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Financial literacy, human capital and long-run economic growth☆

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ABSTRACT

Financial literacy has gained momentum in the policy arena and several countries are currently promoting it. Despite the undeniable importance of financial literacy in improving the allocation of savings across alternative uses, the impact of these policies on economic growth is not obvious. Indeed, financial literacy is a specialized form of human capital, thus favoring financial education may deter general education eventually generating detrimental effects on growth. This paper relies on an endogenous growth framework where human capital can be employed to accumulate financial literacy to assess the conditions under which the current policy setting may be beneficial in the long run. Our calibration based on the US economy over the 1950–2019 period shows that this may effectively be the case if the impact of financial literacy on the allocational efficiency of the financial sector is sufficiently strong.

"The Federal Reserve recognizes that informed, educated consumers not only achieve better outcomes for themselves but, through careful shopping for and use of financial products, help to increase market efficiency and innovation". (Bernanke, 2011)

1. Introduction

Several papers extensively document the importance of financial literacy for sound financial decision-making (Kaiser & Lusardi, 2024; Lusardi & Mitchell, 2023). Financial illiterates make worse financial decisions in terms of planning for retirement and portfolio diversification, they are less likely to participate in financial markets to improve their investment opportunities, and they are more

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likely to be over-indebted (Guiso & Jappelli, 2008; Jappelli & Padula, 2013; Lusardi & Mitchell, 2007; Lusardi & Tufano, 2015; Van Rooij et al., 2011; Von Gaudecker, 2015). Given that financial literacy has consistently remained low worldwide in the last ten to fifteen years (Klapper & Lusardi, 2020), several countries have recently implemented policies aimed at promoting financial education. For example, by 2023, twenty-four states in the US require students to complete some personal finance content before graduating from high school (Harvey & Urban, 2023). Before 2020, more than one hundred initiatives related to financial education were undertaken by national authorities in Europe (EBA Report, 2020), and in 2023, Italy passed a bill incorporating financial education into the civic education curriculum. However, the effect of these policies on economic growth is not obvious a priori. Indeed, financial literacy (FL hereafter) refers to a *"combination of awareness, knowledge, skill, attitude, and behavior necessary to make sound financial decisions and ultimately achieve individual financial wellbeing"* (OECD, 2018). It is thus a specialized form of human capital focused on understanding basic financial concepts (Lusardi & Mitchell, 2008). As such, it can be considered as specialized knowledge, whereas human capital can be viewed as general productive knowledge. While human capital helps to increase the individuals' level of FL (Jappelli & Padula, 2013), it is a rival good. This means that an increase in time spent on financial education could, in principle, reduce the time devoted to general education. Therefore, policies aiming to promote FL could ultimately slow down human capital accumulation. Given that human capital drives long-term growth through knowledge creation, financial innovation, and technological progress, this has negative effects on long-term growth. At the same time, a higher degree of FL among investors could enhance the allocative efficiency of the financial system (Bernanke, 2011), and improve economic growth by conveying savings to the most productive firms (Levine, 2005). This is exactly the dynamic trade-off that we capture in this paper. Our goal is to establish the conditions under which promoting FL may effectively be beneficial for economic growth in the long term.

To address this issue, we develop a macroeconomic framework to theoretically and quantitatively assess how FL may impact long-term growth. We extend a simple multi-sector endogenous growth model driven by human capital accumulation (Lucas, 1988; Uzawa, 1965) in two directions: first, we introduce financial intermediaries that transfer savings intertemporally; second, we allow for human capital to be employed in FL accumulation. Although FL does not serve as an input in the production of the final good, it influences the efficiency with which the financial sector transforms current savings into future (physical) capital.[2] Time is a scarce resource which can be devoted to production activities, general education, or (specialized) financial education. Therefore, acquiring FL generates a dynamic cost-benefit trade-off: on the one hand, FL allows households to obtain higher returns on their savings or assets (Jappelli & Padula, 2013; Lusardi et al., 2017); on the other hand, it increases the opportunity cost of human capital formation (as in Kim et al., 2016; Spataro & Corsini, 2017).

Our analysis provides two important sets of conclusions. (i) The presence of financial intermediaries, whose efficiency is influenced by economic conditions (including FL and human capital), introduces two mechanisms through which the financial sector might promote economic growth. First, as human capital enhances the return on savings managed by intermediaries because it fosters financial development, it might be beneficial to allocate more time to human capital formation than in a model without a financial sector. This could lead to faster human capital accumulation and, consequently, faster growth – we refer to this as the "human capital channel". Second, because the financial sector depends on savings for its intermediation process, it might be advantageous to allocate more human capital to working activities than in a framework without a financial sector. This could result in slower human capital formation but faster physical capital accumulation, ultimately leading to more rapid growth — we refer to this as the "financial efficiency channel". Which of these two mechanisms is in place depends on the relative size of the elasticity of the financial intermediaries' efficiency with respect to human capital and labor time. (ii) The option to allocate time to financial education introduces a trade-off with human capital formation, which interacts non-trivially with the human capital and financial efficiency channels. Specifically, financial education might divert time away from human capital formation or production activities. Conversely, a higher level of FL improves the efficiency of the financial sector, which, given that FL accumulation depends on human capital, provides incentives for human capital accumulation. Ultimately, whether promoting financial education leads to faster economic growth compared to a scenario with constant FL depends on the elasticities of financial intermediaries' allocational efficiency with respect to key variables (i.e., human capital, labor time, financial education, and the aggregate level of FL). Depending on these elasticities, promoting FL accumulation through financial education may or may not be beneficial for long-term economic growth.

Given that the effects of financial literacy on economic growth are not immediately clear, we evaluate the desirability of current policies supporting financial education by calibrating our model based on the US economy from 1950 to 2019. Data show that FL has remained rather stable over time in the US, which is also the only country in which FL has been measured consistently for a sufficiently long period (see the various NFCS reports edited by FINRA from 2009 until 2018). This suggests that in reality, individuals may find it optimal to devote minimal or no time to financial education, potentially due to an externality they fail to internalize. Specifically, households may not recognize that FL affects the overall efficiency of the financial sector. This externality could be one reason why policies are now mandating financial education programs in schools, ensuring that some time is dedicated to this task. This same externality may also create a gap between decentralized and centralized outcomes, which needs to be quantified to assess the impact of these policies on economic growth. Our calibration indicates that the failure of households to internalize the impact of FL on the financial sector leads to lower economic growth compared to the social optimum, especially if FL significantly

[2] We may claim that FL positively influences productivity not only in the financial sector but also in the final goods sector, which would result in a higher allocation of human capital to financial education, both in the decentralized and centralized solutions. Despite the increase in the model's complexity, the qualitative conclusions of our analysis would remain unchanged thus it seems convenient to present our setup in the simplest possible form.

affects the financial sector's allocational efficiency. We determine the threshold level of the financial efficiency elasticity to FL beyond which promoting financial education becomes growth-enhancing. This threshold level is (approximately) three times lower than the calibrated value of the financial efficiency elasticity to human capital.

Our paper intersects two distinct branches of literature, analyzing the effects of FL and the growth-finance nexus, respectively. The economics literature on FL has extensively highlighted its significance for various microeconomic outcomes, showing that higher levels of FL can improve performance in financial markets, enhance retirement security and planning, and lead to better performance and lower fees on financial products (Calvet et al., 2009; Christelis et al., 2010; Clark et al., 2017; Deuflhard et al., 2019; Hastings & Tejeda-Ashton, 2008; Lusardi & Mitchell, 2008; Yoong, 2011).[3] Fewer studies, however, have explored its macroeconomic implications, revealing that FL positively impacts savings, wealth accumulation, and inequality (Jappelli & Padula, 2013; Lo Prete, 2013; Lusardi & Mitchell, 2007). Lusardi et al. (2017) use a stochastic life-cycle model to show that gaps in FL exacerbate disparities in wealth accumulation and perpetuate wealth inequality. To our knowledge, no studies have yet investigated the implications of FL for economic growth through its effects on human capital accumulation. The macroeconomic literature on growth and finance is extensive and discusses the different channels through which financial development affects economic development, emphasizing, in particular, the role of financial innovation and the volume of intermediation, as well as their interdependence with macroeconomic conditions such as the level of human capital (e.g. Allub et al., 2024; Bucci & Marsiglio, 2019; Levine, 2005; Philippon, 2010). Philippon (2010) analyzes an occupational choice model to discuss the importance of general education for financial markets which tend to attract skilled individuals potentially draining human resources away from productive activities. However, as far as we know, no research has yet explored the specific role of FL, which, unlike financial innovation and other types of financial development, might slow down the accumulation of human capital and consequently harm long-term economic growth. Our paper bridges these two different branches of the economics literature by developing a dynamic general equilibrium analysis of the macroeconomic consequences of FL, exploring whether and to what extent FL may effectively be beneficial for long-run outcomes.

In so doing, our paper makes several important contributions. Methodologically, the primary innovation of our work lies in analyzing the endogenous allocation of a scarce resource (i.e., time) across various uses, some of which are productive (e.g., general education and labor) and some of which are not directly productive (e.g., financial education), though they affect investment allocation efficiency. Specifically, while FL is not an input in producing the final consumption good and thus might reduce human capital and output growth, its accumulation can enhance the allocational efficiency of the financial system. This improvement in financial efficiency might offset the potential crowding-out effect on human capital and output growth, suggesting that investing in FL could ultimately benefit economic growth. Unlike existing literature that highlights a complementarity between human capital and financial outcomes – where financial markets ultimately require skilled workers (Allub et al., 2024; Philippon, 2010) – our framework emphasizes the potential for substitutability between human capital and the financial sector efficiency. Specifically, the allocation of time between general and financial education might enhance financial efficiency while lowering the overall skill level, creating a trade-off between economic and financial development. From a policy perspective, by calibrating our model with real-world data, we identify why promoting financial knowledge is crucial among OECD countries. There appears to be an externality preventing individuals from recognizing how their financial knowledge affects financial efficiency, leading to insufficient accumulation of FL. By quantifying how policies favoring FL impact both human capital and the allocational efficiency of financial intermediaries, our conclusions provide insights into the conditions under which promoting FL can be beneficial for long-term economic growth.

The paper is structured as follows. Section 2 introduces our theoretical framework. Section 3 characterizes the decentralized equilibrium while Section 4 the centralized outcome. Section 5 develops a calibration exercise. Section 6 presents concluding remarks. The proofs of all our theoretical results are discussed in appendix A, while some other technicalities and extensions are presented in appendixes B and C.

2. The model

We extend a discrete-time endogenous growth model *à-la* Uzawa-Lucas (1988) along two directions, namely to include a financial sector and to account for the role of financial literacy. Human capital is employed across three alternative uses (La Torre et al., 2015): to provide labor services, to accumulate new human capital, and to accumulate FL.[4] For the sake of simplicity, we abstract from population growth, and the population size is normalized to one, thus aggregate and per capita variables coincide. The economy is composed of infinitely-lived, structurally identical agents, a set of competitive firms producing a homogeneous final consumption good (the *numéraire*), and infinitely-lived, identical financial intermediaries, which we label as "banks" for simplicity. To obtain closed-form solutions, all the functional forms are assumed to take either a logarithmic or Cobb–Douglas specification.

[3] For a recent survey on the effects of FL and financial education, see Kaiser and Lusardi (2024).

[4] Some works have analyzed similar frameworks in which human capital can be employed in a third sector to account for its role in knowledge creation (La Torre & Marsiglio, 2010; La Torre et al., 2015). Differently from these models, in our setting, the third sector (i.e. the specialized knowledge sector) produces an intangible asset (i.e., FL), which does not represent an input in the production of the final good.

2.1. The households

The representative household needs to decide her consumption level, c_t, the amount of her human capital to allocate to production activities, $0 < u_t < 1$, and to financial education, $0 < v_t < 1$, to maximize her welfare taking into account the evolution of physical capital, k_t, human capital, h_t, and FL, a_t. Her welfare is the infinite discounted sum of utilities where her instantaneous utility function is logarithmic and depends only on consumption, $u(c_t) = \ln c_t$. Her objective function reads as follows:

$$U = \sum_{0}^{\infty} \beta^t \ln c_t \tag{1}$$

where $\beta \in (0, 1)$ is the discount factor. At $t = 0$ she is endowed with an initial stock of physical capital $k_0 > 0$, human capital $h_0 > 0$, and FL $a_0 > 0$. In every period t, she decides which share of her current stock of human capital to allocate to financial education and which share to supply as labor to firms producing the final good, such that the remaining share is devoted to general education. As in Lucas (1988), new human capital is produced through a linear technology:

$$h_{t+1} = b(1 - u_t - v_t)h_t \tag{2}$$

where $b > 1$ measures the productivity of general education in human capital formation.

While human capital quantifies general productivity-augmenting skills (e.g., cognitive ability and numeracy skills), FL measures skills and knowledge specific to finance that does not contribute to the aggregate production: specialized financial knowledge (FL) and general productive knowledge (human capital) are not perfect substitutes. Consistent with empirical evidence (Jappelli & Padula, 2013), new FL is produced by combining its existing stock a_t with the allotted share of human capital as follows (Delavande et al., 2008).

$$a_{t+1} = \begin{cases} d(v_t h_t)^{1-\xi} a_t^{\xi} & \text{if } v_t \in (0, 1] \\ a_t & \text{if } v_t = 0 \end{cases} \tag{3}$$

where measures the productivity in the FL creation process and $0 < \xi < 1$ measures the elasticity of FL production to its existing stock. The FL dynamics in Eq. (3) suggests that the investment in financial education determines the regime FL will follow over time. In the absence of financial education FL will remain constant, while positive financial education will allow to accumulate FL.[5]

The representative agent aims to smooth consumption intertemporally by transferring resources to the financial sector, that is by saving an amount s_t in period t. Given that there are no shocks in the economy,[6] in every period the agent invests s_t in a risk-free asset ("bonds") whose (gross) return equals r_t^b. All agents collectively own the banks and therefore collect their profits. When making her optimal choices, the representative agent is constrained by the following budget constraint:

$$c_t + s_t = w_t(u_t h_t) + r_t^b s_{t-1} + \pi_t^{bank} \tag{4}$$

where s_{t-1} denotes the agent's saving in $t-1$, $u_t h_t$ the amount of human capital supplied to firms for production, π_t^{bank} the collective banks' profit, and the wage paid for one unit of human capital by firms producing the homogeneous final good. The agent takes both w_t and r_t^b as given when making her optimal decisions.

2.2. The financial sector

At the aggregate level, the financial sector allocates the agents' savings to the productive sector. Specifically, banks transform the agents' savings at period t into physical capital at $t + 1$.[7] Consistent with empirical evidence over long periods (Goddard et al., 2011), banks earn positive returns on invested capital by improving their allocation and increasing the efficiency of investment (Pagano, 1993). Therefore, we capture these ideas by specifying the financial sector's allocational efficiency as a function F that determines the (gross) return on savings earned by banks. The financial sector efficiency depends on output y_t and therefore on physical and human capital and labor time (Berger & Mester, 2003), and, as suggested by policymakers, also on FL (Bernanke, 2011 and Stark, 2006)[8]. Higher FL allows savers to select banks that allocate their savings more efficiently. Accordingly, we assume that

[5] There is large empirical evidence showing a positive relationship between FL and human capital (see for example Jappelli & Padula, 2013). Our assumption that "specialized" financial knowledge (FL) and "general" productive knowledge (human capital) are not perfect substitute does not contradict these findings. Indeed, the dynamics in Eq. (3) imply that a higher stock of human capital increases the rate of FL growth, *coeteris paribus*.

[6] Following the portfolio choice literature in which financial literacy improves the Sharpe ratio households can earn on the financial markets (see e.g. Jappelli & Padula, 2013; Lusardi et al., 2017), we do not consider aggregate shocks in the economy. This is because we focus on the long run that is a time frame over which the effects of shocks may average out. Therefore, the effects of FL on the magnitude and volatility of systematic risk are negligible in the long run.

[7] This approach may represent a reduced form of a richer framework including an additional competitive productive sector that purchases savings from banks at t and produces physical capital at $t+1$, which is then sold to final-output firms (see the full description of this extended setup in appendix C). As this extension does not modify our conclusions we present the setup in its simplest form.

[8] From the speech by Jurgen Stark, Member of the Executive Board of the ECB at the International Conference of Central Bankers and Economic Educators in Warsaw, 29 September 2006: *"I would like to highlight two channels through which economic literacy works: First, it contributes to an efficient distribution of resources. A basic understanding of the workings of their economic environment improves people's ability to obtain the information they need and to make the best choice among different alternatives. For example, people will be better able to make intelligent and sustainable lending and saving decisions that have a direct impact on their individual welfare. Economic literacy thus helps to allocate resources to their most efficient uses, which ultimately benefits economic progress."*

the financial efficiency depends also on the average (or aggregate, as the agents' homogeneity assumption combined with unitary population size implies that aggregate and average variables coincide) levels of financial education $\bar{v}_t$ and FL $\bar{a}_t$ as follows:

$$F_t = \begin{cases} k_t^{\eta_k} u_t^{\eta_u} h_t^{\eta_h} \bar{a}_t^{\eta_a} \bar{v}_t^{\eta_v} & \text{if} \quad v_t \in (0,1] \\ k_t^{\eta_k} u_t^{\eta_u} h_t^{\eta_h} \bar{a}_t^{\eta_a} & \text{if} \quad v_t = 0 \end{cases} \tag{5}$$

where $\eta_i \geq 0$ for $i = k, u, h, a, v$ denotes the elasticity of financial efficiency with respect to the variable i.[9] The dynamic evolution of physical capital reads as:

$$k_{t+1} = (y_t - c_t)F_t \tag{6}$$

The above arguments suggest that banks collectively may be able to earn a positive return on capital invested (i.e. the aggregate savings), i.e. $F > 1$, at least for some values $(k_t, h_t, a_t, u_t, v_t)$. If all elasticities η equal zero, then $F = 1$ for every $(k_t, h_t, a_t, u_t, v_t)$ and the financial sector does not play any role in the economy.

Banks do not consume and simply distribute as dividends all their profits to agents in every period t. Their revenue comes from selling output k_t to final firms at the rate r_t. Their cost is proportional to the yields r_t^b paid on the agent's savings invested in bonds in $t-1$. Banks' profit at the time t then equals[10]

$$\pi_t^{bank} = r_t k_t - r_t^b s_{t-1} \tag{7}$$

where, from (6), $k_t = s_{t-1}F_{t-1}$. By substituting (7) into (4) we rewrite the representative agent's budget constraint as:

$$s_t = w_t(u_t h_t) + r_t k_t - c_t$$

Eqs. (2), (3), and (6) describe the evolution of the three state variables of our model economy. Together with (5), these equations show that financial knowledge involves a dynamic trade-off. On the one hand, it increases the return on savings generated by banks as long as η_a is positive and therefore increases the future stock of physical capital. On the other hand, it reduces the amount of human capital that can be devoted to production and the acquisition of new human capital slowing human capital accumulation down. Therefore, the macroeconomic impact of FL on long-run economic growth is not obvious a priori.

2.3. The final good sector

Firms producing the consumption good are perfectly competitive. In every period t they produce the amount y_t of final good through a Cobb–Douglas technology by employing the share u_t of the human capital, and the amount k_t of physical capital, as follows:

$$y_t = k_t^{\alpha}(u_t h_t)^{1-\alpha} \tag{8}$$

where $0 < \alpha < 1$ is the physical capital share.[11] Firms rent human capital from agents at the price w_t while they rent physical capital from the banks at the price r_t. While human capital is an input in producing the final good, FL is not and thus does not affect output (see (8)). Perfectly competitive firms earn zero profits at every t. Therefore, r_t equals the marginal productivity of physical capital, and w_t equals the marginal productivity of human capital,

$$r_t = \frac{\partial y_t}{\partial k_t} = \alpha \frac{y_t}{k_t} \tag{9}$$

$$w_t = \frac{\partial y_t}{\partial (u_t h_t)} = (1-\alpha)\frac{y_t}{(u_t h_t)} \tag{10}$$

with:

$$w_t(u_t h_t) + r_t k_t = y_t \tag{11}$$

3. The decentralized outcome

We start by analyzing the outcome in a decentralized economy (DE) in which the representative agent behaves rationally but does not recognize that her own financial education and level of FL may affect the financial sector allocational efficiency. Therefore, she makes her optimal decisions by considering $\bar{a}_t$ and $\bar{v}_t$ in (5) as exogenously given. In other words, the financial intermediation activity involves an externality: financial education and FL increase the efficiency of the financial system, but this is not taken into account by the representative agent, as she is too small with respect to the whole population and financial sector. Her optimization

[9] We allow F to depend also directly on human capital to capture the idea that human capital drives financial innovation and therefore enhances efficiency.

[10] In Appendix B we show that banks earn non-negative profits in every period, under natural conditions on r_t^b and r_t. This proves that it is optimal for them to buy and allocate through final firms the whole savings amount s_t in every period.

[11] FL has been shown to be positively related to entrepreneurial productivity (see e.g. Trombetta 2023) as well as to entrepreneurial ability (McGee & Peterson, 2019) and therefore can improve also the final good production. If this was the case, there would be further incentives to accumulate FL. We limit our analysis to the least favorable scenario in which the only incentive for FL accumulation is related to its role in improving financial efficiency.

problem therefore consists of maximizing (1) subject to the dynamic restrictions (2), (3), and (6), taking $\bar{a}_t$ and $\bar{v}_t$ as given, taking into account Eqs. (8) and (5), and that k_0, h_0, $a_0 > 0$. Given the presence of competitive firms producing the final consumption good, i.e. given (9), and (10), the dynamics of physical capital can be rewritten as:

$$k_{t+1} = (w_t(u_t h_t) + r_t k_t - c_t)F_t$$

which, by (11), corresponds to (6).

After some algebra, it is possible to obtain a closed-form solution to the DE problem and to derive explicitly the optimal policy and the optimal dynamics of physical capital, human capital, and FL. This result is summarized in the next proposition.

Proposition 1. *Provided that* $\eta_k \leq \frac{1-\alpha}{\beta}$, *then:*

(i) The optimal policy rules for consumption, for the share of human capital allocated respectively to the production of final good, and to financial education are given by:

$$c_t = \frac{1-\alpha\beta-\beta\eta_k}{1-\beta\eta_k} y_t = \frac{1-\alpha\beta-\beta\eta_k}{1-\beta\eta_k} k_t^{\alpha} \left(\bar{u}^{DE} h_t\right)^{1-\alpha} \tag{12}$$

$$u_t = \bar{u}^{DE} = 1 - \beta\Theta' \tag{13}$$

$$v_t = \bar{v}^{DE} = 0 \tag{14}$$

where:

$$\Theta' = \frac{(1-\alpha)(1-\beta\eta_k)+\alpha\beta\eta_h}{(1-\alpha)(1-\beta\eta_k)+\alpha\beta^2\eta_h+\alpha\beta(1-\beta)\eta_u} \tag{15}$$

(ii) The optimal dynamics of physical capital, human capital and financial literacy are given by:

$$k_{t+1} = \alpha\beta y_t F_t = \alpha a_0^{\eta_a} \beta k_t^{\alpha+\eta_k} \left(\bar{u}^{DE}\right)^{1-\alpha+\eta_u} h_t^{\,1-\alpha+\eta_h} \tag{16}$$

$$h_{t+1} = b(1-\bar{u}^{DE})h_t \tag{17}$$

$$a_{t+1} = a_t = a_0 \tag{18}$$

Proposition 1 derives explicitly the optimal policy rules (point (i)) and the optimal dynamics of physical capital, human capital and FL (point (ii)). For these policies and dynamics to be well defined the elasticity of the financial efficiency with respect to physical capital, η_k, should not be too large, with no restrictions on the magnitude of the other parameters required. As in similar multi-sector endogenous growth models (La Torre & Marsiglio, 2010; La Torre et al., 2015), the shares of human capital allocated across its alternative uses are constant. Quite intuitively, given that FL does not affect production and the representative agent fails to recognize its impact on financial efficiency, in the DE she optimally decides not to allocate time to financial education ($\bar{v}_t^{DE} = 0$) and the level of FL remains constant over time. Since investing in FL is not beneficial at the individual level, there is no crowding out of general education by financial education and thus FL does not affect the pattern of human capital formation.

Another interesting result is related to the role played by financial efficiency in determining the optimal policy rules, through the magnitude of its elasticities with respect to the different variables, η_i. If $\eta_k = \eta_h = \eta_u = 0$ then the financial efficiency does not depend on k, h, and u, and thus the financial sector does not play any role. The optimal policies and dynamics reduce to those in standard multi-sector endogenous growth models, such that the share of human capital devoted to production equals $\bar{u}^* = 1 - \beta$ and human capital growth rate is $\gamma_h^* = b\beta - 1$ (La Torre et al., 2015). If instead some of these elasticities are positive, then the financial sector produces real macroeconomic effects. More specifically, the relative size of η_u and η_h determines the incentives to accumulate human capital vis-à-vis producing output. If $\eta_u = \eta_h$, then $\bar{u}^{DE} = \bar{u}^*$ and human capital grows at the same rate as in a framework without a financial sector, $\gamma_h^{DE} = \gamma_h^*$ (La Torre et al., 2015). Therefore, banks only affect the physical capital dynamics. By efficiently allocating savings they can earn positive returns on the capital invested and thus increase the stock of physical capital produced at any period, compared to what would happen in an economy without a financial sector. If $\eta_u \neq \eta_h$ instead also human capital accumulation is affected by the presence of a financial sector. Specifically, if $\eta_u < \eta_h$ then $\bar{u}^{DE} < \bar{u}^*$ and human capital grows faster, $\gamma_h^{DE} > \gamma_h^*$: as a higher stock of human capital speeds up physical capital accumulation due to the higher return on savings generated by banks' activities, the presence of the financial sector provides incentives to further accumulate human capital. Conversely, if $\eta_u > \eta_h$, then $\bar{u}^{DE} < \bar{u}^*$ and human capital grows slower, $\gamma_h^{DE} < \gamma_h^*$: as financial efficiency and thus the return on savings is highly dependent on the labor time, the presence of the financial sector disincentivizes human capital formation to favor its allocation to labor services.

The next proposition characterizes the balanced growth path (BGP) equilibrium in the DE.

Proposition 2. *If* $b > \frac{1}{\beta\Theta'}$ *and* $\eta_k \leq \frac{1-\alpha}{\beta}$ *then along the BGP the growth rate of human capital and financial literacy are given by, respectively:*

$$\gamma_h^{DE} = b\beta\Theta' - 1 \tag{19}$$

$$\gamma_a^{DE} = 0, \tag{20}$$

while the growth rates of consumption, physical capital, and output by:

$$\gamma_k^{DE} = (1+\gamma_h^{DE})^{\frac{1-\alpha+\eta_h}{1-\alpha-\eta_k}} - 1 \tag{21}$$

$$\gamma_y^{DE} = \gamma_c^{DE} = (1+\gamma_h^{DE})^{\alpha\frac{1-\alpha+\eta_h}{1-\alpha-\eta_k}+1-\alpha} - 1 \tag{22}$$

Proposition 2 explicitly determines the growth rates of the main variables along the BGP equilibrium. If the productivity of human capital in the creation of new human capital is large enough (i.e., $b > \frac{1}{\beta\Theta'}$), then in the long run physical and human capital grow at a strictly positive and constant rate, and so do consumption and output. With respect to what would happen in an analogous model without a financial sector, the presence of financial intermediaries may introduce a wedge between the growth rates of the main variables, and this is the case whenever $\eta_k > 0$ and $\eta_h > 0$. Specifically, if financial efficiency increases with physical and human capital, then physical capital will grow faster than production and consumption, which in turn will grow faster than human capital. The fact that these variables may grow at different rates along the BGP implies that over time the relative size of different economic sectors may change, with a relative increase in the size of the physical capital sector. Note that this effect disappears whenever $\eta_k = 0$ and $\eta_h = 0$. If financial efficiency is endogenous but independent of physical and human capital, all the variables (apart from FL) will grow at the same constant rate.

Eq. (22) clarifies the two mechanisms through which the financial sector may be beneficial for long-run economic growth. Indeed, output growth positively depends on human capital growth and financial efficiency growth, since it can be rewritten as follows: $\gamma_y^{DE} = (1+\gamma_F)^{\frac{\alpha}{1-\alpha}}(1+\gamma_h)$. (i) If the presence of the financial sector incentivizes the formation of human capital because this increases the return on savings generated by banks (which from our previous discussion may be the case if $\eta_u < \eta_h$), then this will automatically result in faster growth than we would otherwise achieve without financial intermediation. We refer to this as the *"human capital channel"*. (ii) If the presence of the financial sector disincentivizes the formation of human capital because the return on savings generated by banks depends more strongly on labor time (which may be the case if $\eta_u > \eta_h$), then this will tend to result in slower growth than in the absence of financial intermediation. However, this negative effect may be more than compensated by the increased financial efficiency if such growth is sufficiently fast, which ultimately depends on the size of its elasticity with respect to physical and human capital.[12] We refer to this as the *"financial efficiency channel"* (or as the *"efficiency channel"*, for brevity). Therefore, according to the size of the different elasticities of F with respect to labor time, physical capital, and human capital, the financial sector may be detrimental or beneficial for growth, and in the latter case, its growth-enhancing effects may take place through either the human capital or the financial efficiency channel.

4. The centralized outcome

We now turn to the outcome in a centralized economy in which a benevolent social planner (SP) optimally chooses the level of consumption and the shares of human capital to allocate across sectors by accounting for the financial efficiency externality, that is recognizing the fact that $\bar{a}_t = a_t$ and $\bar{\nu}_t = \nu_t$. The SP aims to maximize social welfare, which coincides with individual welfare since the population size is normalized to unity. Therefore, SP maximizes (1), subject to the dynamic restrictions (2), (3), and (6), considering $\bar{a}_t = a_t$ and $\bar{\nu}_t = \nu_t$, taking into account Eqs. (5) and (8), and that k_0, h_0, $a_0 > 0$.

Similar to what we have already seen for the DE, the next proposition presents the optimal policy and the optimal dynamics in the SP outcome.

Proposition 3. *Provided that* $\eta_k \leq \frac{1-\alpha}{\beta}$*, then:*

(i) The optimal policy rules for consumption, for the share of human capital allocated respectively to the production of final good, and to financial education are given by:

$$c_t = \frac{1-\alpha\beta-\beta\eta_k}{1-\beta\eta_k} y_t = \frac{1-\alpha\beta-\beta\eta_k}{1-\beta\eta_k} k_t^{\alpha} (\bar{u}^{SP})^{1-\alpha} h_t^{1-\alpha} > 0 \tag{23}$$

$$u_t = \bar{u}^{SP} = \frac{1-\beta\Theta}{\Delta} \in (0,1) \tag{24}$$

$$\nu_t = \bar{\nu}^{SP} = \frac{1-\beta\Theta}{\Delta} \frac{\eta_\nu + \frac{\beta(1-\xi)}{1-\beta\xi}\eta_a}{\eta_u + \frac{1-\alpha}{\alpha\beta}(1-\beta\eta_k)} \in (0,1) \tag{25}$$

where:

$$\Theta = \frac{1-\alpha-\beta\eta_k+\alpha\beta\left(\eta_k+\eta_h+\frac{\beta(1-\xi)}{1-\beta\xi}\eta_a\right)}{1-\alpha-\beta\eta_k+\alpha\beta\left(\eta_k+\eta_h+\frac{\beta(1-\xi)}{1-\beta\xi}\eta_a\right)+\alpha\beta(1-\beta)(\eta_u+\eta_\nu-\eta_h)} \tag{26}$$

$$\Delta = \frac{\eta_u + \frac{1-\alpha}{\alpha\beta}(1-\beta\eta_k) + \eta_\nu + \frac{\beta(1-\xi)}{1-\beta\xi}\eta_a}{\eta_u + \frac{1-\alpha}{\alpha\beta}(1-\beta\eta_k)} \tag{27}$$

[12] Without the financial sector, in the long run, output grows at the rate $\gamma_y^* = b\beta - 1$. With $\eta_u > \eta_h$ the growth rate $\gamma_h^{DE} < \gamma_h^*$ because $\Theta' < 1$. In this case, a sufficient condition for $\gamma_y^{DE} > \gamma_y^*$ is $(b\beta\Theta')^{\alpha\frac{1-\alpha+\eta_h}{1-\alpha-\eta_k}+1-\alpha} > b\beta$. Given that $b\beta\Theta' > 1$, this condition is verified for sufficiently high $\frac{1-\alpha+\eta_h}{1-\alpha-\eta_k}$, i.e. for sufficiently high η_h and η_k.

(ii) The optimal dynamics of physical capital, human capital and financial literacy are given by:

$$k_{t+1} = \frac{\alpha\beta}{1-\beta\eta_k} y_t F_t = \frac{\alpha\beta}{1-\beta\eta_k} k_t^{\alpha+\eta_k} \left(\overline{u}^{SP}\right)^{1-\alpha+\eta_u} h_t^{\,1-\alpha+\eta_h} a_t^{\eta_a} \overline{v}^{\eta_v} \tag{28}$$

$$h_{t+1} = b(1-\overline{u}^{SP}-\overline{v}^{SP})h_t \tag{29}$$

$$a_{t+1} = d\left(\overline{v}^{SP} h_t\right)^{1-\xi} a_t^{\xi} \tag{30}$$

Proposition 3 shows that the optimal policy rules and dynamics in the SP outcome are qualitatively similar to those derived in the DE, and thus most of the comments presented earlier still apply. It is interesting to observe that since FL does not affect output production the saving rates in the SP and DE outcomes coincide — compare (23) and (12). The most important difference between the SP and DE outcomes relates to financial education and thus the dynamics of FL. Since the SP recognizes their effects on financial efficiency he finds it optimal to allocate a strictly positive share of human capital to financial education (i.e., $\overline{v}^{SP} > 0$), leading to an increase in the level of FL over time. Intuitively, the higher the efficiency elasticity with respect to financial education and FL, the higher the amount of time devoted to financial education.[13] However, whether this diversion of time towards financial education necessarily slows down human capital accumulation is not obvious as this depends also on what it implies for the amount of time devoted to labor services.[14]

Different from what we have seen earlier in the DE outcome, both financial education and the level of FL affect macroeconomic dynamics and the optimal allocation of resources. Indeed, this allocation no longer depends only on the relative magnitude of η_u and η_h, but also on the size of η_v and η_a. To understand how, let us consider first what happens when $\eta_u + \eta_v = \eta_h$. With respect to a framework without financial intermediation, the SP increases the amount of time allocated to financial education and reduces that devoted to output production by the same amount so that the time remaining for general education is unchanged (i.e., $\overline{u}^{SP} + \overline{v}^{SP} = \overline{u}^{*}$). Therefore, the financial sector does not modify human capital dynamics but some human capital gets diverted from output production to financial education, and intuitively the size of this diversion increases with η_a. Whenever $\eta_u + \eta_v \neq \eta_h$ also general education and thus human capital formation change with respect to what would happen without financial intermediation.[15] In particular the elasticity η_v plays a key role. The higher this parameter the more financial education affects the return generated by banks and this in turn provides stronger incentives to sacrifice general education in favor of financial education. To quantitatively assess the role of FL and financial education on output growth, we characterize the BGP equilibrium in the SP outcome.

Proposition 4. *If* $b > \frac{1}{\beta\Theta}$, $d > \frac{1}{(\overline{v}^{SP} h_0/a_0)^{1-\xi}}$ *and* $\eta_k \leq \frac{1-\alpha}{\beta}$ *then along the BGP the growth rates of consumption, physical capital, human capital, financial literacy and output are given by:*

$$\gamma_h^{SP} = \gamma_a^{SP} = b\beta\Theta - 1 \tag{31}$$

$$\gamma_k^{SP} = (1+\gamma_h^{SP})^{\frac{1-\alpha+\eta_h+\eta_a}{1-\alpha-\eta_k}} - 1 \tag{32}$$

$$\gamma_y^{SP} = \gamma_c^{SP} = (1+\gamma_h^{SP})^{\alpha\frac{1-\alpha+\eta_h+\eta_a}{1-\alpha-\eta_k}+1-\alpha} - 1 \tag{33}$$

From Proposition 4 we can derive comments similar to those discussed earlier in the DE outcome. The only noticeable difference is that in the centralized solution FL grows at the same rate as human capital. This in turn affects both human capital and output growth in the long run because financial education and the level of FL interact with the human capital and efficiency channels described above.

To explain more in detail these effects let us compare the long-run growth rates in the SP and the DE solutions. Starting from the dynamics of human capital, the growth rate of human capital in the SP outcome, γ_h^{SP}, is lower (resp. higher) than the one in the DE one, γ_h^{DE}, for sufficiently high (low) η_v and for sufficiently low (high) η_a.[16] As financial education $\overline{v}^{SP}$ increases with η_v, a higher η_v slows down the accumulation of human capital and therefore weakens the human capital channel: the higher η_v, the more likely that financial education partially crowds out human capital formation. The effect of the elasticity η_a on human capital accumulation however is positive, because a higher η_a increases financial efficiency growth $\gamma_F = (1+\gamma_k)^{\eta_k}(1+\gamma_h)^{\eta_h+\eta_a} - 1$. This increases the incentive to accumulate human capital, because, by (3), a higher level of human capital allows a faster accumulation of FL, so that FL crowds in human capital accumulation.

The growth rate of final output in the SP solution (γ_y^{SP}) differs from the one in the DE (γ_y^{DE}) for two reasons. First, because of the different growth rates of human capital. This results from the opposite effects of financial education, which partially crowds out human capital formation, and of FL, which instead fosters it, as described above. Second, in the DE the financial sector's efficiency increases at a lower rate than in the SP because the stock of FL stays constant over time. Given that γ_y^{SP} increases with the elasticity η_a, while γ_y^{DE} does not depend on it, for a given γ_h the difference $\gamma_y^{SP} - \gamma_y^{DE}$ is increasing with η_a – compare (22) with (33).[17]

[13] For comparative statics of the centralized solution, we refer to the proof of the proposition.

[14] See the discussion after Proposition 4 for the precise conditions determining the dynamics of human capital accumulation.

[15] Formally, in this case we have that $\overline{u}^{SP} + \overline{v}^{SP} > \overline{u}^{*}$ (resp. $\overline{u}^{SP} + \overline{v}^{SP} < \overline{u}^{*}$) if $\eta_u + \eta_v > \eta_h$ (resp. $\eta_u + \eta_v < \eta_h$).

[16] Formally, $\gamma_h^{SP} < \gamma_h^{DE}$ if $\Theta < \Theta'$..

[17] Formally, $\gamma_y^{SP} > \gamma_y^{DE}$ if $(b\beta)^{\alpha\frac{\eta_a}{1-\alpha-\eta_k}} > \frac{(\Theta')^{\alpha\frac{1-\alpha+\eta_h}{1-\alpha-\eta_k}+1-\alpha}}{(\Theta)^{\alpha\frac{1-\alpha+\eta_h+\eta_a}{1-\alpha-\eta_k}+1-\alpha}}$.

Overall, we can conclude that the effect of FL on long-run economic growth, and therefore the effect of internalizing the externality in our DE, is ambiguous. The net effect depends on the relative size of all the elasticities of the efficiency term F. Therefore, to assess the effectiveness of policies promoting FL, we now turn to a calibration of the model on the US economy.

5. Calibration and quantitative results

We now present a calibration based on the US economy's data over the 1950–2019 period to assess whether FL policies aiming to increase financial education may effectively benefit economic growth. Given that in the US the level of FL stayed approximately constant in the last decade (FINRA, 2009, 2012, 2015, 2018), the real-world data are representative of a DE outcome, where $\bar{v}^{DE} = 0$ and $\gamma_a = 0$.[18] Therefore, by measuring the wedge between the DE and SP growth rates we aim to quantify the extent to which such policies may be desirable to promote economic growth from a long-run perspective.[19] We obtain the growth rates of the human capital and physical capital net of depreciation from the PWT 10.0 data as 0.53% and 1.623% respectively (Feenstra et al., 2015). Given that in our model both human and physical capital growth rates include depreciation, we include the human capital depreciation rate, i.e. 1.14% per year (Hugget et al. 2006), and physical capital one, i.e. 3.57% per year (Feenstra et al., 2015), so that $\gamma_h = 1.67\%$ and $\gamma_k = 5.193\%$. From PWT 10.0 data we also obtain $\gamma_y = 1.98\%$.

In our baseline parametrization, we set the share of physical capital in the final good production α to the very stylized value of 0.4 (e.g., Feenstra et al., 2015), and the discount factor β as 0.95 (Bozio et al., 2017; Samwick, 1998). We also need an estimate of the intensity of the financial literacy stock in the production of new financial literacy ξ. We arbitrarily set it as 0.6, but our conclusions are robust to different values of this parameter. To the best of our knowledge, the productivity of human capital in human capital accumulation b has not been analyzed extensively. The only available estimates are provided by Wedel (2021), who finds that the values of b yielded from the education production functions in subsamples of the most developed countries range in the interval $[1.01, 1.07]$. Therefore, we calibrate b on the real data, checking that the result we obtain is consistent with the estimated range in Wedel (2021). Concerning the elasticities of the financial intermediaries' efficiency function F, very little information is provided in the empirical literature. Berger and Mester (2003) use the variation in TFP from more than 10,000 US banks between 1984 and 1997, as well as the physical capital stocks of those banks in the given years, to calculate $\eta_k = 0.1086$. We consider $\eta_u = 0.01$, that is equivalent to assuming that the share of human capital employed in output production has a very limited effect on banks' profitability. To summarize, in our baseline parametrization we consider:

$$\alpha = 0.4 \quad \beta = 0.95 \quad \eta_k = 0.1086 \quad \eta_u = 0.01 \tag{34}$$

Our calibration method goes as follows. Proposition 2 provides three equations in three growth rates:

$$\begin{aligned} 1+\gamma_h &= b\beta\Theta' = 1.0167 \\ 1+\gamma_k &= (1+\gamma_h)^{\frac{1-\alpha+\eta_h}{1-\alpha-\eta_k}} = (1.0167)^{\frac{1-\alpha+\eta_h}{1-\alpha-\eta_k}} \\ 1+\gamma_y &= (1+\gamma_k)^{\alpha}(1+\gamma_h)^{1-\alpha} = (1+\gamma_h)^{\alpha\frac{1-\alpha+\eta_h}{1-\alpha-\eta_k}+1-\alpha} = (1.0167)^{\alpha\frac{1-\alpha+\eta_h}{1-\alpha-\eta_k}+1-\alpha} \end{aligned}$$

where the unknowns are (b, η_h). Given that the second and the third equations are linearly dependent, by using $\eta_u = 0.01$, we obtain

$$\eta_h = 0.117\,20 \quad b = 1.066 \tag{35}$$

where the result for b falls into Wedel (2021) interval estimate. We could not find empirical evidence on the elasticity η_h in the US banks, but the magnitude of the calibrated value is consistent with η_k (Berger & Mester, 2003) and thus we believe it represents a realistic benchmark for our purposes.[20] To quantify the long-run effects of the efficiency externality, we rely on the SP growth rate from Proposition 4 to obtain the growth rates of human capital, γ_h, and of the final output γ_y. As the SP growth rates depend on η_a and η_v we set arbitrarily two values $\eta_v = \{0.01, 0.05\}$ and consider a range of values $\eta_a = [0, 0.5]$ to understand how such parameters may affect our conclusions.

Fig. 1 represents the growth rate of human capital (left panel) and output (right panel) as functions of η_a, comparing them in the DE (blue curves) and in the SP setup when $\eta_v = 0.01$ (black curves) and $\eta_v = 0.05$ (red curves). Independently of the size of η_v, we can observe that the failure to internalize the efficiency externality which results in no financial education leads the DE to

[18] Given the measurement errors that have been reported in the literature for objective measures of FL (see for example Bertola & Lo Prete, 2025), we cannot reasonably conclude that the (possible) errors contained in the NFCS indexes vary through time, and, in particular, that they fail to capture an actual growth in FL among US households. What matters for our calibration exercise is the FL growth, not its absolute level. In our calibration procedure we exploit the fact that, according to the NFCS data, the level of FL in the US has remained approximately constant in the last decade, and this in turn reflects our DE solution, with $\bar{v}^{DE} = 0$ and $\gamma_a = 0$. If the NFCS measures of FL are consistently overestimated (or underestimated) through time, this result still holds.

[19] Our argument is that, if households do not internalize the effect of FL on the financial sector's efficiency, and correspondingly do not accumulate FL through time, then a policy forcing financial education could be beneficial for long-run growth, under some conditions on the elasticities η_a, η_v. Therefore, we do not need to match the real-world level of FL. Our calibration results hold as long as this level of FL does not increase substantially through time.

[20] Berger and Mester (1997) points out the importance of the price of labor as a determinant of the efficiency of US banks, but this is not sufficient to calculate an empirical counterpart of η_h. For European banks, Mesa et al. (2014) used a measure of Human Resources Strategy. With the data in that paper, η_h can be evaluated at 0.03. Adesina (2021) relates human capital with a measure of efficiency in a sample of African banks and his data allows us to proxy an elasticity of 1.26.

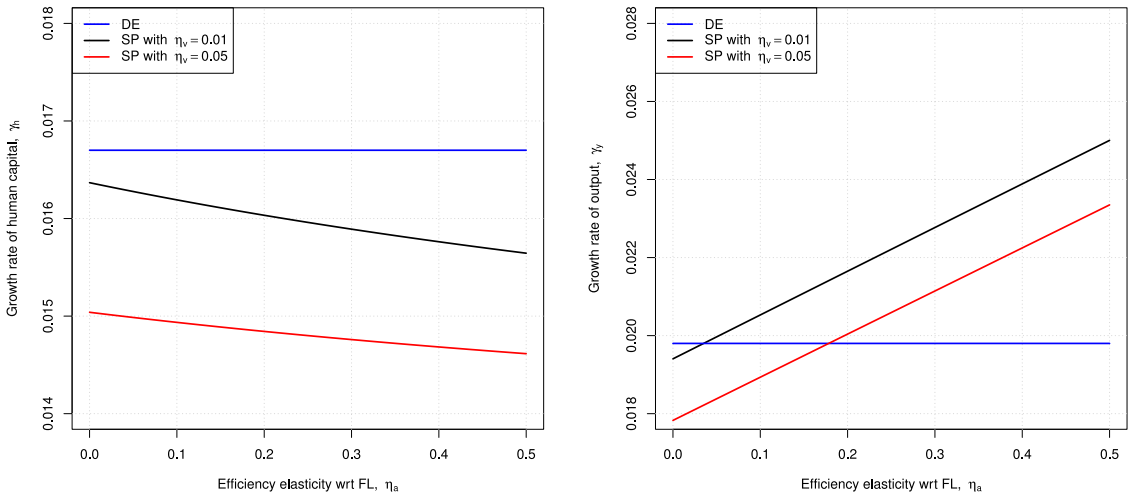

Fig. 1. The growth rate of human capital γ_h (left) and output γ_y (right) as functions of the efficiency elasticity with respect to financial literacy η_a, in the DE outcome (blue curve) and in the SP outcome for $\eta_v = 0.01$ (black curve) and $\eta_v = 0.05$ (red curve). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

experience a higher rate of human capital growth than in the SP economy where instead some positive financial education partially crowds out human capital formation. This gap between the DE and SP human capital growth rates is more pronounced the higher η_v and increases with η_a. These results are driven by the greater importance of these parameters in determining financial efficiency which in turn weakens the motive to accumulate human capital: less human capital is required to reach the same degree of financial efficiency (a sort of "income effect") since FL positively affects the outcome of the financial intermediation process. For low values of η_a these effects straightforwardly extend also to output growth, as lower human capital growth translates into lower output growth. However, when η_a increases the positive impact of FL on financial efficiency, which makes more resources available for physical capital accumulation and production purposes may reverse the results and the SP growth rate may exceed the DE one even when human capital formation is lower. We can observe that the threshold value of the efficiency elasticity with respect to FL beyond which the SP output growth exceeds the DE one varies from $\eta_a = 0.035$ in the $\eta_v = 0.01$ case to $\eta_a = 0.178$ in the $\eta_v = 0.05$ case. This suggests that promoting FL may benefit economic growth if its effects on banks' allocational efficiency are sufficiently strong, and the required intensity of this effect increases with η_v, as the larger this parameter the stronger the crowding out effect on human capital. If we refer to the case with $\eta_v = 0.01$, which is comparable to the baseline assumption of $\eta_u = 0.01$, as the benchmark for our analysis, the threshold value for η_a beyond which the growth rate of output in the SP is larger than the one in the DE is approximately three times lower than the calibrated value of η_h (i.e. 0.035 versus 0.1172). This means that FL needs to affect financial sector efficiency three times lower than the one of human capital for supporting the desirability of FL policies in terms of long-term growth.

5.1. Robustness and sensitivity analysis

We now assess the robustness of our conclusions by changing some of the parameter values from our baseline parametrization and repeating our calibration exercise to understand whether they might significantly affect our analysis. Specifically, we vary η_u and η_k, and for each of these different values we calibrate η_h and b that fit the human capital and output growth rates.

First, we consider higher values η_u with respect to those employed earlier, and in particular we set $\eta_u = 0.05$ and $\eta_u = 0.1$. This results in the calibrated values $\eta_h = 0.1172$ and $b = 1.067$ (for $\eta_u = 0.05$) and $\eta_h = 0.1172$ and $b = 1.07$ (for $\eta_u = 0.1$) which shows that a higher productivity of general education in human capital formation is required to match the growth rates. Fig. 2 plots the human capital (left panels) and output (right panels) growth rates with $\eta_u = 0.05$ (top panels) and with $\eta_u = 0.10$ (bottom panels). Qualitatively, the results are analogous to those presented in our baseline parametrization. The higher η_u increases the amount of time allocated to production and reduces the amount devoted to human capital formation, reducing thus human capital growth and increasing output growth. However, the human capital crowding out effect is lower than in the baseline and so is the threshold value of the efficiency elasticity with respect to FL (varying from $\eta_a = 0.032$ in the $\eta_v = 0.01$ case to $\eta_a = 0.163$ in the $\eta_v = 0.05$ case when $\eta_u = 0.05$, and from $\eta_a = 0.029$ in the $\eta_v = 0.01$ case to $\eta_a = 0.149$ in the $\eta_v = 0.05$ case when $\eta_u = 0.1$).

Then we consider both lower and higher values of η_k with respect to those earlier employed and in particular, we set $\eta_k = 0.05$ and $\eta_k = 0.15$. This results in the calibrated values $\eta_h = 0.2028$ and $b = 1.064$ (for $\eta_k = 0.05$) and $\eta_h = 0.057$, $b = 1.068$ (for $\eta_k = 0.15$), suggesting that a higher productivity of general education in human capital formation and a lower efficiency elasticity with respect to human capital are required to match the growth rates when η_k increases. Fig. 3 plots the human capital (left panels) and output (right panels) growth rates with $\eta_u = 0.05$ (top panels) and with $\eta_u = 0.10$ (bottom panels). The results confirm that higher FL increases growth only if its effect on the financial sector's efficiency is sufficiently strong, and the threshold increases with η_k (it

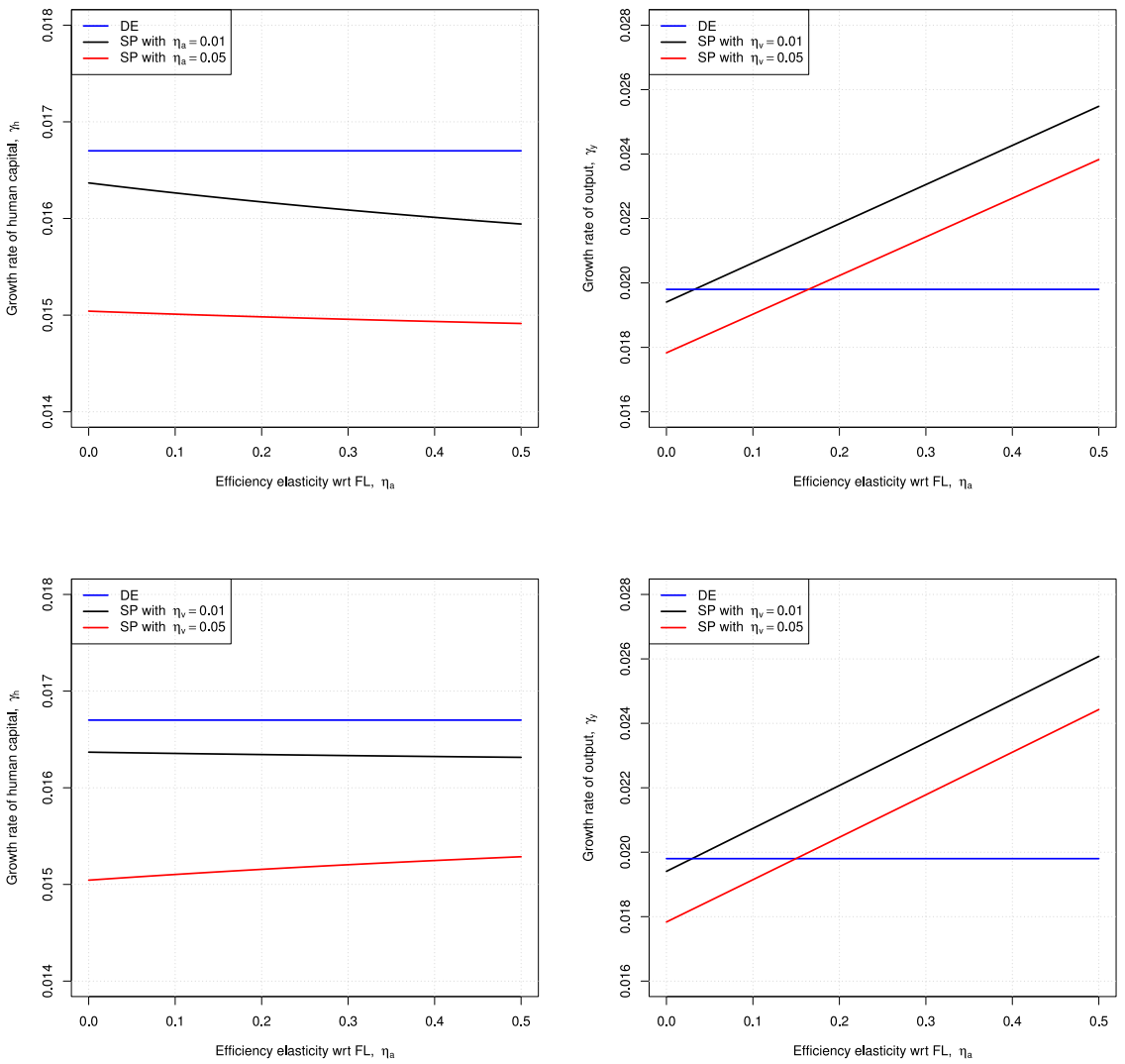

Fig. 2. The growth rate of human capital γ_h (left) and output γ_y (right) in the $\eta_u = 0.05$ (top) and $\eta_u = 0.10$ (bottom) cases.

changes from $\eta_a = 0.042$ in the $\eta_v = 0.01$ case to $\eta_a = 0.214$ in the $\eta_v = 0.05$ case when $\eta_k = 0.05$, and from $\eta_a = 0.032$ in the $\eta_v = 0.01$ case to $\eta_a = 0.162$ in the $\eta_v = 0.05$ case when $\eta_k = 0.15$). The only noticeable difference lies in the human capital growth rate, which in the bottom panels (in which η_k is sufficiently high) increases with η_a, showing that after a certain value of this parameter, the human capital growth rate in the SP exceeds the one in the DE outcome. Therefore, after a specific value of η_a output growth in the SP exceeds the one in the DE via the combined effects of the human capital and financial return channels.

Our sensitivity analysis supports our previous conclusions showing that from a qualitative point of view, they hold for a wide range of parameter values. Therefore, designing policies aiming to increase financial education to promote FL acquisition can be growth-enhancing, as it may result in a higher long-run growth rate than in a decentralized situation. However, this positive effect arises only when the elasticity of financial efficiency with respect to FL is sufficiently high. In other words, FL needs to generate sizeable effects on the allocational efficiency of financial intermediaries for more than compensating its detrimental growth consequences due to human capital crowding out and ultimately promoting long-run growth. The threshold levels above which inducing financial education is growth enhancing are somewhat lower than the calibrated effects of human capital on financial efficiency.

Our quantitative conclusions above are based on our calibration based on the US economy and thus possible policy implications should be limited to this context. It may be interesting to extend our analysis to account for the peculiarities of other countries as well, and a straightforward way to do so would consist of accounting for structural differences across financial sectors internationally. This could be done by examining the variation in financial efficiency between emerging markets and developed economies adjusting the elasticities in the function F – see Eq. (5). Unfortunately, we are unable to find reliable estimates of financial sector efficiency for less developed countries, which would be necessary to recalibrate the model for these economies. However, Adesina (2021) provides compelling evidence on the importance of human capital for various measures of banking performance in African countries, which

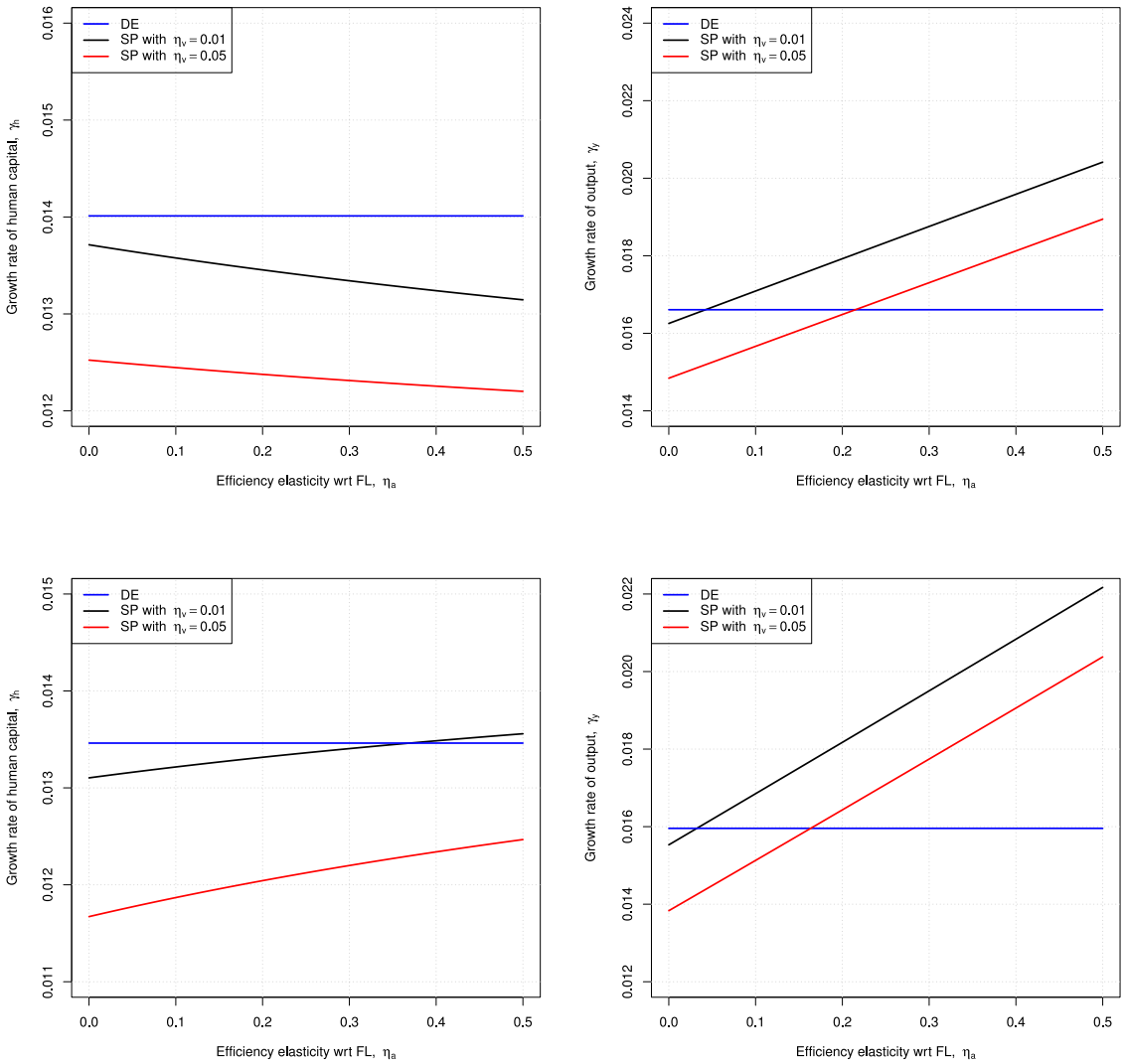

Fig. 3. The growth rate of human capital γ_h (left) and output γ_y (right) in the $\eta_k = 0.05$ (top) and $\eta_k = 0.15$ (bottom) cases.

suggests that many of our conclusions may also be relevant for less developed economies. Such a lack of relevant estimates, especially in the developing world, highlights the need for further empirical research to quantify simultaneously the elasticities of financial sector efficiency with respect to human capital, physical capital, and financial knowledge in these contexts.

6. Conclusion

The importance of FL in improving economic outcomes is widely recognized and as a result, several countries worldwide are introducing policies aiming to support financial education. However, whether these policies are effectively beneficial for economic growth is an open question as FL is a specialized form of human capital and thus, given the rival properties of human capital, more financial education might induce less general education. Our work tries to shed some light on this issue by extending a multi-sector human-capital-based endogenous growth model along two directions: (i) to include a financial sector that transfers savings intertemporally and whose efficiency depends on macroeconomic conditions, and (ii) to introduce FL which may be purposefully accumulated to increase the allocational efficiency of the financial sector and thus the return on saving. Given that FL has not substantially increased in the US in the last decade, it is possible that the representative agent does not take into account the impact of FL and financial education of the financial sector efficiency. By comparing the decentralized and centralized outcomes and calibrating the model to the US economy over the 1950–2019 period, our paper presents some interesting insights.

The presence of financial intermediation allows the financial sector to drive economic growth via two different mechanisms, i.e. the human capital and financial efficiency channels, while FL introduces a trade-off with human capital accumulation which interacts in a nontrivially way with both these mechanisms. This implies that the diversion of time from general education to financial education may or may not be growth-enhancing according to the relative size of the financial efficiency elasticity with respect to

the main variables. Our calibration shows that households' failure to internalize the FL externality on financial efficiency reduces economic growth with respect to the social optimum if the elasticity of the financial efficiency with respect to FL is sufficiently high. The threshold level beyond which FL policies become growth-enhancing is lower than the calibrated value of the financial efficiency elasticity with respect to human capital. This suggests that FL needs to generate sizeable (but not incredibly large) effects on the financial intermediaries' allocational efficiency for promoting long-run growth.

This conclusion abstracts completely from other implementation costs different from the opportunity cost of investing human capital in financial education that we have specifically considered in our model. If we limit ourselves to this trade-off, a practical recommendation in terms of curriculum design and resources allocation consists of implementing financial education mandates by not reducing the time devoted to other topics that are particularly important for employability, such as, for example, STEM subjects. However, existing literature has considered more comprehensively the benefits and the costs of mandating financial education, showing that, if appropriately designed, FL interventions may be quite cost effective, also in the long-term, especially in the case of early educational programs combining different methods (Bucciol & Veronesi, 2014; Kaiser et al., 2022). Since mandating financial education also faces important political barriers (which are outside the scope of our paper and thus not captured by our model), the recommendation (e.g. Kaiser et al., 2022; NEFE, 2021) is to design interventions thoughtfully, and especially to consider decisions that learners are readily able to make and find relevant, taking particular care to help educators acquiring the necessary competence on the subject.

To the best of our knowledge, no other paper has thus far analyzed the long-run macroeconomic effects of FL on economic growth thus we have tried to present our arguments in the simplest possible form. However, this has precluded us from analyzing some other relevant issues, such as the beneficial effects that FL may play in reducing financial return volatility and eventually income fluctuations. Moreover, as our results point to the size of the elasticity of the financial sector's efficiency with respect to FL as the main parameter to assess the desirability of FL policies, they also demand more FL data to empirically validate our conclusions. Extending our analysis along these directions is left for future research.

CRediT authorship contribution statement

Alberto Bucci: Writing – review & editing, Visualization, Validation, Supervision, Conceptualization. **Riccardo Calcagno:** Writing – review & editing, Writing – original draft, Visualization, Validation, Formal analysis. **Simone Marsiglio:** Writing – review & editing, Writing – original draft, Visualization, Validation, Formal analysis. **Tiago Neves Sequeira:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.najef.2025.102468.

Data availability

No data was used for the research described in the article.

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