Higher education funding: The value of information

Limor Hatsor*

E-mail: limor.hatsor@gmail.com

Abstract

I study the key role of information in private higher-education funding. Students receive a signal about their individual skills, and then choose a portfolio of loans. I find that information is harmful, whereas noisier (less informative) signals improve the social welfare.

Keywords: Education finance; Higher education; Human capital; Information; Welfare;

JEL classification: I22; D80

I am thankful to participants in workshops at Tel-Aviv University, Ben-Gurion University and PET13. I also thank the Sanbar Institute for Public Economics for funding this project.

* Limor Hatsor is a visiting scholar at the University of Texas at Austin.

1. Introduction

I analyze the crucial influence of information on students' funding decisions, and thereby on the social welfare. Many countries have recently shifted from public higher-education funding (through income support transfers) to private funding (through student loans). Thus, decisions on how to finance higher-education have become an individual choice of student loans. Facing an intrinsic uncertainty about their future human-capital, students' funding decisions are inherently subject to information.

The effect of information on microeconomic as well as macroeconomic behavior has been studied extensively in the literature. Blackwell (1953) argues that private information is beneficial for individual decision-makers. However, it is well-known that public information may be harmful in a wide range of circumstances (e.g., Green, 1981, Schlee 2001)[1]. Eckwert and Zilcha (2004, 2010) are the first to assess a negative impact of information in a higher-education model. While they focus on investment (effort) decisions, I highlight the 'value of information' in a completely different channel, funding decisions.

Consider risk-averse agents who receive a noisy public signal on their individual ability. Then, they self-finance their higher-education choosing a portfolio of two common student loans. Credit market loans (CMLs) impose fixed repayments on all students. In contrast, income-contingent loans (ICLs) apply paybacks that depend on the future incomes. Students with large income realizations (discovered after they complete higher-education) have larger paybacks than those with low incomes. Therefore, ICLs provide 'insurance' (risk-sharing) against the uncertainty in future incomes[2].

---

[1] For example, the large industrial organization literature emphasizes the smoothing effect of uncertainty. In the beauty contest game of Morris and Shin (2002) the key factor is a coordination motive, which induces overreaction to information.

[2] Several countries implement ICLs, including Chile, Sweden, New Zealand and the United Kingdom. Chapman (2006) describes the experience in Australia, the first country to establish ICLs. Eckwert and Zilcha (2012) analyze alternative ICLs, differing in the degree of risk-pooling.

I derive two key insights. First, ICLs participants are adversely-selected, because students with favorable income prospects underinvest in ICLs. Second, better information (in terms of screening on abilities) is destructive and aggravates the adverse-selection. Consistent with Hirshleifer (1971), though in another context, revealing information destroys the possibility of insuring against bad times. On the one hand, better screening introduces risk from *ex-ante* perspective, because agents cannot insure against risks the signals had already resolved. The more precise the information, the less scope left for 'insurance' through ICLs, and the more adversely-selected the ICLs-program. On the other hand, noisier (less informative) signals push promising students into the ICLs-program as a risk-sharing tool, which alleviates the adverse-selection and improves the social welfare.

Section 2 introduces the model. Section 3 derives a closed-form solution for students' funding decisions. Section 4 reveals the value of information. Section 5 concludes. Unless otherwise mentioned, proofs are relegated to the Appendix.

2. The Model

This section briefly depicts the model's essential basics: timeline, human-capital formation, higher-education funding, individual behavior and definition of the value of information. See Hatsor (2015) for a thorough description of the model, including the production sector, equilibrium definition and equilibrium existence.

2.1. Timeline and human-capital formation

The lifetime of agents contains a youth period and a working period. A continuum of agents $[0,1]$ is randomly endowed with innate ability. Note that there is no *aggregate* uncertainty in the economy, because the ability distribution is known. Then, agents acquire compulsory public education (K-12), which provides them a basic level of human-capital A. After secondary education, they receive a public signal, $y \in \left[y^1, y^2\right] \subset R_+$ (high-school achievements), with the distribution $\nu(y)$. Denote all agents with signal y as signal-group y, and their ability at this point as a realization of a random variable $\tilde{a}_y$. To simplify the analysis,

Assumption 1: $\tilde{a}_y = y + \tilde{\varepsilon}$, *and* $\tilde{\varepsilon} \sim \left(0, \sigma^2\right)$ ◦

By definition, the signal reflects the expected ability in signal-group y, $\bar{a}_y = E\left[\tilde{a}_y\right] = y$. Therefore, larger signals are 'good news' because they forecast higher expected ability. Blackwell (1953) proposed a criterion to compare information systems. An information system becomes less informative by adding some random noise (randomization) to the system. Accordingly,

Definition 1 *(informativeness)*

The variance σ^2 measures the signals' noise (/quality/precision). As the variance declines, the signals become more informative (in terms of screening on abilities).◦

Given their signal, agents choose whether to invest in higher-education ($I = 1$) and upgrade their level of human-capital to $A + \tilde{a}_y$ or not ($I = 0$). When students complete higher-education, abilities fully reveal. Then, in the working period, their labor income equals their human-capital multiplied by the wage rate for an effective unit of human-capital, ω. They repay their student loans and consume the rest of their income.

2.2. Higher-education funding

At the outset of their higher education, students diversify their loans between ICLs and CMLs. The payback of CMLs is exogenously given by the gross international interest rate, $R = 1 + r$. In contrast, the ICLs payback, $R\frac{\tilde{a}_y}{\bar{a}}$, depends on the realization of ability, and on $\bar{a}$, a plug number that breaks even the loans program without governmental funds. Accordingly, high-signal ICLs participants, with $\bar{a}_y > \bar{a}$, are expected to cross-subsidize the remaining participants (because their expected repayments, $R\frac{\bar{a}_y}{\bar{a}}$, are larger than the interest rate). Mixing the two loans, the random payback of signal-group y is

(1) $\theta_y R + (1-\theta_y) R \frac{\tilde{a}_y}{\bar{a}}$

where $\theta_y \in [0,1]$ is the CMLs-share and $1-\theta_y$ is the ICLs-share in the portfolio. The government designs the loans program to break even by equating the *expected* paybacks *across all signal-groups* to the interest rate. Therefore, $\bar{a}$ is a weighted mean ability of ICLs participants (with $\theta_y < 1$),

(2) $\bar{a} = \frac{E\left[(1-\theta_y)\bar{a}_y\right]}{E\left[1-\theta_y\right]}$

Note that the selection of students into the ICLs-program affects $\bar{a}$. Augmented participation of high-signal-groups, with $\bar{a}_y > \bar{a}$, improves loan terms for *all* ICLs participants ($\bar{a}$ rises, and therefore the ICLs paybacks, $R\frac{\bar{a}_y}{\bar{a}}$, decline).

2.3. Individual behavior

Students choose the share of CMLs, θ_y, by maximizing their expected utility from consumption,

(3) $$\tilde{c}_y = \begin{cases} A\omega & , \quad if\ I = 0 \\ \underbrace{(A+\tilde{a}_y)\omega}_{income} - \left[\underbrace{\overset{CML}{\theta_y R} + \overbrace{(1-\theta_y) R \frac{\tilde{a}_y}{\bar{a}}}^{ICL}}_{repayment\ obligation}\right], & if\ I = 1 \end{cases}$$

I ensure that investment in higher-education is profitable,

Assumption 2: $\bar{a}\omega > R$ ◦

It is easy to verify that all agents invest in higher education[3].

[3] Adding admission-standards for higher education would add realism to the model, though it would not change the qualitative results.

2.4. Value of information – definition

I evaluate information based on the following social planner's welfare function,

Definition 2 *(welfare)*

(4) $$W = \int_{y^1}^{y^2} \upsilon\left(\bar{c}_y\right) v\left(y\right) dy$$

where $\bar{c}_y = E\left[\tilde{c}_y\right]$

and $\upsilon : R_+ \rightarrow R$ *is strictly increasing and concave.* ◦

The welfare function aggregates observable data—the mean consumption in each signal-group. Then, I simply ask: Are agents better off when signals are more informative? If the answer is yes, then information is valuable,

Definition 3 *(value of information)*

Information is valuable (harmful) if the social welfare is decreasing (increasing) in σ^2 ◦

After introducing the model, the following sections exhibit the results.

3. Heterogeneous funding decisions

The commonly-used (increasing and concave) quadratic utility functions $u\left(\tilde{c}\right) = \alpha\tilde{c} - \frac{1}{2}\beta\tilde{c}^2$ provide a tractable closed-form solution for the CMLs-share,

(5) $$\theta_y = \frac{k\bar{a}\left(y - \bar{a}\right)}{R\left(\left(y - \bar{a}\right)^2 + \sigma^2\right)} - \left(\frac{\bar{a}\omega - R}{R}\right)$$

where $k = \frac{\alpha}{\beta} - \left(\left(A + \bar{a}\right)\omega - R\right) > 0$

Eq. (5) indicates that low-signal-groups, with $\bar{a}_y \leq \bar{a}$, behave differently from the rest of the students[4]. Specifically, *Low-signal-groups participate solely in the ICLs-*

[4] See a comprehensive analysis of Eq. (5) and formal proofs for the arguments in this section in Hatsor (2015). She also explores other utility functions.

program because of two reasons. First, ICLs are a risk-sharing tool that reduces the uncertainty in future incomes. Second, the cross-subsidization provides them relatively improved borrowing terms. In contrast, the funding decisions of high-signal-groups are heterogeneous. High-signal-groups face a tradeoff between the expected payback and risk. ICLs provide them insurance against the uncertainty in future incomes and, at the same time, less favorable borrowing terms than CMLs. Therefore, while low-signal-groups choose ICLs-only, high-signal-groups choose a mixture of loans that balances their contradicting incentives. After solving for the CMLs-share, I reveal that information is harmful.

4. Value of information

This section highlights that ICLs participants are adversely-selected, and that better information (in terms of screening on abilities) aggravates the problem. High-signal-groups underinvest in ICLs. They do not consider their positive effect on the borrowing terms of *all* ICLs participants[5]. As a result, the ICLs-program is adversely-selected, which worsens the borrowing terms, and reduces the attractiveness of the ICLs-program. Consequently, high-signal-groups further depart to CMLs to lower their repayment obligation, which pushes the financing costs of ICLs even higher.

Proposition 1 *(adverse-selection)*

Investment of high-signal-groups in ICLs is sub-optimally low. ◦

The adverse-selection reveals another surprising insight— information is harmful. It is easy to verify from Eq. (5) that an increase in the signal noise induces ICLs participation of high-signal-groups as a risk-sharing tool.

Corollary 1 *(information discourages 'insurance' via ICLs)*

θ_y *is decreasing in* σ^2 ◦

[5] Students take $\bar{a}$ as given. However, high-signal-groups increase the weighted mean ability of all ICLs participants, $\bar{a}$, which reduces the expected ICLs paybacks, $R\frac{\bar{a}_y}{\bar{a}}$.

The noisier the signals, the higher the insurance through ICLs, and thereby the lower the adverse-selection. As the pool of students who participate in the ICLs-program is less adversely-selected, the borrowing terms of all ICLs participants improve.

Proposition 2 *(information is harmful)*

The social welfare is increasing in σ^2 。

Therefore, better information (more precise signals) harms the social welfare.

5. Conclusion

Focusing on private higher-education funding, I reveal that information is harmful. However, noisier (less informative) ability signals encourage risk-sharing through ICLs, and thereby alleviate the adverse-selection and improve the social welfare.

One example for deterioration of the signal quality over time is 'grade inflation' (see Bar et al. 2009). If grades increase over time, the percentage of highest-score graduates may grow vis-à-vis an increase in the variance of their actual ability.

6. Appendix

Proof of proposition 1

Using definition 3 and propositions 2 and 4 in Hatsor (2015), y' and y'' are the cutoff-signals between low-signal-groups, the following portfolio set and the CML-only set, respectively. I prove that $\frac{\partial W(y')}{\partial y'} > 0$. The rest of the proof is similar and available on request. The mean consumption (3) in signal-group y equals

$$\int_{y^1}^{y^2} \bar{c}_y v(y)dy = \int_{y^1}^{y^2} \left(A\omega + \bar{a}_y\omega - R\right)v(y)dy \tag{6}$$
$$= \int_{y^1}^{y'} \left(A\omega + \bar{a}_y\left(\omega - \frac{R}{\bar{a}}\right)\right)v(y)dy + \int_{y'}^{y''}\left(A\omega + \bar{a}_y\left(\omega - \frac{(1-\theta_y)R}{\bar{a}}\right) - \theta_y R\right)v(y)dy + \int_{y''}^{y^2}\left(A\omega + \bar{a}_y\omega - R\right)v(y)dy$$

because the ICLs-program breaks even. Differentiation with respect to y' yields

$$\frac{R\left(\partial\bar{a}/\partial y'\right)}{\bar{a}^2}\left(\int_{y^1}^{y'} \bar{a}_y v(y)dy + \int_{y'}^{y''}\left((1-\theta_y)\bar{a}_y\right)v(y)dy\right) = v(y')\left(\bar{c}_{y',\theta} - \bar{c}_{y',0}\right). \tag{7}$$

where $\bar{c}_{y',0}$ and $\bar{c}_{y',\theta}$ denote mean consumption of signal-group y' if it chooses ICLs-only or a portfolio, respectively. Differentiating the welfare function by y' obtains

$$\frac{\partial W}{\partial y'} = v(y')\left(\upsilon\left(\bar{c}_{y',0}\right) - \upsilon\left(\bar{c}_{y',\theta}\right)\right) +$$
$$\frac{R\left(\partial\bar{a}/\partial y'\right)}{\bar{a}^2}\left(\int_{y^1}^{y'}\left(\partial\upsilon\left(\bar{c}_{y,0}\right)/\partial\bar{c}_{y,0}\right)\bar{a}_y v(y)dy + \int_{y'}^{y''}\left(\partial\upsilon\left(\bar{c}_{y,\theta}\right)/\partial\bar{c}_{y,\theta}\right)\left((1-\theta_y)\bar{a}_y\right)v(y)dy\right)$$
$$> v(y')\left(\upsilon\left(\bar{c}_{y',0}\right) - \upsilon\left(\bar{c}_{y',\theta}\right)\right) +$$
$$\left(\partial\upsilon\left(\bar{c}_{y'',\theta}\right)/\partial\bar{c}_{y'',\theta}\right)\frac{R\left(\partial\bar{a}/\partial y'\right)}{\bar{a}^2}\left(\int_{y^1}^{y'}\bar{a}_y v(y)dy + \int_{y'}^{y''}\left((1-\theta_y)\bar{a}_y\right)v(y)dy\right)$$
$$\overset{(7)}{=} v(y')\left(\upsilon\left(\bar{c}_{y',0}\right) - \upsilon\left(\bar{c}_{y',\theta}\right)\right) + \left(\partial\upsilon\left(\bar{c}_{y'',\theta}\right)/\partial\bar{c}_{y'',\theta}\right)v(y')\left(\bar{c}_{y',\theta} - \bar{c}_{y',0}\right) > 0$$

The inequalities follow from the concavity of $\upsilon(\cdot)$.

Proof of proposition 2

I define two equilibria: high signal quality (HSQ) equilibrium and low signal quality (LSQ) equilibrium. All individuals invest in higher-education (recall assumption 2). Therefore,

$$E\left[\bar{c}_y^{HSQ}\right] = E\left[\bar{c}_y^{LSQ}\right] \tag{8}$$

Using corollary 1, it is easily verified that

$$\bar{c}_y^{LSQ} \overset{(\leq)}{>} \bar{c}_y^{HSQ}, \quad if\ \bar{a}_y \overset{(\geq)}{<} \bar{a}^{LSQ} \tag{9}$$

Eq. (8)-(9) imply that $\bar{c}_y^{HSQ}$ is a mean-preserving spread of $\bar{c}_y^{LSQ}$ from which I conclude that LSQ equilibrium dominates HSQ equilibrium in welfare terms.

References

Bar, T., Kadiyali, V., Zussman, A., 2009. Grade Information and Grade Inflation: The Cornell Experiment. *Journal of Economic Perspectives*, 23(3), 93-108.

Blackwell, 1953. Equivalent comparison of experiments. *Annals of Mathematical Statistics*, 24, 265-272.

Chapman, B., 2006. Income contingent loans for higher education: International reforms. In: Hanushek, E., Welch, F. (Eds.), Handbook of the Economics of Education (2), North Holland, Amsterdam, 1435-1500.

Eckwert, B., Zilcha, I., 2004. Economic implications of better information in a dynamic framework. *Economic Theory*, 24, 561–581.

Eckwert, B., Zilcha, I., 2010. Improvement in information and private investment in education. *Journal of Economic Dynamics and Control*, 34, 585–597.

Eckwert, B., Zilcha, I, 2012. Private Investment in Higher Education: Comparing Alternative Funding Schemes. *Economica* (79), 76–96.

Hatsor, L., 2015. Higher education funding: A portfolio of loans. Working paper. Available on request.

Hirshleifer, J., 1971. The Private and Social Value of Information and the Reward to Inventive Activity. *American Economic Review*, 61(4), 561-74.

Green, J., 1981. The value of information with sequential futures markets. *Econometrica*, 49, 335-358.

Schlee, E., 2001. The value of information in efficient risk sharing arrangements. *American Economic Review*, 91(3), 509–524.

Morris, S., Shin, H, S., 2002. Social Value of Public Information. *American Economic Review*, 92(5), 1521-1534.