement is imposed then the self-financing proposal (method (a)) is equivalent to a form of lump-sum taxation and, consequently, imposes no distortion on the profit maximising decisions of firms within the industry. The other methods ((b) and (c)) impose distortions and tend also to disadvantage different types of firms. For example, high productivity firms[9] would be taxed more under a sales tax than under a payroll tax, while the opposite is true for low productivity firms. As well, sales and payroll taxes in specific industries would introduce larger distortions into the economy than would an economy-wide tax yielding equivalent revenues.

In summary, on aggregate welfare criteria the methods of financing can be ranked as follows. First, financing by lump-sum taxation is equivalent to each firm in the industry financing its own training (method (a)) and is preferred to financing by economy-wide taxation. Second, economy-wide taxation is preferred to financing by a sales tax or by a payroll tax within the industry (methods (b) and (c)).

If the ultimate incidence of benefits from additional training is spread broadly through the economy (for example, through increased consumer surplus only) or if the distribution of benefits cannot be reliably determined, then an equity argument would support the spread of training costs throughout the economy. However, in some situations firms within the industry may possess a degree of monopoly power so that a large share of the welfare gains will be realised as additional producer surplus in the form of increased profits. In such a situation, an equity argument would support the financing of a mandatory training requirement on the basis of a levy applied to firms within the

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[9] In the notation of the model, productivity of the ith firm is given by Y_i/L_i.

relevant industry.

An overall assessment of aggregate welfare and equity arguments suggests that additional training should be funded by economy-wide taxation or by requiring that each firm fund its own additional training provision at market rates. Funding by economy-wide taxation should be viewed more favourably if benefits from training externalities are expected to be distributed throughout the economy. On the other hand self-financing of training by firms should be viewed more favourably if the ultimate benefits from training externalities are expected to accrue within the industry only.

5. THE CONSEQUENCES OF MISGUIDED INTERVENTION

So far it has been shown that, under certain circumstances, welfare improvements may be achieved from government intervention in the provision of training. But, as illustrated above, it may be extremely difficult for the government to determine the best distribution of training requirements across firms within an industry. Indeed, even the government's estimate of training requirements for the aggregate industry may be very inaccurate. Also, distortions may be introduced by the method of financing government intervention. In this section, the possibility that the government may intervene incorrectly is canvassed.

If the benefits of mandatory training requirements are small and the method of financing the additional training requirement introduces a further distortion to economic decisions, then the welfare gains arising from enforced training may well be more than offset by losses associated with distortions introduced by the method of financing. Intervention under such a scenario will lead to an aggregate welfare loss.

Government intervention in training provision can only be effective if welfare gains from training externalities are large enough to offset both the losses from the associated distortions and the costs of monitoring the effectiveness of such intervention.

Thus government intervention will only be welfare improving up to some threshold training level. As mandatory training increases beyond the threshold level aggregate welfare gains will diminish and may eventually become negative.

The important point is that there is a danger that intervention can do more harm than good for the economy. Effective intervention requires that the government make an accurate assessment of whether or not there are sufficient benefits to be gained from such intervention and care must then be taken to ensure that firms in the industry are not forced to maintain excessive training requirements. This can be achieved if the government monitors profit and price levels, as well as returns to factors of production within the industry, to ascertain whether or not real gains have been achieved. Ultimately training intervention is only warranted if the perceived benefits are large and a circumspect approach to intervention is adopted.

6. CONCLUSION

Two propositions have been canvassed which, if true, imply that externalities result from training. They are that training increases a firm's ability to develop, adapt and implement new technology and that the innovations associated with this process are diffused with relative ease to the firm's competitors. If either proposition is false a case for government intervention in on-the-job training must rely on other arguments. However the indirect evidence for the basic propositions is apparently consistent with both.

Using an example, it has been demonstrated that if training leads to technological advances, there may be training underprovision throughout the economy because individual firms are unable to internalise the benefits arising from innovations. It has been asserted here that such training underprovision can arise under a variety of market structures.

The consequences of government intervention were then canvassed. Ideally the government could intervene to encourage or require all firms in the industry to provide a level of training expenditure that increases aggregate welfare. But it must be recognised that the government will have imperfect information about the manner in which training externalities interact with different production technologies, and that distortions will be introduced by some methods of financing. Government intervention on the basis of imperfect information and the introduction of associated financing distortions must therefore involve some offsetting welfare losses.

There are no easy rules for determining whether government should intervene in the determination of on-the-job training provision. As the strength of the case for intervention is very sensitive to production technologies and their interaction with externalities, any assessment of whether or not intervention is appropriate should proceed on an industry-by-industry basis. In particular, and of relevance to the contemporary policy debate, no general case can be made in the externalities context for government intervention in the form of a uniform levy imposed on all industries.

In evaluating whether intervention is appropriate for a particular industry, it will be necessary at the outset to assess the benefits that may accrue, and to determine which sectors of the economy will be the ultimate beneficiaries. If, for a particular industry, the available information is relatively poor the case for intervention must be considered to be more tenuous. As well, if the benefits from intervention are determined to be sufficiently large the method of financing and the distribution of mandatory training requirements must still be decided.

From the modelling exercise, it has been demonstrated that given a combination of equity and aggregate welfare criteria, mandatory training requirements are best financed either by economy-wide taxation or by requiring that each firm finance its own training provision or expenditure. On equity grounds, determination of the appropriate financing

method should be based on where the ultimate incidence of benefits of government intervention occurs. Economy-wide taxation is appropriate if the ultimate benefits are widely dispersed throughout the economy and self-financing within the industry is appropriate if the benefits accrue within the industry.

On the process side of the policy question it is likely that the distribution of mandatory training expenditure requirements are best determined by an industry board with appropriate representation by all firms within that industry. In consultation with the government the board could then define both the level of industry-wide training to be adopted, and the distribution and type of training across firms within the industry.

It is important to recognise that if the benefits derived from the externalities are overestimated, the industry and the whole economy could be worse off as a consequence of intervention. However, this will not be the case if it can be established that there are significant training externality gains in a particular industry and a cautious approach to intervention is adopted.

APPENDIX

The profit maximising solution under industry-wide collusion presented in Section 3 of this paper is derived from an optimisation problem of the form:

Choose L, T so as to maximise

$$\Pi = p\,[a + b\,(m - 1)^{\alpha}\,T^{\alpha}]\,(L + T)^{\beta} - wL - cT \qquad (A.1)$$

The first-order conditions for a maximum satisfy

$$\frac{\partial \Pi}{\partial L} = \beta\, p\,[a + b\,(m - 1)^{\alpha}\,T^{\alpha}]\,(L + T)^{\beta-1} - w = 0 \qquad (A.2a)$$

$$\frac{\partial \Pi}{\partial T} = \alpha\, p\, b\,(m - 1)^{\alpha}\,T^{\alpha-1}\,(L + T)^{\beta}$$

$$+ \beta\, p\,[a + b\,(m - 1)^{\alpha}\,T^{\alpha}]\,(L + T)^{\beta-1} - c = 0 \qquad (A.2b)$$

The appropriate second-order conditions for a maximum are also satisfied.

Equations (A.2a, A.2b) reduce to:

$$\beta\, p\,[a + b\,(m - 1)^{\alpha}\,T^{\alpha}]\,(L + T)^{\beta-1} = w \qquad (A.3a)$$

$$\alpha\, p\, b\,(m - 1)^{\alpha}\,T^{\alpha-1}\,(L + T)^{\beta} = c - w > 0 \qquad (A.3b)$$

Clearly, the optimal solutions for L and T satisfy

$$L + T > 0 \qquad (A.4a)$$

$$T > 0 \qquad (A.4b)$$

The profit maximising solution of a free-riding firm is derived from an optimisation problem of the form:

Choose L, T (≥ 0) so as to maximise:

$$\Pi = p\,[a + b\,Z^{\alpha}]\,(L + T)^{\beta} - wL - cT \qquad \text{(A.5)}$$

The profit maximising solutions for L and T satisfy:

$$L > 0 \qquad \text{(A.6a)}$$

$$T = 0 \qquad \text{(A.6b)}$$

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