Human Capital and Optimal Income Taxes in a life-cycle model with heterogeneous agents †

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Abstract

We study a life-cycle model with heterogeneous agents of discrete skill types. In the model, unobservable skills evolve over time through endogenous human capital investment, rather than via stochastic shocks. Our main findings are as follows. First, even though our model has no uncertainty and thus no insurance motive, the capital wedge is positive. Next, the labor wedge is neither always positive nor constant over time, but is negative in first period and ambiguous before the terminal period of the life cycle. Finally, these wedges can be implemented as linear taxes on capital and labor, along with lump-sum taxes, in the competitive market and there is a welfare gain from the second-best optimal mechanism, with the gain increasing in the gap of agents' skills.

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Introduction

This paper studies how human capital investment affects the design of optimal income tax policies. We consider a life-cycle model with discrete skill-type agents whose abilities to work are augmented by unobservable human capital investment. In the existing dynamic Mirrlees literature, people differ simply through their skills (i.e., their earnings) which follow a stochastic process over time. The government wants to redistribute from high-skill to low-skill agents but can only observe earnings (and not abilities), leading to a non-degenerate equity-efficiency trade off. Thus, the optimal tax system is designed based on insurance and redistribution motives. Along the literature, if the skill distribution is fixed and thus there is no uncertainty on skills, a zero capital wedge is called for, because of the lack of motives to insure against lifetime risks. (e.g., Werning, 2007; da Costa and Masestri, 2007; Anderberg, 2009; Farhi and Werning 2013; Kopczuk, 2013; Stantcheva, 2016). Moreover, the labor wedge for low-skill types is positive, so that high-skill agents do not mimic low-skill types and work less (e.g., Stiglitz, 1982; Golosov et al. 2006; Piketty and Saez, 2013). In particular, the labor wedge is constant over time (perfect labor tax smoothing), unless there are persistent idiosyncratic shocks on skills that vary with aggregate shocks (e.g., Golosov et al. 2006; Werning, 2007; Farhi and Werning, 2013). The departure of our paper from the dynamic Mirrlees literature is that we study optimal income tax policies when skills evolve according to unobservable human capital investment rather than stochastic uncertainties.

We use a discrete skill-type model. To simplify the analysis, we follow Stiglitz (1982) and posit two types of agents, differing in abilities to work but having the same utility function. In addition to working and savings, all agents choose human capital investment. Agents' heterogeneities in skills mainly come from endogenous human capital investment. To streamline the study, we assume that when born, both types of agents have identical human capital levels and thus identical skills, but the high-skill type has advantages in accumulating skills.[1] Expenses for human capital investment is non-verifiable: private expenditures for consumption may be pretended as private expenses for education purposes and are not distinguishable from the viewpoint of the government.[2] Under asymmetric information, the government (the social planner) solves the second-best program: it chooses the (constrained) optimal allocations to maximize the utilitarian social welfare subject to resource constraints and incentive

[1] Such initial advantages to accumulate human capital capture innate abilities and cognitive and noncognitive skills in early childhood development, as emphasized by Todd and Wolpin (2003, 2007) and Cunha and Heckman (2008)

[2] For non-verifiable investment in human capital, see, among others, Bovenberg and Jacobs (2005), Kapička (2006, 2015), and Grochulski and Piskorski (2010). For example, Bovenberg and Jacobs (2005) argued that, in practice, books, computers and travelling costs are difficult to verify, because individuals may misrepresent expenditures for private consumption purposes as expenses for education investment.

compatibility constraints.

We obtain two novel findings concerning the constrained efficient allocations. First, even though our model does not have any uncertainties and thus no role for insurance purposes, the capital wedge on low skills is positive. Moreover, the labor wedge on low skills is neither always positive nor constant over time, but it is positive only in the terminal period and negative in first period and ambiguous in all other periods of the life cycle.

These wedges arise, because human capital investment is endogenous and non-verifiable by the government. These wedges aim to foster human capital investment. First, with unobservable human capital investment, if high-skill agents shirk, the benefit is not only from working less for leisure, but also from saving more for future by reducing expenses on education. Thus, even without uncertainty on skills, the intertemporal marginal rate of substitution in consumption is distorted by the informational friction concerning human capital investment. A positive capital wedge on low skills is optimal, because the policy discourages high-skill agents from misreporting low skills and from saving too much through reducing unobservable expenses in human capital investment. Next, a negative labor wedge on low skills in the first period and possibly in other early periods of the life cycle is optimal, because the policy attracts low-skill agents to work more early in their life-cycle. The policy deters high-skill agents from misreporting as low skills; if they misreport as low skills, they have to work more.

While it is tempting to interpret these capital and labor wedges as actual taxes on capital and labor, the relationship between wedges and taxes is not straightforward, because there is a *double deviation* problem.[3] The tax implementation is to find tax systems so that the resulting competitive equilibrium yields these optimal allocations. This paper proposes a history-dependent tax system, wherein capital and labor income are taxed linearly, along with lump-sum taxes, if an agent's history of capital and effective labor satisfies some conditions; otherwise, an agent would face extremely high taxes. We show that, under this tax system, the linear tax rates are consistent with the optimal capital and labor wedges.

Finally, we carry out numerical analysis. We find that the consideration of endogenous human capital increases capital wedges and decreases labor wedges. Moreover, there is a welfare gain from our second-best optimal mechanism relative to the laissez-fare economy with linear taxes, with the welfare gain

[3] Intuitively, each wedge controls only one aspect of worker's behavior (labor in a period, or savings) taking all other choices fixed *at the optimal level*. For example, assuming that an agent supplies the socially optimal amount of labor, a capital tax defined by an intertemporal wedge would ensure that the agent also makes a socially optimal amount of savings. However, agents choose labor and savings jointly; if an agent considers to change her labor, then, in general, she also considers to change her savings. Thus, there are *double deviations*. Kocherlakota (2005), Albanesi and Sleet (2006) and Golosov and Tsyvinski (2006) showed that such double deviations would give an agent a higher utility than the utility from the socially optimal allocations, and therefore the optimal tax system must be enriched with additional elements in order to implement the optimal allocations.

increasing in the gap of abilities between agents.

Related literature

Our paper is related to human capital accumulation and the optimal taxation. The process of human capital formation has been a long-lasting literature, starting with Becker (1964), Ben-Porth (1967) and Heckman (1976). The structural branch of the literature emphasizes that human capital acquisition occurs throughout a life cycle, underscoring the need for a life cycle model (Cunha and Heckman, 2007). Ex ante heterogeneity in the returns to human capital matters. A large body of empirical work documents the importance of human capital as a determinant of earnings (Goldein and Katz, 2008), and cognitive and noncognitive skills as being equally important (Todd, P. and Wolpin, 2003; Cunha and Heckman, 2008). The model developed in our paper attempts to embrace some of this literature's main findings in a stylized way.

There is a growing literature named new dynamic public finance which analyzes the optimal taxation pioneered by Mirrlees (1971) in dynamic settings. As opposed to the Ramsey approach wherein agents are homogeneous and information is complete, agents are heterogeneous in earning skills that are private information in the Mirrlees approach. In the Mirrlees framework, the benevolent government chooses the allocation that trades off between efficiency and equity. The new dynamic public finance literature typically considers exogenously evolving abilities, thus abstracting from endogenous skill acquisition.[4] Our paper contributes to this literature by taking into account individuals' skills which evolve over time based on endogenous human capital investment.

A series of papers in the dynamic Mirrlees approach have jointly considered optimal taxation and endogenous human capital.[5] Investment in human capital may take the form of labor effort and expenditures. Thus, the existing model can be divided into two strands. Though different, our paper uses expenses as investment in human capital and is complementary to the strand that uses labor as input.

In our paper, expenses for human capital investment are non-verifiable. In a static model, Bovenberg and Jacobs (2005) considered both verifiable and non-verifiable expenses for human capital investment. They found positive optimal income taxes for re-distributional purposes and positive optimal subsidies on verifiable education expenses for offsetting some tax-induced distortions on learning.[6] In a dynamic

[4] See Golosov et al. (2003), Kocherlakota (2005), Albanesi and Sleet (2006), Werning (2007), Farhi et al. (2012), and Farhi and Werning (2013), among others. Golosov et al. (2006), Kocherlakota (2010), Piketty and Saez (2013) and Kopczuk (2013) provided excellent survey.

[5] See Kapička (2006, 2015), da Costa and Masestri (2007), Boháček and Kapička (2008), Anderberg (2009) and Stantcheva (2015). Among these papers, education time is unobservable in Kapička (2006), Anderberg (2009) and Kapička (2015) and is observable in other studies.

[6] For other static models, see also Maldonado (2007), Jacobs and Bovenberg (2011), DaCosta and Maestri (2007), Gelber and Weinzierl (2012) and Findeisen and Sachs (2016).

model with only verifiable education expenses, Stantcheva (2016) highlighted the importance of the complementarity between ability and education, which can be used to measure the distortion to human capital. Moreover, in these two papers, agents' earning skills are also affected by stochastic shocks, which lead to a positive capital tax. Our model is different from these two existing papers in that we study only non-verifiable education expenses and moreover agents' earning skills are not affected by stochastic shocks. Yet, even without uncertainties on skills, it is optimal to tax capital income on low types in our model. In particular, our capital taxation on low types serves as a mechanism to increase educational investment, as opposed to educational subsidies proposed by these two papers.

Kapička (2006, 2015) and Grochulski and Piskorski (2010) also study dynamic models with the setting of unobservable human capital investment, so there are no feasible schooling policies. First, our model assumes ex ante different skill types, as opposed to ex ante identical agents with ex post different skill types in these two models. Next, in Kapička (2006, 2015), investment in human capital is labor time, wherein ex post different skill types do not affect human capital formation. By contrast, in our model, investment in human capital is expenses, wherein ex ante different skill types affect human capital formation. In Grochulski and Piskorski (2010), ex ante identical agents invest in human capital only in the initial period, and then, agents' human capital may completely depreciate due to stochastic depreciation shocks, so some agents enter a low human capital state, which is an absorbing state. As a result, their labor wedge is always positive for low skills and, except in the terminal period of an agent's life, is always negative for high skills. Note that, in the case without stochastic shocks on skills in Grochulski and Piskorski (2010), the capital wedge is zero in every period. In contrast, our model has ex ante heterogeneous agents, who invest in human capital in all except the terminal period of their life. Hence, even without stochastic shocks on skills, the capital wedge is positive in all except the initial period when all agents are born with the same human capital level. Besides, because high and low skill agents invest in human capital, the labor wedge for low skills is negative in the first period and may be negative or positive in all other periods except the final period.

On the technical side, several papers studied models with agents of a continuous distribution of skills (e.g., Farhi et al., 2012; Farhi and Werning, 2013; Kapička and Neira, 2015), dubbed as the first-order approach, since their incentive compatible constraints are typically written in terms of envelop conditions. As these envelop conditions are only necessary but not sufficient, the solution to the program might not be a solution to the full program (Ebert, 1992). Thus, the approach needs to validate that the constrained efficient allocations solved by these conditions indeed give the utility intended by the planner (e.g., Farhi and Werning, 2013; Stantcheva, 2016). Our model posits skills of a discrete type, and the solutions are necessary and sufficient. Moreover, even if the first-order approach is used, in the Appendix

we have shown that, except for the top and bottom ability in the distribution, our results continue to hold.

Finally, to tackle double deviation problems, Albanesi and Sleet (2006) implemented the constrained efficient allocations in terms of non-linear taxes in a competitive equilibrium. They showed that these taxes are non-separable in wealth and labor and depend in each period on agents' wealth and labor income in that period and not on other aspects and past history. By restricting to linear capital taxes and arbitrarily nonlinear labor income taxes, Kocherlakota (2005) implemented the constrained efficient allocations by separating capital from labor taxes and both taxes are history-dependent. Following the tax structure in Kocherlakota (2005), Grochulski and Piskorski (2010) found that deferred capital taxes are the necessary condition for linear capital taxes, with negative expected capital taxes early in the life-cycle and positive expected capital taxes later in the life-cycle so that the ex ante expected present value of lifetime capital taxes is zero. Parallel to these studies, our paper proposes a non-separable and history-dependent tax system to implement the constrained efficient allocations. We show that the optimal linear tax on capital and labor income in this tax system are exactly the capital and labor wedges.

Organization of the paper

In Section 2, we present the model. The social planner's problem is studied in Section 3, and the signs of capital and labor wedges are analyzed in Section 4. Section 5 provides a tax system to implement the constrained efficient allocation obtained in the planner's problem as a competitive equilibrium. In Section 6, we offer numerical analysis. Finally, concluding remarks are offered in Section 7.

References

Albanesi, S. and C. Sleet (2006) Dynamic optimal taxation with private information. *Review of Economic Studies* 73, 1-30.

Anderberg, D. (2009) Optimal policy and the risk properties of human capital reconsidered. *Journal of Public Economics* 93, 1017-1026.

Autor, D., L.F. Katz and A.B. Krueger (1998) Computing inequality: Have computers changed the labor market? *Quarterly Journal of Economics* 113(4), 1169-1213.

Becker, G.S. (1964), Human Capital: *A Theoretical And Empirical Analysis, With Special Reference To Education.* University of Chicago Press.

Ben-Porath, Y. (1967) The production of human capital and the life cycle of earnings. *Journal of Political Economy* 75(4), 352–365.

Boháček, R. and M. Kapička (2008) Optimal human capital policies. *Journal of Monetary Economics* 55, 1-16.

Bovenberg, A.L., and B. Jacobs (2005) Redistribution and education subsidies are Siamese twins. *Journal of Public Economics* 89, 2005-2035.

Conesa, J.C., S. Kitao, and D. Krueger (2009) Taxing capital? Not a bad idea after all! *American Economic Review* 99(1), 25–38.

Cunha, F. and J.J. Heckman (2007) The technology of skill formation. *American Economic Review* 97(2), 31–47.

Cunha, F. and J.J. Heckman (2008) Formulating, identifying and estimating the technology of cognitive and noncognitive skill formation. *Journal of Human Resources* 43, 738-782.

Da Costa, C. and L.J. Masestri (2007) The risk properties of human capital and the design of government policies. *European Economic Review* 51, 695-713.

Diamond, P. (1980) Income taxation with fixed hours of work. *Journal of Public Economics* 13, 101–110.

Diamond, P. A. (1998) Optimal income taxation: an example with a U-shaped pattern of optimal marginal tax rates. *American Economic Review* 88(1): 83-95.

Ebert, U. (1992) A reexamination of the optimal nonlinear income tax, *Journal of Public Economics* 49, 47-73.

Farhi, E. and I. Werning (2013) Insurance and taxation over the life cycle. *Review of Economic Studies* 80, 596-635.

Farhi, E., C. Sleet, I. Werning and S. Yeltekin (2012) Non-linear capital taxation without commitment. *Review of Economic Studies* 79, 1469-1493.

Goldin, C.D. and L.F. Katz (2008) *The Race Between Education And Technology*. Harvard University Press.

Golosov, M., N.R. Kocherlakota and A. Tsyvinski (2003) Optimal indirect and capital taxation, *Review of Economic Studies* 70, 569-587.

Golosov, M., A. Tsyvinski, and I. Werning (2006) New dynamic public finance: A user's guide. *NBER Macroeconomic Annual*, MIT Press.

Golosov, M. and A. Tsyvinski (2006) Designing optimal disability insurance: A case for asset testing. *Journal of Political Economy* 114(2), 257-279.

Grochulski, B. and T. Piskorski (2010) Risky human capital and deferred capital income taxation. *Journal of Economic Theory* 145, 908-943.

Heathcote, J., F. Perri, and G.L. Violante (2010) Unequal we stand: An empirical analysis of economic inequality in the United States, 1967-2006. *Review of Economic Dynamics* 13(1), 15-51.

Heckman, J.J. (1976) A life-cycle model of earnings, learning, and consumption, *Journal of Political Economy* 84, S9-S44.

Jacobs, B. and L. Bovenberg (2011) Optimal taxation of human capital and the earnings function. *Journal of Public Economic Theory* 13(6), 957-971.

James, J. (2012) The college wage premium. *Economic Commentary*. Federal Reserve Bank of Cleveland, Issue 2012-10.

Kapička, M. (2006) Optimal income taxation with human capital accumulation and limited record keeping. *Review of Economic Dynamics* 9, 612–639.

Kapička, M. (2013) Efficient allocations in dynamic private information economies with persistent shocks: a first-order approach. *Review of Economic Studies* 80, 1027–1054.

Kapička, M. (2015) Optimal Mirrleesean taxation in a Ben-Porath economy, *American Economic Journal: Macroeconomics* 7(2), 219-248.

Kapička, M. and J. Neira (2015) Optimal taxation with risky human capital. Working Paper, University of California, Santa Barbara.

Kocherlakota, N.R. (2005) Zero expected wealth taxes: A Mirrlees approach to dynamic optimal taxation. *Econometrica* 73, 1587-1621.

Kocherlakota, N. R. (2010) *The New Dynamic Public Finance*. Princeton: Princeton University Press.

Kopczuk, W. (2013), Taxation of Intergenerational Transfers and Wealth, in A.J. Auerbach, R. Chetty, M. Feldstein and E. Saez (eds.), *Handbook of Public Economics* 5, 329-390.

Maldonado, D. (2008) Education policies and optimal taxation, *International Tax Public Finance* 15, 131–143.

Manuelli, R.E. and A. Seshadri (2014) Human capital and the wealth of nations. *American Economic Review* 104(9), 2736-2762.

McDaniel, C. (2007) Average tax rates on consumption, investment, labor and capital in the OECD 1950-2003. Working Paper, Arizona State University.

Mirrlees, J. (1971) An exploration in the theory of optimum income taxation. *Review of Economic Studies* 38, 175-208.

Murphy, K.M. and F. Welch (1992) The structure of wages. *Quarterly Journal of Economics* 107(1), 285-326.

Peterman, W.B. (2016) The effect of endogenous human capital accumulation on optimal taxation. *Review of Economic Dynamics* 21, 46-71.

Piketty, T. and E. Saez (2013), Optimal Labor Income Taxation, in A.J. Auerbach, R. Chetty, M. Feldstein and E. Saez (eds.), *Handbook of Public Economics* 5, 391-474.

Saez, E. (2002) Optimal income transfer programs: intensive versus extensive labor supply responses. *Quarterly Journal of Economics* 117, 1039-1073.

Stantcheva, S. (2015) Learning and (or) doing: Human capital investments and optimal taxation. Working Paper, Harvard University.

Stantcheva, S. (2016) Optimal taxation and human capital policies over the life cycle, forthcoming, *Journal of Political Economy.*

Stiglitz, J. (1982) Self-selection and Pareto efficient taxation. *Journal of Public Economics* 17, 213-240.

Todd, P. and K. Wolpin (2003) On the Specification and estimation of the production function for cognitive achievement. *Economic Journal* 113(485), 3–33.

Todd, P. and K. Wolpin (2007) The production of cognitive achievement in children: Home, school and racial test score gaps. *Journal of Human Capital* 1(1), 91-136.

Tuomala, M. (1990), *Optimal Income Taxation and Redistribution.* Oxford, Clarendon Press.

Vogl, T. (2016). Differential fertility, human capital, and development. *Review of Economic Studies* 83, 365–401.

Werning, I. (2007) Optimal fiscal policy with redistribution. *Quarterly Journal of Economic*s 122, 925-967.