Banning Information as a Redistributive Device*

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Abstract

In this paper we analyze the optimality of allowing firms to observe signals of workers' characteristics in an optimal taxation framework. We show that it is always optimal to prohibit signals that disclose information about differences in the intrinsic productivities of workers like mandatory health exams and IQ tests, for example. On the other hand, it is never optimal to forbid signals that reveal information about the comparative advantages of workers like their specialization and profession. When signals are mixed (they disclose both types of information), there is a trade-off between efficiency and equity. It is optimal to prohibit signals with sufficiently low comparative advantage content.

Keywords: Optimal Taxation, Productivity Learning.

JEL Classification: H21, H24

Resumo

Nesse trabalho, analisamos a otimalidade de permitir às firmas observar sinais que representem características de trabalhadores em um contexto de taxação ótima. Mostramos que é sempre ótimo proibir sinais que revelem informações sobre diferenças intrínsicas de produtividade dos trabalhadores, tais como exames obrigatórios de saúde ou testes de Q.I. Por outro lado, nunca é ótimo proibir sinais que revelem informações sobre vantagens comparativas dos trabalhadores, tais como suas especializações e suas profissões. Quando sinais são mistos (revelam ambos os tipos de informação) há um dilema entre eficiência e eqüidade. É ótimo proibi-los quando possuem pouco conteúdo de vantagem comparativa.

Palavras Chaves: Taxação Ótima, Aprendizagem de Produtividade

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1 Introduction

There is a controversial debate about the rights of firms to impose mandatory exams on workers. In the U.S., a supreme court decision limits the use of employment tests that are not directly relevant for the job (Griggs v. Duke Power Co., 3 FEP Cases 175, 1971). There are also a series of Equal Employment Opportunity Commission guidelines about employee selection procedures (U.S. Department of Labor, 1978).

This dispute has been in the core of political discussions at least since the 1940's, when the U.S. Army began screening draftees for their ability to read and write. Worried about the disproportion of black and white individuals' who were able to pass the literacy test, Southern Congressman demanded the Army to relax the passing standards.

Nevertheless, economists have not devoted sufficient attention to this issue. Since the work of Akerlof (1970), it is known that the presence of asymmetric information may lead to inefficient outcomes. Then, most policy prescriptions suggest reducing the asymmety of information in order to increase welfare. In this case, this would lead to allowing firms to obtain any relevant information about workers.

Despite these recommendations, not only laws ban the requirement of some exams but also some types of information that could be disclosed at virtually no cost are not available. For instance, most exams are not graded in sufficiently detailed grading systems which would allow a clearer comparison between students.[1]

Implicit in these prescriptions is a *first-best argument*. The government should first try to correct the labor market inefficiency. Then, workers made worse off can be compensated through lump-sum redistribution. However, as has been widely studied in the public finance literature, the type of required lump-sum taxes (varying person-by-person and independent of individual behavior) is usually unfeasible. Instead, available taxes depend on observable behavior and generate some distortion.

In this paper, we consider the optimality of banning the firms' access to signals which reflect workers' characteristics in an environment where lump-sum taxes are not available (due to asymmetric information). We consider two types of signals: (i) productivity signals, and (ii) comparative advantage signals.

The first type of signals is the focus of most of the job-market signaling literature and includes health exams, cognitive and non-cognitive tests. In this model, firms have an identical technology but workers differ in their intrinsic productivity. Then, signals reveal each worker's productivity to firms. We show that *it is always optimal to prohibit productivity signals* (such as health exams or IQ tests). Moreover, when they enhance workers' productivities (as education or employer-sponsored health-care programs) it is optimal to ban signals if and only if the productivity enhancing component is below a certain threshold.

The reason for this result is that prohibiting the disclosure of information about workers' productivities approximates lump-sum redistributions better than what can be implemented

[1] Examples include pass-or-fail systems or letter grades. The pass-or-fail system is used in the GED, for example, which is taken by more than 1 million people in the U.S. each year. Most universities employ letter-grade systems.

by the government when this information is available to firms. However, this policy implies in the emergence of adverse selection: since more (less) able individuals receive lower (higher) wages and leisure is a normal good, there are less qualified (more unqualified) workers than the socially optimal amount in equilibrium.

Our result is related to the second-best arguments of Lipsey and Lancaster (1956). Eliminating the labor-market inefficiency would generate too much inequality while increasing the aggregate income. Then, redistributing the increased income would imply in much higher inefficiency.[2]

However, differently from usual job-market signaling models, education generally signals more than just a worker's productivity. Each profession often signals a particular set of characteristics which are desirable for some specific type of jobs. For example, a degree in design signals very different characteristics from a degree in accounting. Firms use this information in the internal allocation of tasks. We call such signals comparative advantage signals as they reflect different comparative advantages instead of different intrinsic productivities among workers.

We show that *a prohibition of comparative advantage signals is never optimal.* The reason for this result is that banning the disclosure of such information would not redistribute wealth but would lead to inefficiencies in the productive process. Thus, it would always be welfare reducing.

Therefore, the main conclusion of the paper is that an optimized economy with concerns about income distribution would prohibit signals that reflect different productivities among workers with sufficiently homogenous comparative advantages and permit signals that reflect different comparative advantages among workers with sufficiently similar productivities.

When signals are mixed (i.e., they convey information about comparative advantages and different productivities), there is an equity-efficiency trade-off as the prohibition of signals reduces aggregate production but redistributes income. Hence, Diamond and Mirrlees' (1971) efficiency result does not hold in this model since an optimized economy may not be in the production frontier.

This article is related to the theory of optimal taxation initiated by Mirrlees (1971). However, unlike most articles in this literature, we do not assume that firms have full knowledge about the productivities of workers (or, equivalently, that individuals have access to a home production technology). Instead, firms progressively learn the workers' productivities in our model. This assumption is associated with a relatively new strand of literature on productivity learning and wage dynamics which has found significant empirical support [Farber and Gibbons (1996), Altonji and Pierret (1996)].

Two other papers have studied welfare effects of taxing signals. Andersson (1996) showed

[2] This conclusion also resembles arguments presented at Elul (1995), Ghatak et al. (2001), and Vercammen (2002) though applied to different contexts. Elul proved that in almost every incomplete markets economy with more than one consumption good and sufficiently uninsured states of nature, there is an asset whose introduction makes all agents worse off. Gatak at al. showed that when labor markets feature suboptimal effort (due to moral harzard, for example), an increase in the inefficiency of credit markets may increase welfare. Vercammen showed that in the pooling equilibrium of a model of simultaneous adverse selection and moral hazard in a credit market, aggregate borrower welfare may be higher than in the moral-hazard-only case.

that in the presence of linear income-taxation and job-market signaling, imposing some tax on signals and progressive tax on income may have favorable welfare consequences. Ireland (1994) presented a model of status signals. His result is that taxing the signal and subsidizing consumption may be Pareto improving.

Some papers have analyzed models of competitive insurance markets where individuals may choose whether or not to gather and disclose information. Doherty and Thistle (1996) considered the existence of equilibrium and the welfare properties under several different informational structures. Hoy and Polborn (2000) presented a model of genetic tests in life insurance competitive markets. Both papers obtained ambiguous results. Our paper departs from Doherty and Thistle's and Hoy and Polborn's in that we allow the government to combine the regulation of access to information with redistributive policies.[3]

The paper is organized as follows. Section 2 presents the model with a productivity signal. Section 3 considers a model with a comparative advantage signal. Section 4 generalizes the results to the cases where the productivity signal enhances workers' productivity and where signals are mixed and discusses other possible extensions. Then, Section 5 concludes.

2 The Model with a Productivity Signal

Consider an economy that lasts for two periods, denoted 1 and 2. There is an equal amount of two types of individuals, denoted H and L. Individuals are identical except for their productivity parameters θ: L-workers are less productive than H-workers $(\theta^L < \theta^H)$.

There is a large number of firms with the same technology $f\left(\theta^i l\right) = \theta^i l$, where l is the amount of labor. In the first period, firms do not know each worker's productivity parameter θ. Hence, they are unable to condition wages on workers' productivities. As in Holmstrom (1999), we assume that wages must be paid before the end of the productive process implying that it cannot be conditional on production.[4]

After the first period, all firms observe the productivity of each worker. Then, in period 2, firms may offer wages conditional on the worker's productivity. The assumption that all firms observe each worker's productivity allows us to abstract from the wage bargaining process.[5]

As in most of the wage bargaining literature, we assume that firms cannot commit to a two-period contract in the first period. Thus, firms offer a (one-period) contract in each period.

We assume that first-period contracts are non-exclusive.[6] Thus, as firms do not know the worker's productivities in period 1, individuals may manipulate the contracts in order to

[3] Autor and Scarborough (2004) empirically test the existence of an equality-efficiency trade-off in the adoption of standardized tests.

[4] This is also obtained when production cannot be perfectly verified by a court and, hence, the contract would not be enforceable. When production can be verified before wages are paid, firms will typically offer a menu of contracts. In order to simplify the analysis, we will not consider such possibility in this paper.

[5] When only the employer observes the worker's productivity, wages are determined through a bargaining process. This could be introduced in this model by reinterpreting θ^i as the wage received by a type-θ^i worker after the bargain in the second period but would slightly change the stucture of the model since firms would have ex-post non-zero profits (thus, the ownership of firms would matter).

[6] This assumption is also made by Hoy and Polborn (2000) and Villeneuve (1996).

obtain a higher utility. For example, if firms try to screen workers conditioning wages on the number of hours worked, individuals may deviate by moonlighting (or by trading with agents of different types). Thus, incentive-compatibility requires that wages in the first period be linear [see Hammond (1987)].

As the productivity of each worker is not known to the firms in the first period, they cannot distinguish between workers. In the second period, workers of different types cannot change contracts because the firm will be able to distinguish them (i.e., second-period contracts are exclusive for individuals with different types).

Worker's preferences can be represented by an additively separable, time-independent utility function with time preference parameter 1:

$$U(c_1) - \varphi(l_1) + U(c_2) - \varphi(l_2), \tag{1}$$

where c_j and l_j denote consumption and labor in period j.

We assume that U and φ satisfy the usual conditions for interior solutions:

Assumption 1 *U is strictly increasing, strictly concave, $\lim_{x\to 0} U'(x) = +\infty$.*

Assumption 2 *φ is strictly increasing, strictly convex, $\lim_{x\to 0} \varphi'(x) = 0$ and $\lim_{x\to 1_-} \varphi'(x) = \infty$.*

In the absence of government intervention, a type-i worker faces the following problem:

$$\max_{\{s,l_1,l_2\}} u(c_1^i) - \varphi(l_1^i) + u(c_2^i) - \varphi(l_2^i), \tag{2}$$

$$\text{s.t. } c_1^i \leq l_1^i w_1 - s^i \tag{3}$$

$$c_2^i \leq l_2^i w_2^i + s^i \tag{4}$$

where interest rates are normalized to 1 and s^i is the amount of saving.

Definition 1 *A competitive equilibrium is a profile of labor, consumption and wages $\{l_j^i, c_j^i, w_1, w_2^i\}_{j=1,2}^{i=L,}$ such that:*

1. *$\{l_j^i, c_j^i\}_{j=1,2}$ solve worker's i problem given the profile of wages, and*
2. *Wages in each period equal the expected productivity of the worker (conditional on the information available to firms): $w_1 = \left(\frac{\theta^L l_1^L + \theta^H l_1^H}{l_1^L + l_1^H}\right)$, $w_2^i = \theta^i$.*

Solving the worker's problem yields:

$$\frac{u'(c_1^i)}{u'(c_2^i)} = 1, \tag{5}$$

$$u'(c_1^i) w_1 = \varphi'(l_1^i), \tag{6}$$

$$u'(c_2^i)\theta^i = \varphi'(l_2^i). \tag{7}$$

Equation (5) is the usual equality between the marginal rate of substitution and the marginal rate of transformation (in this case the marginal rate of transformation is 1). Equations (6) and (7) are the equality between marginal benefit of labor (right hand side) and its marginal cost (left hand side) for periods 1 and 2, respectively.

Notice that $\theta^L < w_1 < \theta^H$ implies that low-productivity individuals work more in the first period than in the second, while high-productivity individuals work more in the second. This is the usual adverse selection effect, where type-θ^L workers benefit from the information asymmetry by obtaining wages higher than their productivity.

2.1 First-best solution

As in most public-finance literature, we take a utilitarian government that maximizes the unweighted sum of each individual's utilities. In this subsection, we present the benchmark case where the government can observe each worker's productivities (first-best).

Let Y_i^j be the income of type-j worker in period i:

$$Y_i^j \equiv \begin{cases} w_1 l_i^j, & \text{for } i = 1 \\ \theta^j l_i^j, & \text{for } i = 2 \end{cases}.$$

A social planner must face the resource constraint, which states that the total amount of consumption must not exceed the total income:

$$Y_1^L + Y_1^H + Y_2^H + Y_2^L \geq c_1^L + c_2^L + c_1^H + c_2^H.$$

In order to write the intertemporal resource constraint above, we have assumed that the government is able to transfer wealth between periods at the market interest either through access to an exogenous capital market.[7] Then, the first-best problem is

$$\max_{\{c_i^j, Y_i^j\}_{i=1,2}^{j=L,H}} u(c_1^L) - \varphi\left(\frac{Y_1^L}{\theta^L}\right) + u(c_2^L) - \varphi\left(\frac{Y_2^L}{\theta^L}\right)] + [u(c_1^H) - \varphi\left(\frac{Y_1^H}{\theta^H}\right) + u(c_2^H) - \varphi\left(\frac{Y_2^H}{\theta^H}\right)$$

$$\text{s.t.} \quad Y_1^L + Y_1^H + Y_2^H + Y_2^L \geq c_1^L + c_2^L + c_1^H + c_2^H$$

The (necessary and sufficient) first-order conditions yield:

$$u'(c_1^L) = u'(c_2^L) = u'(c_1^H) = u'(c_2^H) = u'(c^*), \tag{8}$$

[7] The intertemporal resource constraint specified can also be justified by assuming the existence of a linear storing technology. A caveat that could emerge in this case is that, in general, we would be unable to guarantee that production will take place before consumption. However, this can be avoided by assuming that individuals start with some 'sufficiently large' amount of wealth (which may be interpreted as bequests). This problem could also be avoided by specifying an overlapping-generations model, where individuals from different generations would be able to trade. However, this approach would deviate us from the points we wish to analyze.

$$\frac{\varphi'(l_j^i)}{\theta^i} = u'(c^i), \quad i = L, H, \quad j = 1, 2. \tag{9}$$

Equation (8) equalizes the workers' marginal utilities in each period. Equation (9) states that the marginal cost of an additional time of work ($\varphi'(l^i)$) must equal its marginal benefit ($\theta_i u'(c^*)$). This condition implies that more productive individuals should work more but consume the same as less productive ones. Clearly, this allocation is not incentive-compatible when workers' productivity is not observable since type-θ^H workers would obtain a higher utility by taking the contract of type-θ^L.

2.2 Second-best solution

In this subsection we consider the problem of choosing the optimal nonlinear taxation when productivity is unobservable by the government.

The informational structure differs from the one used in most optimal-taxation models. While most models assume that firms are always able to access the workers' productivities, the present structure considers the case where firms only observe their productivities in the second period. However, as in most models, we maintain the assumption that the government does not observe workers' productivities in both periods. The only variable observed by the government is the income received by each worker. Thus, with no loss of generality, we can restrict the search of an optimal taxation mechanism to the space of contracts consisting of income-consumption pairs $\left\{\left(c_j^i, Y_j^i\right)\right\}_{j=1,2}^{i=L,H}$.

As before, we assume that in the first period wages are determined competitively so that they are given by the expected productivity.

$$\begin{aligned} w_1 &= \frac{\theta^L l_1^L + \theta^H l_1^H}{l_1^L + l_1^H} = \frac{\theta^L \left(\frac{Y_1^L}{w_1}\right) + \theta^H \left(\frac{Y_1^H}{w_1}\right)}{\left(\frac{Y_1^L}{w_1}\right) + \left(\frac{Y_1^H}{w_1}\right)} \\ &= \frac{\theta^L Y_1^L + \theta^H Y_1^H}{Y_1^L + Y_1^H}. \end{aligned} \tag{10}$$

Since firms know workers' productivities in the second period, wages are given by

$$w_2^i = \theta^i.$$

As shown in the appendix, the relevant incentive problem is to discourage productive workers from getting the contract designed to unproductive ones. Hence, the only binding incentive-compatibility constraint is the one which prevents type-θ^H workers from getting type-θ^L workers' contract. Then, the second-best problem is to maximize the social welfare function subject to the resource constraint, this incentive-compatibility constraint and equation (10), which determines wages in the first period:

$$\max_{\{c_i^j, w_1, Y_i^j\}_{i=1,2}^{j=L,H}} u(c_1^L) - \varphi\left(\frac{Y_1^L}{w_1}\right) + u(c_2^L) - \varphi\left(\frac{Y_2^L}{\theta^L}\right) + u(c_1^H) - \varphi\left(\frac{Y_1^H}{w_1}\right) + u(c_2^H) - \varphi\left(\frac{Y_2^H}{\theta^H}\right)$$

$$\text{s.t. } Y_1^L + Y_1^H + Y_2^H + Y_2^L \geq c_1^L + c_2^L + c_1^H + c_2^H, \tag{11}$$

$$u(c_1^H) - \varphi\left(\frac{Y_1^H}{w_1}\right) + u(c_2^H) - \varphi\left(\frac{Y_2^H}{\theta^H}\right) \geq u(c_1^L) - \varphi\left(\frac{Y_1^L}{w_1}\right) + u(c_2^L) - \varphi\left(\frac{Y_2^L}{\theta^H}\right), \tag{12}$$

$$w_1 = \frac{\theta^L Y_1^L + \theta^H Y_1^H}{Y_1^L + Y_1^H}. \tag{13}$$

Denote by λ, η, and μ the multipliers associated with equations (11), (12), and (13), respectively. Then, two first-order conditions obtained by differentiating the Lagrangian with respect to c_1^L and c_1^H are

$$u'(c_1^L) = u'(c_2^L) = \left(\frac{\lambda}{1-\eta}\right), \tag{14}$$

$$u'(c_1^H) = u'(c_2^H) = \left(\frac{\lambda}{1+\eta}\right). \tag{15}$$

Equation (14) states that the amount of consumption obtained by type-L workers depends on the marginal utility of resources λ and the fact that higher consumption increases the incentive from type-H workers to deviate (through the shadow price of the incentive-compatibility constraint η). Equation (15) affirms that the consumption acquired by type-H workers depends on the marginal utility of resources λ and the fact that higher consumption reduces their incentive to deviate.

From these equations, it follows that an individual must consume the same amount in both periods, but more productive individuals must consume more ($c_1^L = c_2^L < c_1^H = c_2^H$).

Differentiating the Lagrangian with respect to Y_2^L yields:

$$\varphi'\left(\frac{Y_2^L}{\theta^L}\right)\frac{1}{\theta^L} - \eta\varphi'\left(\frac{Y_2^L}{\theta^H}\right)\left(\frac{1}{\theta^H}\right) = \lambda. \tag{16}$$

Equation (16) states that three elements determine the amount of work from type-L in the second period: his productivity parameter θ^L, the marginal utility of resources λ, and the fact that higher work relaxes the incentive compatibility constraint. Notice this equation gives an upper bound on the shadow cost of incentive compatibility since it implies in

$$\frac{\varphi'\left(\frac{Y_2^L}{\theta^L}\right)}{\varphi'\left(\frac{Y_2^L}{\theta^H}\right)}\frac{\theta^H}{\theta^L} > \eta.$$

This follows from the fact that if the cost of inducing productive workers to reveal their types exceeded the difference in productivity, it would be better to allow them not to distinguish themselves (pool).

Differentiating the Lagrangian with respect to Y_1^L yields:

$$\varphi'\left(\frac{Y_1^L}{w_1}\right) = w_1\frac{\lambda}{1-\eta} - w_1\frac{\mu}{1-\eta}\left(w_1 - \theta^L\right). \tag{17}$$

From equation (17) it follows that the amount of work from type-L in the first period is determined by the same elements as in the second period and one additional element: the fact that an additional amount of labor decreases the average productivity and, thus, the equilibrium wages w_1 (general equilibrium effect). This effect is proportional to the difference between average productivity w_1 and type-L's productivity θ^L and its utility effect is captured by the shadow price μ. As $w_1 > \theta^L$, it follows that the general equilibrium effect distorts downward the optimal amount of work by type-L individuals in the first period.

However, the overall effect on labor supply is ambiguous since there is another effect coming from the fact that low productivity individuals now earn higher wages (which decreases the amount of work necessary to raise a given amount of income). More formally, the ambiguity emerges since

$$\varphi'\left(l_1^L\right) < w_1 u'\left(c_1^L\right) > \theta^L u'\left(c_1^L\right).$$

Differentiating the Lagrangian with respect to Y_2^H and Y_1^H, we get the following first-order conditions:

$$\varphi'\left(\frac{Y_2^H}{\theta^H}\right)\frac{1}{\theta^H} = \frac{\lambda}{1+\eta}, \tag{18}$$

$$\varphi'\left(\frac{Y_1^H}{w_1}\right) = w_1\frac{\lambda}{1+\eta} + w_1\frac{\mu}{1+\eta}\left(\theta^H - w_1\right). \tag{19}$$

The interpretation of equation (18) is analogous to that of equation (16). The amount of work from type-H individuals in the second period is determined from his productivity, the marginal utility of resources, and the fact that higher work increases the incentive to deviate. Moreover, substituting in equation (15), it follows the marginal cost of working is equal to the benefit it generates to high-productivity individuals in the second period.

Equation (19) is analogous to equation (17). The difference is that both effects have opposite signs since wages are lower than type-H worker's productivity.

2.3 Introduction of a costless signal

In this subsection, we consider the introduction of a costless signal which allows firms to observe the workers' productivity in the first period (but which cannot be observed by the policy maker). Then, firms offer wages which equal each workers productivity in both periods. This signal can be thought as a test, an exam or an interview.

In the absence of government intervention, the introduction of this signal has two effects. It has a positive effect on welfare by removing the adverse selection (since workers now equate marginal cost of production to the marginal utility of consumption in both periods). However, it has a negative impact on welfare by worsening the distribution of income. The total effect on welfare is ambiguous: it depends on the curvatures of the utility and cost of work functions.

The following proposition formalizes that intuition.

Proposition 1 *The introduction of a costless signal: (i) reduces welfare if the labor supply in the first period is sufficiently inelastic, and (ii) increases welfare if the risk-aversion coefficient is sufficiently small.*

Proof. i) Denote by $V^x(l_1^j, l_2^j)$ the utility received by a type-j worker when working (l_1^j, l_2^j) where $x = 0$ in the absence of signal and $x = 1$ in the presence of signal. Let l_i^j and $\bar{l}_i^j$ be the optimal amount of work when signaling is and is not allowed, respectively. Since first-period labor supply is inelastic, $\bar{l}_1^j = l_1^{j'}$, for all j, j'.

We need to show that the following inequality holds:

$$\frac{1}{2}V^0(l_1^H, \bar{l}_2^H) + \frac{1}{2}V^0(l_1^L, \bar{l}_2^L) \geq \frac{1}{2}V^1(l_1^H, l_2^H) + \frac{1}{2}V^1(l_1^L, l_2^L).$$

As second-period wages are given by the worker's productivity in both cases, it follows that l_2^i and $\tilde{l}_2^i$ are available. Hence, by revealed preference, it follows that:

$$V^0(l_1^i, \bar{l}_2^i) \geq V^0(l_1^i, l_2^i). \tag{20}$$

Next, we will show that the following inequality holds:

$$\frac{1}{2}V^0(l_1^H, l_2^H) + \frac{1}{2}V^0(l_1^L, l_2^L) \geq \frac{1}{2}V^1(l_1^H, l_2^H) + \frac{1}{2}V^1(l_1^L, l_2^L). \tag{21}$$

Then, from (20), we will be able to obtain the desired result.

Define U^0 and U^1 as the utility obtained when supplying the amount of labor which solves the problem when signals are allowed (l_i^j):

$$\begin{aligned}
U^1 &= \frac{1}{2}V^1(l_1^H, l_2^H) + \frac{1}{2}V^1(l_1^L, l_2^L) = \frac{1}{2}[2u(c_1^H) - v(l_1^H) - v(l_2^H)] \\
&+ \frac{1}{2}[2u(c_1^L) - v(l_1^H) - v(l_2^H)], \\
U^0 &= \frac{1}{2}V^0(l_1^H, l_2^H) + \frac{1}{2}V^0(l_1^L, l_2^L) = \frac{1}{2}[2u(c_0^H) - v(l_1^H) - v(l_2^H)] \\
&+ \frac{1}{2}[2u(c_0^L) - v(l_1^H) - v(l_2^H)],
\end{aligned}$$

where we have used the fact that each type will choose the same consumption in the two periods.

It is easy to see that $c_1^L < c_1^H$ and that $c_1^H - \frac{l_1^H(\theta^H - w_1)}{2} = c_0^H > c_1^L = c_0^L + \frac{l_1^H(\theta^H - w_1)}{2}$ (since $l_1^H = l_1^L$ from the fact that the first-period labor supply is inelastic). Hence, we have:

$$U^0 - U^1 = \int_0^{\theta^H - w_1} [u'(c_0^H - \frac{l^H\theta}{2}) + u'(c_0^L + \frac{l^H\theta}{2})] l^H d\theta > 0,$$

which is strictly positive from the strict concavity of u.

(ii) When risk-aversion is zero, the utility function can be written as

$$u(x) = Kx,$$

for some $K > 0$.

When the signal is allowed ($w_1 = \theta^i$), equations (15) and (16) yield

$$\frac{\varphi'(l_j^i)}{\theta^i} = K,$$

for all i, j.

But, in this case, equations (8) and (9), which characterize the first-best can be rewritten as

$$\frac{\varphi'(l_j^i)}{\theta^i} = K.$$

Thus, the competitive equilibrium coincides with the first-best solution.

In the absence of signal, equation (15) yields

$$K = \frac{\varphi'(l_1^i)}{w_1}.$$

Then, as $w_1 \neq \theta^i$ and the first-best solution is unique (from the strict concavity of the welfare function), it follows that the welfare is increased by the introduction of the signal. Q.E.D.

As argued in Section 2.1, the first-best solution would involve a type-specific lump-sum taxation and the equalization of the marginal costs of production among workers. However, these policies are not incentive-compatible.

Then, the second-best solution distorts the amount of work from each individual as a mean for achieving redistribution. The intuition for this result is straightforward: the initial amount of distorting taxes has a second-order effect on efficiency but, as long as the economy has concerns about distribution, changes on income distribution have a first-order effect on welfare.

Our next proposition establishes that an optimized economy with concerns about income distribution will always prohibit unproductive signals. The proof consists of showing that the same allocation implemented in the case where signals are allowed can be implemented when signals are prohibited. Moreover, the incentive-compatibility constraint is no longer binding, implying that higher welfare can be reached.

Proposition 2 *When the government is taxing optimally, the introduction of the signal is always welfare decreasing.*

Proof. Let $\{\tilde{c}_i^j, \tilde{Y}_i^j\}_{i=1,2}^{j=L,H}$ be the solution to the optimal non-linear taxation problem when signals are allowed, corresponding to the the allocation $\{\tilde{c}_i^j, \tilde{l}_i^j\}_{i=1,2}^{j=L,H}$. First, we will show that when signals are forbidden, the same allocation is also feasible.

When signals are forbidden, wages in the first period are equal to the average productivity. Hence, the income obtained with the same amount of labor in the first period is given by

$$\bar{Y}_1^j = \tilde{Y}_1^j \left(\frac{w_1}{\theta^j}\right).$$

As the amount of labor in this case is the same as when signals are permitted, it is clear that $\{\tilde{c}_i^j, \bar{Y}_i^j\}_{i=1,2}^{j=L,H}$ satisfies the resource constraint.

Next, we will show that $\{\tilde{c}_i^j, \bar{Y}_i^j\}_{i=1,2}^{j=L,H}$ is incentive-compatible when signals are forbidden and that the incentive-compatibility constraint is no longer binding.

Suppose that the incentive-compatibility constraint (in Gottlieb and Maestri (2004) is given a proof that this is the only relevant incentive-compability constraint) does not hold or holds with equality in the case where signals are forbidden and allocation $\{\tilde{c}_i^j, \tilde{l}_i^j\}_{i=1,2}^{j=L,H}$ is implemented:

$$u(\tilde{c}_1^H) + u(\tilde{c}_2^H) - \varphi\left(\frac{\bar{Y}_1^H}{w_1}\right) - \varphi\left(\frac{\tilde{Y}_2^H}{\theta^H}\right) \leq u(\tilde{c}_1^L) + u(\tilde{c}_1^L) - \varphi\left(\frac{\bar{Y}_1^L}{w_1}\right) - \varphi\left(\frac{\tilde{Y}_2^L}{\theta^L}\right).$$

Then, the type-θ^H will choose to supply the following amount of labor in the first period:

$$\frac{\bar{Y}_1^L}{w_1} = \frac{\tilde{Y}_1^L}{\theta^L} > \frac{\tilde{Y}_1^L}{\theta^H}.$$

since $\theta^H > \theta^L$.

Thus, it follows that

$$\frac{\tilde{Y}_1^L}{\theta^H} = \frac{\bar{Y}_1^L}{w_1}\left(\frac{\theta^L}{\theta^H}\right) < \frac{\bar{Y}_1^L}{w_1}.$$

Hence, the type-θ^H will strictly prefer the contract designed for type-θ^L, which contradicts the assumption that $\{\tilde{c}_i^j, \tilde{Y}_i^j\}_{i=1,2}^{j=L,H}$ solves the optimal non-linear taxation problem when signals are allowed. Q.E.D.

The intuition for this result is that prohibiting signals redistributes wealth from high-skilled to low-skilled workers independently of their behavior. Thus, it enables the government to redistribute some wealth in a nondistorcive way. Furthermore, equalizing first-period wages reduces the high-skilled workers' informational rent since the utility obtained when getting the low-skilled workers' contract is diminished.

3 The Model with a Comparative Advantage Signal

In this Section, we consider how signals may affect welfare through the firms' technological decisions. Thus, instead of focusing on signals that reveal different productivities among workers for the same technology, we analyze how signals may reflect workers' productivities in different technologies.

Consider an economy composed of an equal amount of two types of workers, denoted 1 and 2, and many firms with two distinct technologies, 1 and 2. Technologies can be costlessly changed in each period.

A type-1 worker has productivity $\theta > 0$ when working under technology 1 and a type-2 worker has productivity $\theta + \varepsilon$ under technology 2. Hence, if firms cannot verify each worker's type and wages cannot be conditional on production, each worker will announce to be of type 2.

If a firms chooses technology $i \in \{1, 2\}$ and hires a type-j worker such that $j \neq i$, it incurs in a misallocation cost $c > 0$. Thus, a type-i worker is more productive when the firm implements the type-i technology.

In order to focus on the effect of different comparative advantages alone, we assume that workers have similar productivities. Hence, we assume that $\varepsilon > 0$ is sufficiently small.

As in previous sections, firms may learn the worker's type through some costless signal. In this case, signals can be interpreted as specializations in different areas (an accountant and a designer, for example).

When signals are prohibited, firms must offer the same wages to both types of workers. Then, a firm will choose to implement technology j in the first period if, and only if, the probability of hiring a type-j worker is higher than the probability of hiring a type-i worker, $i \neq j$. Hence, the optimal technological choice in the first period when signals are not allowed is

$$\begin{array}{rcl} 1 \text{ if } l_1^1 & > & l_1^2, \\ 2 \text{ if } l_1^1 & < & l_1^2, \end{array} \tag{22}$$

where l_1^i is the amount of labor supplied by a type-i individual in period 1.[8]

Wages in the first period are given by

$$w_1 = \theta - \frac{c}{l_1^1 + l_1^2}.$$

When signals are allowed, the technology chosen by a firms is given by

$$\begin{array}{l} 1 \text{ if the worker is type } 1, \\ 2 \text{ if the worker is type } 2. \end{array}$$

Then, wages are $w_1^i = \theta > w_1$, $i = 1, 2$. As, for any given labor supply, the income of both workers is higher when signals are allowed, it is obvious that welfare is higher in this case. Indeed, introducing signals is not only welfare increasing but also Pareto-increasing. We summarize this result in the following proposition:

Proposition 3 *When a firm must choose between different technologies and workers have heterogeneous comparative advantages, the introduction of signals is always welfare increasing.*

Proof. When the signal is allowed, all the workers will earn the same wage: θ. Therefore, the first-best allocation is achieved. Furthermore, when the signal is forbidden, every worker will receive a wage equal $w_1 < \theta$ in the first period (and equal to θ in the second period). Hence, everyone is worse than in the first-best solution. Q.E.D.

[8] This follows from the fact that ε is sufficiently small and could be stated in a more precise (but perhaps less intuitive) way as follows. Take the sequence $\{\varepsilon_n\}$, where $\varepsilon_n > 0$ for all n and $\lim \varepsilon_n = 0$. Let T_n denote the optimal technological choice for each n. Then, $\{T_n\}$ converges to equation (22).

4 Extensions

4.1 The Model with a Productive Signal

In this subsection, we consider the same economy as in Section 2 except for the assumption that signals not only reveal but also augment a worker's productivity. The usual interpretation is that of a schooling decision, where the history of a student's academic life not only reveals his type but also enhances his productivity. One can also think about these signals as employer-sponsored health-care programs, which not only reveal information about the worker's health situation but also augments his productivities.

We assume that the productive signal is provided in a fixed amount and enhances productivity at rate β. Thus, the productivity of a type-θ^j worker after receiving the fixed amount of signal is $(1+\beta)\,\theta^j$. We also maintain the assumption that schooling reveals a worker's productivity.

In this case, banning the signal would imply in an efficiency loss since it would reduce the amount of aggregate income. However, as in the unproductive signals case, it would allow a more equal wealth distribution. Thus, the usual trade-off between efficiency and equity emerges (although in a different context).

If the signal is sufficiently productive, the efficiency loss will be high. Hence, it will be optimal to allow signaling. However, if it is sufficiently unproductive, it will be optimal to ban signals (in the limit, we obtain the result from Section 2.3). This result is summarized in the following proposition:

Proposition 4 *There exists a $\bar{\beta} \in (0, \frac{\theta^H - \theta^L}{\theta_1})$ such that when the government is taxing optimally:*

i. *the introduction of the signal is welfare increasing if $\beta > \bar{\beta}$, and*

ii. *the introduction of the signal is welfare decreasing if $\beta < \bar{\beta}$.*

Proof. Proposition 2 implies that in the case of $\beta = 0$, forbidding the signal improves welfare. From the Maximum Theorem, it follows that the "indirect social utility" is continuous, implying that prohibiting the signal is optimal when β lies in a neighborhood of zero.

Clearly, welfare is a constant function of β when signals are forbidden. In order to show that it is strictly increasing in β when signals are allowed, let $\beta^1 > \beta^0$ and $\{\tilde{c}_i^j, \tilde{l}_i^j\}_{i=1,2}^{j=L,H}$ be the corresponding optimal allocation when $\beta = \beta^0$. This allocation is also implementable when $\beta = \beta^1$, and production is increased by $(\beta^1 - \beta^o)[\theta^L(\tilde{l}_1^L + \tilde{l}_2^L) + \theta^H(\tilde{l}_1^H + \tilde{l}^H)] > 0$. Hence, the resource constraint is no longer binding, implying that welfare can be increased.

Finally, when $\beta = \frac{\theta^H - \theta^L}{\theta^L}$, permitting signals implies that a type-θ^L worker will have productivity θ^H. Hence, the welfare must be higher than when signals are not allowed.

Thus, as welfare when signals are allowed is a continuous strictly increasing function of β, it follows that the introduction of signals increases welfare if and only if $\beta > \bar{\beta}$. Q.E.D.

Hence, the determination of which signals are desired is intrinsically related to their productivity. Signals that have low productivity-enhancing components are welfare reducing while those with high productivity-enhancing components are welfare increasing.

In this model, we have assumed that signals are costless. However, productive signals are usually costly. It must be clear from the proof 4 that the result also holds when signals are costly. The only difference is that the threshold $\bar{\beta}$ would be higher.

4.2 The Model with Mixed Signals

We can summarize the conclusions on the desirability of signals by considering an economy with a mixed signal. Thus, instead of revealing information only on productivity or comparative advantage, we allow both pieces of information to be reflected in the same signal.

In practice, most signals convey some information on productivity and some on comparative advantage. For example, a degree from a well-known university reveals information not only about a worker's comparative advantages but also his productivity.

As in Section 3, we consider an economy with two distinct technologies, 1 and 2. There is an equal amount of three types of workers, 1, 2, and 3. A type-i worker has productivity θ^H when working under technology $i \in \{1,2\}$. If a firm chooses technology $i \in \{1,2\}$ and hires a worker with type $j \in \{1,2\}$ such that $j \neq i$, it incurs in a misallocation cost $c > 0$. Hence, individuals with types $i \in \{1,2\}$ have characteristics which allow them to be more productive under technology i.

A type-3 worker has productivity $\theta^L < \theta^H$ under both technologies. Thus, type-3 workers have lower productivity than type-i workers under the appropriate technology, $i \in \{1,2\}$.

The present framework generalizes the models from Sections 2 and 3. As in Section 3, the technological choice determines the productivity of workers with types 1 and 2. As in Section 2, the productivity of workers is also determined from their intrinsic characteristics.

The game is structured in the following way. In each period, firms choose their technology and offer a wage conditional on the available information. Then, workers decide how many hours to work and how much to consume.

In the case where signals are allowed, each worker earns his productivity in both periods and there is no misallocational cost. When signals are not allowed, first-period wages are equal to the expected productivity of the economy in the first period minus the expected misallocation cost:

$$w_1 = \frac{\left(l_1^1 + l_1^2\right)\theta^H + l_1^3\theta^L - c}{l_1^1 + l_1^2 + l_1^3},$$

and second-period wages equal the worker's productivity.

Banning signals implies in incurring the misallocation cost and the adverse selection cost but also implies in the welfare gain from redistributing income. Then, if the misallocation cost is sufficiently high, it follows that this policy is welfare decreasing. This result is stated formally in the following proposition:

Proposition 5 *There exists a $\bar{c} \in \left(0, 6\sqrt{2}\sigma\left(\theta\right)\right)$ such that when the government is taxing optimally:*

i. *the introduction of the signal is welfare increasing if* $c > \bar{c}$ *and*

ii. *the introduction of the signal is welfare decreasing if* $c < \bar{c}$*,*

where $\sigma(\theta)$ *is the standard deviation of* θ*.*

Proof. When there is no misallocation cost ($c = 0$), this model is identical to the one presented in Section 2, where there is a productivity signal. Hence, from Proposition 2, introducing the signal is welfare decreasing. Then, from the continuity of the welfare function, this also holds in a neighborhood of $c = 0$.

Clearly, welfare is a strictly decreasing function of c when signals are forbidden. Furthermore, as no firm will ever incur in the misallocation cost when signals are allowed, welfare is constant in c in that case.

Thus, showing that introducing the signal is welfare increasing for some $c > 0$ concludes the proof. Take $c = 4(\theta^H - \theta^H)$. Then, it follows that the avarage productivity of the economy in both periods will be no greater than θ^L. Hence, welfare is increased by the introduction of the signal. Simple algebra allows us to write $4(\theta^H - \theta^H)$ as $6\sqrt{2}\sigma(\theta)$. Q.E.D.

It is clear from the proposition above that when uncertainty about the productivity of workers is sufficiently low, it is optimal to allow signals. Analogously, when the cost of misallocation is sufficiently low, it is optimal to forbid signals. Hence, there is a trade-off between equity and efficiency: banning information redistributes income but generates an allocational distortion.

Proposition 5 contrasts with the efficiency result of Diamond and Mirrlees (1971). This result states that the economy should be on the production frontier under non-linear taxation. In this model, however, it may be optimal to move firms away from the production frontier (through the prohibition of signals), implying that their result does not hold.

The efficiency result breaks down in this model due to the presence of general equilibrium effects [Naito (1999)]. In this model, information can be seen as firms' input. Reducing some of the available information, moves the economy away from the production frontier but also relaxes the incentive-compatibility constraint. Thus, when the efficiency loss generated by such policy is not too big ($c < \bar{c}$), it is optimal not to work on the production frontier.

4.3 Discussion

Throughout this paper, we have assumed that signals are costless. Nevertheless, the revelation of information is usually costly. When signals are costly, the benefit of banning information is increased (since it saves resources). Thus, it remains optimal to ban information about productivity in this case. However, if the cost of signaling is sufficiently large, it may be optimal to ban information about comparative advantage.

The technology and the informational structure of the models presented is very particular. It consists of an extreme case where firms know nothing about the workers in the first period and have full knowledge in the second period. Firms are not able to infer the characteristics of workers in the first period because contracts are non-exclusive (individuals may change their contract with other types of workers). Then, as shown by Hammond (1987), workers would be able to deviate through "unofficial" markets if wages were not linear.

The informational structure presented could be extended in two natural ways: gradual learning and exclusive contracts. The introduction of graduate learning is straightforward and does not change the result of this paper as long as one maintains the assumption that identical workers (from the firms' perspective) cannot be denied to change contracts (i.e., identical workers' contracts are non-exclusive).

If first-period contracts were exclusive, firms would be able to screen workers through non-linear wages. The welfare effects of banning information in this case would depend on the distribution of informational rents among types. If low-productivity individuals have an incentive to deviate (as in the autarky case), the prohibition of information would redistribute wealth through informational rents. In such case, the prohibition of productivity signals would be welfare increasing just as in the model of Section 2. However, if high-productivity individuals are the ones obtaining informational rents, the prohibition of information would be welfare decreasing since it would concentrate wealth. These possibilities suggest the extension of the models to the case where contracts are exclusive. In such circumstance, the optimal taxation problem can be modelled through a common agency game since workers face two principals: a firm and the government.

5 Conclusion

Economists usually argue in favor of policies that reduce informational asymmetries in order to increase welfare. Examples of such policies include allowing firms to: impose mandatory health exams, apply IQ or any other tests, or require any information related to a prospective worker's education. These signals allow the firm to access a worker's characteristics which are not directly observable.

In this paper, we consider two distinct types of signals which reveal information relevant for the firm. The first type reveals information about the productivity of workers with similar comparative advantages (productivity signals). These are the signals usually considered in the job-market signaling literature and include health exams or IQ tests. The other type reveals information about the comparative advantages of workers with similar productivities (comparative advantage signals).

We show that it is always optimal to ban productivity signals when the government is able to tax income non-linearly. This follows from the fact that hiding this information transfers wealth from more productive individuals to less productive ones more efficiently. Thus, the introduction of an inefficiency in the job market reduces the distortion caused on optimal taxes due to asymmetric information. This result is closely related to the second-best arguments of Lipsey and Lancaster (1956):

> The general theorem for the second best optimum states that if there is introduced into a general equilibrium system a constraint which prevents the attainment

> of one of the Paretian conditions, the other Paretian conditions, although still attainable, are, in general, no longer desirable.

When productivity signals enhance the productivity of the workers (as education and employer-sponsored health-care, for example), banning firms from accessing that information is optimal if, and only if, the productivity enhancing component is sufficiently low.

We also show that it is never optimal to prohibit comparative advantage signals since they do not redistribute wealth but imply an efficiency loss (and, thus, reduce aggregate income).

In general, most signals convey two pieces of information: one about the intrinsic productivity of an individual, and one about his comparative advantages. In this case, prohibiting firms to access such information is welfare increasing (decreasing) in and only if the productivity component is sufficiently high (low).

Our results suggest that, when the government is taxing optimally, allowing firms to impose tests that do not significantly enhance a worker's productivity is welfare decreasing. These tests include health exams, IQ and non-cognitive tests, and the GED, for example. Nevertheless, prohibiting firms from accessing information such as worker's profession and specialization is welfare decreasing since it consists mostly of comparative advantage information.

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