# HUMAN AND CULTURAL CAPITAL COMPLEMENTARITIES AND EXTERNALITIES IN ECONOMIC GROWTH

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Working Paper n. 2009-05

FEBBRAIO 2009


***DIPARTIMENTO DI SCIENZE ECONOMICHE AZIENDALI E STATISTICHE***

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# Human and Cultural Capital Complementarities and Externalities in Economic Growth♦

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***Abstract***

*The aim of this paper is to investigate the role of culture, viewed according to Throsby's definition of cultural capital (that is, an asset of tangible and intangible cultural expressions), in fostering economic growth. Recent literature in the field of cultural economics highlights a possible inversion of the usual causality relation, and culture can be seen as one of the engine of economic wealth. In this article we analyze one possible channel through which it may occur: human capital investment. Using a two-sectors endogenous growth model, the relation between cultural and human capital is deeply investigated.*

***Key Words*:** Economic Growth; Culture; Human Capital; Complementarities; Externalities

***JEL Codes:*** O40; O41; Z10; J24

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♦ Paper presented at the conference *Arts, Culture and the Public Sphere*, Venice, 4 - 8 November 2008. We thank the participants for helpful comments.

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## 1. Introduction

Culture is often considered just the outcome of wealth and political power. However, recent development of the economic literature in the field of cultural economics highlights a possible inversion of the causality relation: culture is one of the engine of economic development. Cultural production generates, directly and indirectly, substantial economic effects. It has an important function of animation and enhancement of the quality of life, which is an increasingly important element of an area's competitiveness and attractiveness for tourist and residents, and it sustains labor market developments, since cultural industries are typically labor-intensive. It is also seen as a major source of capacity to innovate. A culture-rich environment can, then, make the city an ideal location for people and firms, and a preferred cultural destination for tourists. Furthermore, culture may contribute to a more balanced and sustainable economic development; it provides opportunities for personal development and social interaction among weaker groups, and gives to 'excluded' individuals a chance to start their own businesses or to catch up socially (Heilbrun, 1992; Peacock and Rizzo, 1994; Montgomery, 1995; Zukin, 1995; Castells, 1996; Landry, 2000; Scott, 2000; Dziembowska-Kowalska, 2000; Throsby, 2001; Frey, 2003; Santagata, 2006). Within this context, different programs of economic valorization have been added in the 1980s and 1990s to the traditional activities of preservation and conservation of historical and artistic heritage, in pursuit of positive repercussion on occupation, on tourist sector, on human capital growth and generally on everybody's welfare.

In order to clarify the different approaches followed by the cultural economic literature, Cunningham, Banks and Potts (2008) identify four models, based on the analysis of the dynamic relation between the cultural economy and the rest of the economy. The authors label them as follows: Welfare model (1), Competitive model (2), Growth model (3) and Innovation model (4). Traditionally the study of the cultural economy has been dominated by models 1 and 2. The cultural value produced by the cultural economy was commonly considered a merit good that requires public transfers, since it is in general impossible for the market to earn enough from it (Welfare model, based on a 'market failure' argument). Cultural industries characterized by large and industrial-scale production, frequently hold by multinational enterprises, are the only exceptions, where cultural value has a market and profit maximizing firms behave just like in other non cultural markets (Competitive model, typically for film, music and broadcasting sectors and some part of publishing and print). Models 3 and 4 introduce in the analysis the role of creative industries,[1] suggesting a positive relation between them and the economic system. In the

[1] The authors underline that the term 'creative industries' is introduced "not because cultural forms, such as the established arts and media, cannot be regarded as part of the creative industries – they can and are – but because the term creative industries is more an idea or proposition than a neutral descriptor of an industry sector. The creative industries are a dynamic force and not just another static sector." (Cunningham, Banks and Potts, 2008, p. 17).

Growth model, the growth of creative industries is considered an economic growth driver, because numerous spillovers originate from the creative sectors into other productive sectors, such as from games to simulation and virtual reality training in aerospace, from design to production. More generally, the Innovation model suggests that the economic value of the creative industries arises from their contribution to the production of new ideas or technologies, not because cultural industries really are a sector per se, but because they represent a system of cultural values stimulating innovation and technological progress.[2]

In the literature, however, all important factors are generally considered together, and the causal relationships between them is not deeply investigated, as highlighted by Sacco and Segre (2009). Following the authors' suggestions, we analyze one possible crucial channel through which culture may affect economic growth: human capital accumulation. The conceptual framework characterizing our paper can be identified in the intersection between the Growth model and the Innovation model, with two peculiar elements: we explicitly take into account the role of human capital for economic growth and we refer to cultural capital instead of cultural industries.

In particular, this paper investigates the role of culture, defined according to Throsby's (2001) definition of cultural capital, in fostering economic growth; an issue almost completely neglected by growth theory. Our claim is that the creative use of skills and knowledge, which are attained by means of education (in the classical human capital view), has an autonomous role, and cultural capital is the main source of creativity.

In paragraph 2, the conceptual framework linking economic growth to culture is further extended to the analysis of the role of creativity. Within this framework, we suggest that, in a complementarity relation with human capital, cultural capital may be a key element of economic growth. The results of a simple empirical exploration of the relation between wealth and some possible measures of cultural capital are presented in paragraph 3, as an introduction to the two-sector endogenous growth model described in paragraphs 4 and 5. Some conclusions are drown in paragraph 6.

## 2. Human capital, cultural capital and the role of creativity

When economists analyze economic growth, the accumulation of human capital is usually considered one of the main channel of the growth process. However, despite the strong theoretical support, empirical

[2] The increase in economic importance of the creative industries as a productive sector is, of course, also a direct source of overall economic growth.

evidence that increases in educational attainments matter for growth is unexpectedly not clear-cut.[3] There are many different attempts of explanation of this puzzle, mainly based on data or estimation techniques problems.[4]

Within this framework, we suggest that, in a complementarity relation with human capital, another variable may be of particular interest: cultural capital.

The definition of 'culture' given by Throsby (2001) introduces the concept of cultural capital, as the stock of tangible and intangible cultural expressions. The stock of tangible cultural capital assets exists in buildings, structures, sites and locations endowed with cultural significance (cultural heritage) and artworks and artefacts existing as private goods, such as paintings, sculptures, and other objects. Intangible cultural capital comprises the set of ideas, practices, beliefs, traditions and values which serve to identify and bind together a given group of people, however the group may be determined, together with the stock of artworks existing in the public domain as public goods, such as certain instances of literature and music.

Accordingly, Scott (2000) argues that the presence of skilled workers is not a sufficient condition to obtain efficacious patterns of productive employment. It is not only the usual concept of agglomerations of technologically dynamic firms that generate developments in a regional system, but also the existence of qualities such as cultural insight, imagination, and originality created from within the local system of production. Creative and innovative energies are endogenous properties of a production system. The production system and the geographic milieu are therefore just two faces of a single economic and cultural reality represented by dense agglomerated structures of employment and social life. In the same direction, Florida (2002, 2005) introduces a new theory of regional economic growth based on the creative class, that is composed of creative and innovative people and, as a result of this, remarkable for its high productivity. Therefore, economies whose populations show high levels of creativity grow faster. Creativity is now considered as a collective process that overcome the Romantic view of creative genius, once regarded as a gift from the gods and therefore extraneous to the determination of the surrounding social context.

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[3] Empirical results on this topic still remain largely controversial depending on: 1) the methodological approach being used, whether *cross-country growth accounting* (Benhabib and Spiegel, 1994; Krueger and Lindahl, 2001; Pritchett, 2001 and Caselli, 2005, among others) or *cross-country growth regressions* (Barro, 1999; Easterly and Levine, 1997; Islam, 1995); 2) the measure of human capital employed. Wößmann (2003) provides a detailed survey of all the main measures of human capital used to date by empirical studies on growth (in particular adult literacy rates, school enrollment ratios and average years of schooling of the working-age population), and analyzes the pros and cons of each of them; 3) the type of data utilized. Studies using cross-section data, unlike those based on panel data, generally find that human capital accumulation has a positive effect on the rate of growth of real per-capita income. Islam (1995) summarizes this finding by observing that: *"…whenever researchers have attempted to incorporate the temporal dimension of human capital variables into growth regressions, outcomes of either statistical insignificance or negative sign have surfaced"*. See also Topel (1999) and Mathur (1999) for reviews.

[4] See, among others, Temple (1999; 2001), Benhabib and Spiegel (2005), Bassanini and Scarpetta (2001).

In industrialized countries, an increasing number of goods and services incorporate an intangible added value deriving from design, aesthetics, and symbolic and identity values. When competition cannot take place through costs cutting, product innovation represents the distinctive successful factor, and a talented labor force, not the last expensive, is needed. In the past, firms generally selected locations for new factories or offices based on costs. Today, looking for the less costly workers is an obsolete strategy and the competition for people is the key element of global competition, but competition requires not only people with a high level of education but also creative people.

In their analysis of Florida's creative capital theory in comparison with human capital theory, Marlet and van Woerkens (2004) conclude that Florida's creative class is a better standard to measure human capital than education is, since "members of the creative class are essentially working, but not necessarily highly educated, while highly educated people are not necessarily doing any work at all" ( p. 19).

Human capital measured by the level of education is one key variable for economic growth, but this picture has to be completed: our claim is that economic growth depends not only on the level of education but also on creativity. Creative people react more promptly to change and adjust easily to new ideas and new technologies: creativity makes labor-force more productive both for modern and mature firms, as well as it stimulates Schumpeterian entrepreneurs in establishing new firms. Moreover, highly educated and creative people have higher incomes and participate more in all the activities offered to the community, revealing a higher marginal propensity to consume local services, thus sustaining more the local economy. A positive externality effect can also be envisaged since the use of human capital may be more productive where more creative people are working and living.

If the *creative use of* skills and knowledge, which are attained by means of education (in the classical human capital view), has an autonomous role, the focal point of the discussion should be: where does creativity (the creative use of human capital) come from?

Our answer is that cultural capital is the main source of creativity, essential for economic growth in a complementary relation with human capital.

As reported in Sacco and Segre (2009) there are examples that support the view that culture and human capital accumulation may be linked by a relation of complementarity. Throughout the history, science, math and technology have flourished only were and when all the arts have flourished. In the same direction, a study of 150 biographies of great inventors - from Pasteur to Einstein - demonstrates that nearly all of the eminent scientists were also musicians, artists, writers or poets. Several recent studies reveal that exposure to and participation in the arts strengthens children's educational performance. A nine-month study of three-year-old children demonstrated that early training in singing and playing musical instruments stimulates the brain in pre-school children and enhances learning. Moreover, college student test scores were higher when students listened to ten minutes of Mozart's piano music immediately prior to taking an IQ test. Similarly, UNESCO Universal Declaration on Cultural Diversity, states: "As source of exchange, innovation and creativity, cultural diversity is as necessary for humankind

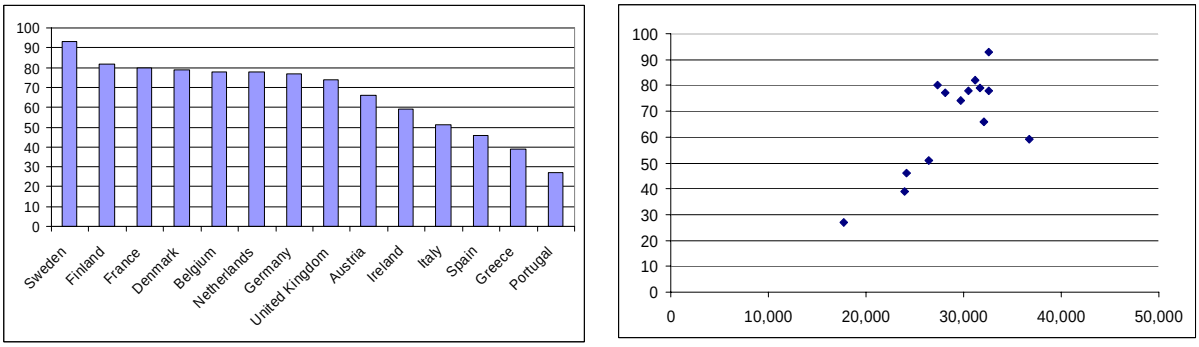
as biodiversity is for nature". The Lisbon objectives, adopted by the Lisbon European Council in 2000, that Europe should become the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion, dismiss however the role of cultural capital. The framework developed by the EU Education Council concentrate only on the idea that, in all the aspect of modern life, education should be involved. It lacks of any explicit discussion about the role of arts and creativity in this important and strategic process. Conversely, in what follows we empirically and theoretically discuss the importance of culture in fostering economic growth.

## 3. Stylized facts

If a role for cultural capital in the explanation of different economic growth rates exists, a crucial point is how to measure it. In the European Union cultural statistics are not yet available on a comparative base, even if there is an evident lack and an increasing demand on this kind of information. In response to this, in 1997 the "Leadership Group on Cultural Statistics" was set up, and in 2000 it was converted into a Eurostat Working Party with mandate to collect harmonized data on cultural employment, cultural expenditures and participation in cultural activities.

In 2007 a first edition of "Cultural Statistics in Europe" was released by Eurostat (2007), but without any attempt of delivering time series information. A significant set of indicators presented, is the proportions of people participating in some artistic activity. In the Eurobarometer survey on cultural values within Europe respondents were asked about their active involvement on an amateur basis in a range of artistic activities, whether on an individual basis, as part of a group, or in classes. Figure 1 presents the results in a decreasing order for the EU-15, excluding Luxembourg, of the percentage of people participating in some artistic activity (left-hand side of the figure).

**Figure 1. People participating in some artistic activity and the relation with GDP per capita**




Source: Eurostat (2007) and Oecd for GDP per capita.

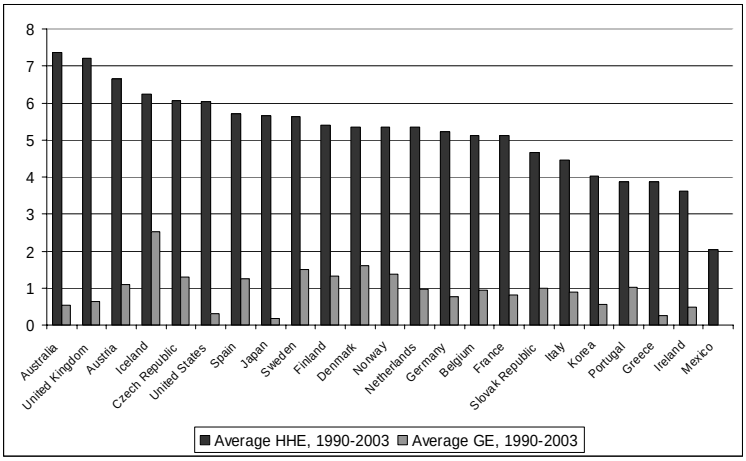
On average, the most popular activities of those presented to respondents is decorating, handicrafts or gardening, with this being selected by over a third (36%) of the full sample. Participation in artistic and creative activity is generally higher amongst the youngest age groups and those educated for longest. In general, the survey highlight also that the vast majority of Europeans see culture as playing an important role in their own lives. Over three-quarters say that culture is important to them personally, and the majority express that they are interested in arts and culture: 69% in their own country, 57% in other European countries, 56% in the rest of the world.

Figure 1 also presents a first attempt of empirically investigating the relation between cultural capital and economic development, plotting (on the right-hand side) the relation between the percentage of people participating in artistic activities and the level of GDP per capita in 2007. The figure shows a striking positive correlation: the richer the country, the higher the percentage of people involved in cultural and artistic activities. This result is usually interpreted as the effect of a supposed luxury good nature of culture, but we aim at underling that also a positive effect of culture on growth may exist, as discussed in paragraphs 1 and 2.

When a time series dimension is needed to further investigate this statement, the only available database on cultural activities is published by Oecd in the Factbook on Economic, Environmental and Social Statistics. In particular, two variables are available on expenditure on recreation and culture: Household expenditure (HHE) and Government expenditure (GE). Also the level of total expenditure on recreation and culture is published, as the sum of household and government expenditures. These three variables, however, group together several different expenditures,[5] unfortunately not all strictly related to Throsby's definition of cultural capital. The dataset, on the other hand, allows to extend the analysis to a wider set of countries and gives the possibility of time series investigations. Figure 2 shows the average level of private and public expenditure, between 1990 and 2003, as a GDP percentage for a sample of 23 Oecd countries. The figure displays the countries according to the level of private expenditure, in a decreasing order.

[5] Household expenditure on recreation and culture includes purchases of audio-visual, photographic and computer equipment; CDs and DVDs; musical instruments; camper vans; caravans; sports equipment; toys; domestic pets and related products; gardening tools and plants; newspapers; tickets to sporting matches, cinemas and theatres; and spending on gambling (including lottery tickets) less any winnings. It excludes expenditures on restaurants, hotels, and travel and holiday homes but includes package holidays. Government expenditures on recreation and culture include administration of sporting, recreational and cultural affairs as well as the maintenance of zoos, botanical gardens, public beaches and parks; support for broadcasting services and, where present, support for religious, fraternal, civic, youth and other social organizations (including the operation and repair of facilities and payment to clergy and other officers.) Also included are grants to artists and arts companies. Capital outlays such as the construction of sports stadiums, public swimming pools, national theatres, opera houses and museums are included.

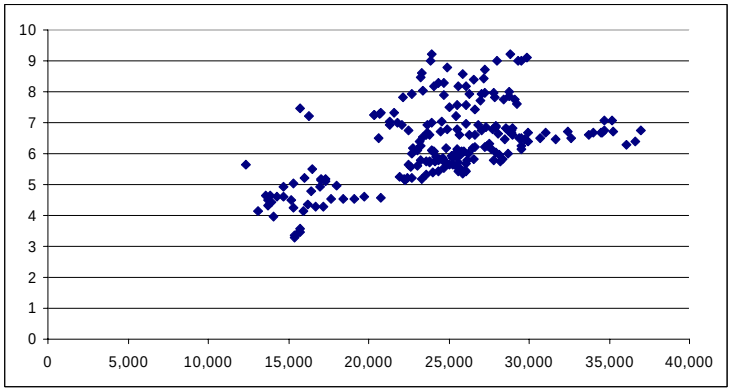
**Figure 2. Household and government expenditure on culture**




Note: GDP percentages. Average, period 1990-2003. HHE: Household expenditure.
GE: Government expenditure. For Mexico GE is not available.
Source: Oecd (2006)

Figure 3 confirms the positive relation between real per capita income and culture, when the latter is measured as the GDP percentage of the sum of household and government expenditure on recreation and culture.

**Figure 3. Total expenditure on culture and GDP per capita**




Note: 21 countries are plotted for the period 1990-2003.
Source: Own calculations on Oecd (2006) data.

The figure displays the results for the years 1990-2003, for 21 countries: Australia, Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Italy, Japan, Korea, Netherlands, Norway, Portugal, Slovak Republic, Spain, Sweden, United Kingdom, United States. Ireland is not considered in the sample because of its sharp decline in expenditure as a fraction of GDP, due to the intense increase in the GDP of the country in the 1990s. Note that this particular situation makes the country one outlier in figure 1, where a quite high GDP per capita (36,700 euro) is related to a relatively low participation rate (59%).

## 4. Human and cultural capital in economic growth: The basic model

Long-run economic growth is usually understood as the outcome of the accumulation of such factor-inputs, both tangible and intangible, as labor (either skilled or unskilled) and capital (mainly physical and technological capital). Until now, however, the possible role played by cultural capital has been almost completely neglected by growth theory, old and new. Our model aims at filling this gap in the literature. In this regard, in what follows we analyze the predictions of the simplest possible growth model in which cultural and human capital can interact with each other not only in goods production but also, and more importantly, in affecting agents' skill investment decisions.

### *4.1 THE PRODUCTION OF CONSUMPTION GOODS*

Consider a closed economy. Consumption goods (or final output, $Y$) are used as the numeraire good ($P_Y = 1$) and produced competitively (the sector is populated by a very large number of small, atomistic firms). In order to obtain its own output, the industry's representative firm combines human ($H_Y$) and cultural ($A$) capital:

$$Y_t = \beta A_t^{1-\alpha} H_{Yt}^{\alpha}, \qquad \beta > 0, \qquad \alpha \in (0;1), \qquad H_{Yt} \equiv u_t H_t. \quad (1)$$

In Eq. (1) $\beta$ represents the total factor productivity, $\alpha$ and $1-\alpha$ are, respectively, the human and cultural capital shares in aggregate GDP, and $u$ denotes the fraction of the total stock of human capital being employed at time *t* in goods production. The representative firm operating in the final output sector is so small that it takes total factor productivity as given.[6] Thus, $\beta$ represents the level of technology at the aggregate level, common to each firm producing goods. Variable $u$ is endogenous and, along the balanced growth path equilibrium (BGPE, henceforth), to be defined more formally in a moment, it will be also constant (that is $u_t = u$, $\forall\ t$).

For given $u$, the aggregate production function displays decreasing returns to scale to cultural ($A$) and human ($H$) capital, taken separately, and constant returns to scale to $A$ and $H$ together. Note that in eq. (1) we not only expressly omit disembodied technological progress from the analysis ($\beta$ is assumed to be a positive constant), but also neglect any other reproducible input, apart from cultural and human capital. This is done because our objective in this paper is twofold: using a setting where cultural and human capital are two complementary inputs in the process of human capital investment, we want to

[6] The representative firm is unable to affect the economy-wide disembodied technological progress. For this reason it takes $\beta$ as a given positive constant.

highlight the role of cultural capital in influencing the equilibrium growth rate of the economy and to analyze the effects of changes in the cultural capital share in total GDP ($1-\alpha$) on real per capita income.

Even though it is taken as a constant by each single representative firm producing consumption goods, we postulate that the common total factor productivity depends on some function of the *"relative intensity"* of cultural capital at the economy-wide level (the ratio of the aggregate cultural to human capital stock, $A_t / H_t$) and assume that the function linking $\beta$ and $A_t / H_t$ is non-linear, that is:

$$\beta \equiv \left( \frac{A_t}{H_t} \right)^{\phi}, \qquad \phi \neq \alpha, \qquad \phi \neq 0. \qquad (1')$$

$\frac{A_t}{H_t}$ is another relevant endogenous variable of this model and can also be interpreted as a measure of the economy's *average* cultural capital (cultural capital per unit of human capital). Along the BGPE this ratio will also be constant (and, clearly, positive). Notice that, in order to have the most general possible model, in Eq. (1') we do not impose any constraint on the parameter $\phi$, except that it should be different from $\alpha$.[7] The reason behind this assumption is that, as we shall show in a moment (see eq. 2 below), when $\phi < \alpha$ an increase in the stock of cultural capital ($A_t$) always reduces, *ceteris paribus*, the productivity of cultural capital in goods production (this can be seen as a negative *congestion externality*, due to the fact, for example, that cultural capital is already so abundant in the economy that a further increase of it reduces its own productivity in goods manufacturing). Instead, when $\phi > \alpha$ an increase in the aggregate stock of cultural capital in the economy ($A_t$) increases, *ceteris paribus*, the productivity of cultural capital in the sector producing consumption goods (unlike the previous case, this can be seen as a positive *capital-rationing externality*, due to the fact that now cultural capital could be so scarce in the economy that an increase of it causes its own productivity in manufacturing activity to rise). With $\phi \neq \alpha$ we are able to capture, within the same setting, these two different situations and the parameter $\phi$ measures the strength of the two distinct types of externalities we try to model in this paper.

By combining (1) and (1'), the aggregate technology for goods production reads as:

$$Y_t = \underbrace{\left( \frac{A_t}{H_t} \right)^{\phi}}_{\equiv \beta} A_t^{1-\alpha} H_{Yt}^{\alpha}, \qquad H_{Yt} \equiv u_t H_t, \qquad \alpha \in (0,1), \qquad \phi \neq \alpha, \qquad \phi \neq 0. \qquad (1')$$

When $\phi > 0$, since it is constant, in the aggregate production function the term $A_t / H_t$ suggests that goods production tends to become more and more *cultural capital intensive* through time as the total stock of human capital in the economy increases.

[7] If $\phi = 0$, $\beta$ would equal 1 for each positive $A_t$ and $H_t$. We neglect this over-simplified case, too.

As consumption goods are produced competitively, profit maximization implies:

$$r_t \equiv \frac{\partial Y_t}{\partial A_t} = \beta(1-\alpha)\left(\frac{H_{Yt}}{A_t}\right)^{\alpha} = (1-\alpha)u^{\alpha}\left(\frac{A_t}{H_t}\right)^{\phi-\alpha} \tag{2}$$

$$w_t \equiv \frac{\partial Y_t}{\partial H_{Yt}} = \beta\alpha\left(\frac{A_t}{H_{Yt}}\right)^{1-\alpha} = \frac{\alpha}{u^{1-\alpha}}\left(\frac{A_t}{H_t}\right)^{1+\phi-\alpha}, \tag{3}$$

where $r_t$ and $w_t$ denote, respectively, the marginal productivities of cultural and human capital in goods production (*i.e.*, the marginal contributions of one more unit of cultural/human capital to GDP formation). In this respect, while $w$ represents the wage rate per unit of human capital, $r$ can be taken as indicative of the *shadow price* of cultural capital in terms of goods. As already mentioned, under our restrictions on parameter values (see Eq. 1'), the effect of an increase in the stock of cultural capital ($A_t$) on its shadow price ($r_t$) is not monotonic, since it can be, for given $u$, $A_t$ and $H_t$, either positive or negative depending on whether $\phi$ is greater or lower than $\alpha$. Later on we shall see that the relative size of $\phi$ with respect to $\alpha$ also plays a major role in the analysis of the effects of changes of the cultural capital share in aggregate GDP on per-capita real income.

After describing the production side of the economy, we can now analyze the consumers behavior.

### *4.2 CONSUMERS BEHAVIOR*

Population is stationary and made of many structurally identical households. Hence, we can concentrate on the consumption behavior of a single dynastic family whose size (*L*) is constant and, for the sake of simplicity, normalized to one. We assume that the representative household uses the income it does not consume just for cultural capital investment purposes. Thus:

$$\dot{A}_t = Y_t - C_t - \delta_A A_t, \qquad \delta_A \geq 0, \qquad A_0 > 0,$$

where $\dot{A}_t$ represents net cultural capital investment, $C_t$ is consumption and $\delta_A$ is the constant instantaneous depreciation rate of cultural capital.[8] The above equation says that savings $(Y_t - C_t)$ are employed just to accumulate (gross) cultural capital, $\dot{A}_t + \delta_A A_t$. Using Eq. (2) and (3), the previous equation can also be written as:

[8] Indeed, it is well known that cultural heritage and artistic works might need continuous conservation and maintenance expenditures. These are caught by $\delta_A$.

$$\dot{A}_t = (r_t - \delta_A)A_t + w_t H_{Yt} - C_t, \qquad Y_t = r_t A_t + w_t \left( \underbrace{u_t H_t}_{\equiv H_{Yt}} \right). \tag{4}$$

In the model a fraction $u$ of the available stock of human capital is devoted to production of final goods ($H_{Yt}$) and the remaining fraction $(1-u)$ of it is, instead, used to create new human capital. The law of human capital accumulation at the aggregate level is postulated to be:

$$\dot{H}_t = \sigma(1-u_t)H_t + (\varphi\gamma_{At})H_t, \qquad H_0 > 0, \qquad \sigma > 0, \qquad \varphi \in (0;1) \tag{5}$$

In (5) $\sigma$ is the productivity of human capital in producing new human capital and $\varphi$ reflects the impact of the growth rate of $A$ ($\gamma_{A_t} \equiv \dot{A}_t / A_t$) on the accumulation of *H*. Since $\varphi \in (0;1)$, this parameter can be interpreted as a measure of the degree of *complementarity* between human and cultural capital in the production of new human capital. This describes the role of cultural capital as an input for a beneficial education. According to this view, for instance, in 2002 the Los Angeles County Board of Supervisors decided that sequential instruction in the multiple arts disciplines would be scheduled into each school day and accounted for in the budget of every county school district.

Simple inspection of equation (5) reveals that the main difference with Uzawa (1965) and Lucas (1988) consists in postulating a technology for human capital formation in which a faster growth of cultural capital (higher $\gamma_{A_t}$) accelerates, *ceteris paribus*, the rate at which human capital accumulates over time, $\gamma_{H_t} \equiv \dfrac{\dot{H}_t}{H_t}$. This equation formally describes also the empirical evidence quoted in paragraph 2, which shows that artistic consumption may result in stronger education attainments. In other words, we claim that human capital accumulation depends not only on the fraction of the total stock of this factor-input employed in the education system [$(1-u)H$], but also on cultural capital investment, our claim being that investing in cultural capital enables people to accumulate human capital faster.

For given $\sigma > 0$ and $u \in (0,1)$, the constraint $\varphi \in (0;1)$ prevents the growth rate of the model's variables from either exploding ($\varphi = 1$) or being negative ($\varphi > 1$) along a BGPE where $A_t / H_t$ remains time-invariant (*complementarity hypothesis*). If $\varphi = 0$ we end up with the same human capital accumulation technology of Uzawa (1965) and Lucas (1988). This possibility is ruled out in equation (5) by the fact that $\varphi$ is assumed to be strictly positive.

The novelty of our approach resides in the fact that growth of cultural capital acts in this framework as a mechanism of *endogenous* appreciation of human capital stock in the equation of skill-supply. In other words cultural and human capital can be seen as two *complementary* factor-inputs in the production

of new skills since in the long run an increase in $\gamma_A$, and thus in $A_t$, stimulates human capital investment ($\dot{H}_t$), its growth rate ($\gamma_H$), and eventually leads to a rise of $H_t$, as well.

Given $\dot{H}_t$, the problem of the representative household can be recast as:

$$\underset{\{C_t,u_t,A_t,H_t\}_{t=0}^{\infty}}{\text{Max}}\ \text{U} \equiv \int_0^{\infty}\left(\frac{C_t^{1-\theta}-1}{1-\theta}\right)e^{-\rho t}dt, \qquad \rho>0 \qquad \theta>1 \qquad \frac{\dot{L}_t}{L_t}\equiv n=0 \qquad L_0\equiv 1 \qquad (6)$$

$$\text{s.t.:} \qquad \dot{A}_t=\left(r_t-\delta_A\right)A_t+w_t\left(u_tH_t\right)-C_t, \qquad u_t\in[0;1] \qquad \forall t \qquad \delta_A\geq 0$$

$$\dot{H}_t=\sigma\left(1-u_t\right)H_t+\left(\varphi\gamma_{A_t}\right)H_t, \qquad \sigma>0 \qquad \varphi\in(0;1).$$

$$\lim_{t\to\infty}\lambda_{A_t}A_t=0, \qquad \lim_{t\to\infty}\lambda_{H_t}H_t=0 \qquad (7)$$

$$A_0,\ H_0>0.$$

We denoted by $\rho$ the pure rate of time preference of the representative agent, by $1/\theta$ the intertemporal elasticity of substitution in consumption and by $\lambda_{A_t}$ and $\lambda_{H_t}$ the co-state variables associated, respectively, to cultural and human capital. The hypothesis $\theta>1$ is dictated by available evidence (Growiec, 2006). Households are competitive in that, in solving for the optimal paths of $\{C_t,u_t,A_t,H_t\}_{t=0}^{\infty}$, each takes $r_t$, $w_t$ and the growth rate of aggregate cultural capital ($\gamma_{A_t}$) as given at each point in time.

## 5. The Balanced Growth Path Equilibrium

We focus on a balance growth path equilibrium where:

*(i)* The growth rate of all time-dependant variables is constant (and possibly positive);

*(ii)* The ratio $A_t / H_t$ remains invariant over time.

Equations (5), (2) and (3) suggest that *u*, *r* and *w* are constant along the BGPE.

***PROPOSITION 1*:** Characterization of the BGPE

Along the BGPE:

$$\gamma_C=\gamma_A=\gamma_H=\gamma_Y\equiv\gamma=\left(\frac{\sigma-\rho}{\theta-\varphi}\right) \qquad (8)$$

$$u = \frac{\sigma(\theta - 1) + \rho(1 - \varphi)}{\sigma(\theta - \varphi)} \tag{9}$$

$$r = \frac{\theta(\sigma + \delta_A) - \varphi(\rho + \delta_A)}{(\theta - \varphi)} \tag{10}$$

$$\left(\frac{A_t}{H_t}\right) = \left\{\left[\frac{\theta(\sigma + \delta_A) - \varphi(\rho + \delta_A)}{(1-\alpha)(\theta - \varphi)}\right]^{\frac{1}{\alpha}} \cdot \frac{\sigma(\theta - \varphi)}{\sigma(\theta - 1) + \rho(1 - \varphi)}\right\}^{\frac{\alpha}{\phi - \alpha}} \tag{11}$$

*Proof:* See Appendix A.

Equation (8) gives the common balanced growth rate of the main variables of the model. Equation (9) represents the share of human capital devoted in equilibrium to production activities and equations (10) and (11) provide, respectively, the shadow price of cultural capital and the equilibrium ratio of cultural to human capital.

With our parameter values, the condition $\sigma > \rho$ is sufficient to guarantee that the household's problem has an interior solution ($0 < u < 1$) and that the equilibrium values of the other relevant variables of the model are strictly positive. Therefore, in what follows we assume that, together with the other parameter values, the condition $\sigma > \rho$ is checked. With $\sigma > \rho$, since $\theta$ is greater than $\varphi$, it is immediate to conclude that $r$ (the shadow price of cultural capital) in terms of goods is larger than one.

As a final comment it is possible to observe that the parameter $\phi$ (a measure of the strength of externalities coming from the average cultural capital in the economy) affects solely the $A_t / H_t$ ratio along the BGPE and that $(1-\alpha)$ – *i.e.*, the share of cultural capital in total GDP – has only level effects, since it does not affect neither economic growth, nor the sectoral distribution of human capital, nor the shadow-price of cultural capital. We can now state the main results of the paper.

***PROPOSITION 2*:** The role of cultural and human capital complementarities in growth

*Along the BGPE, economic growth depends positively on the parameter measuring the degree of complementarity between cultural and human capital in the production of new human capital ($\varphi$).*

*Proof*: Immediate from Eq. (8).

In words, Proposition 2 says that in the long-run the more complementary for each other cultural and human capital are in the production of new human capital (the greater $\varphi$), and the higher the equilibrium growth rate $(\gamma)$.

***PROPOSITION 3*:** The role of cultural capital depreciation in growth

*Along the BGPE, economic growth is independent of the rate of cultural capital depreciation ($\delta_A$).*

*Proof*: Immediate from Eq. (8).

To see why economic growth is independent of cultural capital depreciation, notice that $\gamma$ can also be recast as:

$$\gamma = \left( \frac{\sigma - \rho}{\theta\sigma - \varphi\rho} \right)\left( r - \delta_A \right). \tag{12}$$

Accordingly, $\frac{\partial \gamma}{\partial \delta_A} = \left( \frac{\sigma - \rho}{\theta\sigma - \varphi\rho} \right)\left( \underbrace{\frac{\partial r}{\partial \delta_A}}_{=1} - 1 \right) = 0$. In sum, $\delta_A$ can affect economic growth both directly (through the term $-\delta_A$ in Eq. 12) and indirectly (through *r*). However, these two effects have opposing signs and the same magnitude and, therefore, exactly cancel out with each other. The conclusion is that in equilibrium changes in the depreciation rate of cultural capital will exert no impact on the growth rate of real per capita income.

***PROPOSITION 4*:** The effect of a change in the GDP share of cultural capital on the level of real per capita income.

*Along the BGPE, the effect of a change in the GDP share of cultural capital on the level of real per-capita income, i.e. the sign of* $\frac{\partial Y_t}{\partial(1-\alpha)}$, *is not monotonic and crucially depends on whether* $\phi$ *(the parameter measuring the strength of externalities from average cultural capital in the economy,* $A_t / H_t$*) is higher or lower than* $\alpha$*. In particular,*

- *When* $\phi > \alpha$*, then* $\frac{\partial Y_t}{\partial(1-\alpha)} < 0$*;*

- *When* $\frac{\eta-\sqrt{\eta^2+4\varepsilon}}{2}<\phi<\frac{\eta+\sqrt{\eta^2+4\varepsilon}}{2}<\alpha$, *with* $\eta\equiv(2\alpha-1)+(1-\alpha)\ln(u)$ *and* $\varepsilon\equiv\alpha(1-\alpha)$, *the condition:*

$$\ln\left(\frac{r}{1-\alpha}\right)<\frac{(1+\phi-\alpha)(\alpha-\phi)}{(1-\alpha)}+\phi\ln(u)$$

*ensures that* $\frac{\partial Y_t}{\partial(1-\alpha)}>0$.

*Proof:* See Appendix B.

In words, Proposition 4 says that over the very long run, if cultural capital produces *congestion externalities* ($\phi<\alpha$) – as said earlier this could occur, for instance, if $A$ is so plentiful in the economy that a further increase of it leads, *ceteris paribus*, to a reduction of its productivity in manufacturing activity – the effect of an increase of its share in total GDP on real per capita income can be positive provided that its shadow-price ($r$) is sufficiently low.

On the other hand, if cultural capital produces *capital-rationing externalities* ($\phi>\alpha$) – contrary to the previous situation this could happen, for example, whenever $A$ is so scant in the economy that an increase of it contributes, *ceteris paribus*, to a rise of its productivity in goods production – the effect of an increase of its share in total GDP on real per capita income is always negative. This can also be interpreted as the result of the 'addictive goods' nature of cultural goods and of their high costs of activations[9], which imply that a certain degree of cultural capital diffusion in needed in order to produce sizeable effects, in any field.

Thus, and as a whole, in order for an increase of the cultural capital share in total GDP to have a positive effect on real per capita income, the proposition above seems to suggests that, as a pre-condition, there should be *ceteris paribus* relative abundance of cultural capital at the economy-wide level ($\partial r_t/\partial A_t<0$ must be checked). Instead, in all those situations where cultural capital appears to be a factor-input relatively in short supply ($\partial r_t/\partial A_t>0$) it is more likely that an increase of its share in total GDP produces a reduction (instead of a rise) in real per capita income. We may conclude that, in order for an increase of the cultural capital share in GDP to produce beneficial effects on real per capital income,

[9] See Sacco and Segre (2009) for a more extensive discussion of this point.

the stock of cultural capital already existing at the economy-wide level should be higher than a threshold level (such that, first of all, the requirement $\partial r_t / \partial A_t < 0$ is always met).[10]

To convey the economic (and algebraic) intuition behind Proposition 4, we write $Y_t$ as (see Eq. 4):

$$Y_t = r_t A_t + w_t \left( uH_t \right).$$

Using Eqs. (2) and (3) it is possible to show that:

$$\frac{\partial r_t}{\partial A_t} = \left(1-\alpha\right) u^{\alpha} \left( \frac{A_t}{H_t} \right)^{\phi-\alpha} \frac{\left(\phi-\alpha\right)}{A_t}$$

$$\frac{\partial w_t}{\partial A_t} = \frac{\alpha}{u^{1-\alpha}} \left( \frac{A_t}{H_t} \right)^{1+\phi-\alpha} \frac{\left(1+\phi-\alpha\right)}{A_t}$$

For given $\alpha \in \left(0;1\right)$, $u \in \left(0;1\right)$, $A_t > 0$ and $H_t > 0$, when $\phi > \alpha$ (the *capital-rationing externalities* case) the two derivates written above are both positive. This means that, following an increase of $A_t$, $Y_t$ would certainly rise (in part because $A_t$ increases and in part because $r_t$ and $w_t$ also grow up). In turn, $r_t A_t$ can also be recast as:

$$r_t A_t = s Y_t,$$

where $s$ is the share of cultural capital in income $\left( s \equiv \frac{r_t A_t}{Y_t} = 1-\alpha \right)$. Plugging the last expression into the one for $Y_t$ leads to:

$$\left(1-s\right) Y_t = w_t \left( uH_t \right).$$

When $\phi > \alpha$, the RHS of the equation above increases when $A_t$ goes up. With $Y_t$ being also rising in $A_t$, the LHS would go up (without any ambiguity) if $s$ diminished. This is the negative relationship between $s$ and $Y_t$ we find whenever $\phi > \alpha$ applies.

Suppose, instead, that $\phi < \alpha$ (the *congestion externalities* case). We see that, for given $\alpha \in \left(0;1\right)$, $u \in \left(0;1\right)$, $A_t > 0$ and $H_t > 0$:

$$\frac{\partial r_t}{\partial A_t} = \left(1-\alpha\right) u^{\alpha} \left( \frac{A_t}{H_t} \right)^{\phi-\alpha} \frac{\left(\phi-\alpha\right)}{A_t} < 0$$

whereas the sign of $\frac{\partial w_t}{\partial A_t}$ is now ambiguous. Clearly, $Y_t$ can always be written either as:

[10] We can not determine analytically this threshold level of $A$. The reason is that, as it is well known, in models with two state variables (like ours) what can be found out in equilibrium is the value of the ratio of the two states, but not the value of each state in isolation.

$$Y_t = r_t A_t + w_t\left(uH_t\right).$$

or as:

$$\left(1-s\right)Y_t = w_t\left(uH_t\right).$$

From the first equality we see that, following an increase of $A_t$, the final effect on income ($Y_t$) is totally ambiguous. From the second condition, instead, we conclude that, following the same rise of $A_t$, $s$ could either augment or diminish for it to continue to be checked. In sum, the relation between $s$ and $Y_t$ is *a priori* completely ambiguous when $\phi < \alpha$. However, in this case Proposition 4 provides a formal condition for an increase of the cultural capital share in GDP to produce an unambiguously positive effect on real per capital income.

The empirical evidence presented in paragraph 3 indicates a overall positive relation between the measures of cultural capital considered and per capita GDP, both for EU-15 countries and for 21 Oecd countries. We find, therefore, a general positive relation between $\left(1-\alpha\right)$ and $Y_t$. In the light of the results obtained in the theoretical model, this should be interpreted as the indication that, for most of the countries in the sample, the following conditions are matched:

- $\dfrac{\eta-\sqrt{\eta^2+4\varepsilon}}{2} < \phi < \dfrac{\eta+\sqrt{\eta^2+4\varepsilon}}{2} < \alpha$, *with* $\eta \equiv \left(2\alpha-1\right)+\left(1-\alpha\right)\ln\left(u\right)$ *and* $\varepsilon \equiv \alpha\left(1-\alpha\right)$

*and*

- $\ln\left(\dfrac{r}{1-\alpha}\right) < \dfrac{\left(1+\phi-\alpha\right)\left(\alpha-\phi\right)}{\left(1-\alpha\right)} + \phi\ln\left(u\right)$

However, the simple representation of some stylized facts is not adequate to drive any conclusion on the causal relation and on the probability to actually meet the conditions identified. These concerns are certainly a strong driver for more research, mainly at the empirical level.

## 6. Concluding Remarks

In this paper we show that, in a complementarity relation with human capital, cultural capital may be a key element of economic growth. In industrialized countries competition cannot take place through costs cutting anymore; product innovation represents a distinctive successful factor and an increasing number of goods and services incorporate an intangible added value deriving from design, aesthetics, and symbolic values. Creativity, now considered as a collective process that overcome the Romantic view of creative

genius, and a talented labor force are essential for economic growth. Our claim is that the simple use of knowledge attained with education is not a sufficient condition to obtain efficacious patterns of productive employment, since cultural insight, imagination, and originality are essential, and the main source of it is cultural capital.

Long-run economic growth is usually considered the outcome of the accumulation of labor and capital, mainly physical and technological. The possible role played by cultural capital, almost completely neglected by this literature, is investigated in the paper through a simple growth model in which cultural and human capital can interact with each other.

Our main conclusion is that in order for an increase of the cultural capital share in total GDP to have a positive effect on real per capita income, there should be - ceteris paribus - relative abundance of cultural capital at the economy-wide level. Instead, in all those situations where cultural capital is scarce, it is more likely that an increase of its share in total GDP produces a reduction in real per capita income. Moreover, in the long-run the more complementary for each other cultural and human capital are in the production of new human capital, the higher is the equilibrium growth rate.

This results are obtained under some particular conditions, which should be empirically investigated in further research. A very promising field for further research will also be the development of a more sophisticated growth model, capable to describe the entire mechanics of strategic complementarity between access to culture and innovativeness in non-cultural sectors.

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## APPENDIX A

In this Appendix we prove the results stated in Eqs. (8)-(11) in the main text.

The Hamiltonian function ($J_t$) associated with the dynamic optimization problem of the representative household is:

$$J_t = \left( \frac{C_t^{1-\theta} - 1}{1-\theta} \right) e^{-\rho t} + \lambda_{A_t} \left[ \left( r_t - \delta_A \right) A_t + w_t \left( u_t H_t \right) - C_t \right] + \lambda_{H_t} \left[ \sigma \left( 1 - u_t \right) H_t + \left( \varphi \gamma_{A_t} \right) H_t \right]$$

The first order conditions (FOC) of this problem read as:

$$\frac{\partial J_t}{\partial C_t} = 0 \quad \Rightarrow \qquad \frac{e^{-\rho t}}{C_t^{\theta}} = \lambda_{A_t} \tag{A1}$$

$$\frac{\partial J_t}{\partial u_t} = 0 \quad \Rightarrow \qquad \lambda_{A_t} = \frac{\sigma}{w_t} \lambda_{H_t} \tag{A2}$$

$$\frac{\partial J_t}{\partial A_t} = -\dot{\lambda}_{A_t} \quad \Rightarrow \qquad \lambda_{A_t} \left( r_t - \delta_A \right) = -\dot{\lambda}_{A_t} \tag{A3}$$

$$\frac{\partial J_t}{\partial H_t} = -\dot{\lambda}_{H_t} \quad \Rightarrow \qquad \lambda_{A_t} u_t w_t + \lambda_{H_t} \left[ \sigma (1 - u_t) + \varphi \gamma_{A_t} \right] = -\dot{\lambda}_{H_t} \tag{A4}$$

Along the BGPE $u$ is constant and all time-dependant variables grow at a constant rate. Combining (A2) and (A4) and using (A3) yields, respectively

$$\frac{\dot{\lambda}_{H_t}}{\lambda_{H_t}} = -\left( \sigma + \varphi \gamma_A \right) \tag{A5}$$

$$\frac{\dot{\lambda}_{A_t}}{\lambda_{A_t}} = -\left( r_t - \delta_A \right) \tag{A3'}$$

Equation (A2) also implies

$$\frac{\dot{\lambda}_{A_t}}{\lambda_{A_t}} = \frac{\dot{\lambda}_{H_t}}{\lambda_{H_t}} - \gamma_w , \qquad \gamma_w \equiv \dot{w}_t / w_t . \tag{A2'}$$

Plugging (A3') and (A5) into (A2') gives:

$$r_t = \left( \sigma + \delta_A \right) + \varphi \gamma_A + \gamma_w . \tag{A6}$$

From (2) and (3) it follows that along the BGPE (where $A$ and $H$ grow at the same constant rate, $\gamma_A = \gamma_H \equiv \gamma$, and $u$ is constant) $r$ and $w$ are both constant. In particular, the constancy of $w$ (*i.e.*, $\gamma_w = 0$) implies:

$$r_t = \left( \sigma + \delta_A \right) + \varphi \gamma = r . \tag{A6'}$$

Equalization of (A6') and (2) in the main text leads to:

$$\left( \frac{u H_t}{A_t} \right) = \left[ \frac{\sigma + \delta_A + \varphi \gamma}{\beta \left( 1 - \alpha \right)} \right]^{1/\alpha} = \left[ \frac{r}{\beta \left( 1 - \alpha \right)} \right]^{1/\alpha} . \tag{A7}$$

Recall that the representative firm producing consumption goods takes $\beta$ as given and, in turn, the representative household takes $r$ as given, too. Using (A1), (A3') and (A6') yields:

$$\frac{\dot{C}_t}{C_t} \equiv \gamma_C = \frac{1}{\theta}\left[(\sigma - \rho) + \varphi\gamma\right]. \tag{A8}$$

From (A3') and (4) one obtains:

$$\frac{\dot{\lambda}_{A_t}}{\lambda_{A_t}} = -\gamma + wu\frac{H_t}{A_t} - \frac{C_t}{A_t}. \tag{A9}$$

Instead, by combining (5) and (A5), we get

$$\frac{\dot{\lambda}_{H_t}}{\lambda_{H_t}} = -\gamma - \sigma u. \tag{A10}$$

Since $\gamma_w = 0$, from (A2')

$$\frac{\dot{\lambda}_{At}}{\lambda_{At}} = \frac{\dot{\lambda}_{Ht}}{\lambda_{Ht}}, \tag{A2"}$$

and, then, by equating (A9) and (A10):

$$\frac{C_t}{A_t} = wu\frac{H_t}{A_t} + \sigma u. \tag{A11}$$

With *w*, *u* and $A_t / H_t$ constant along the BGPE, equation (A11) -together with (1) and (5)- implies:

$$\gamma_C = \gamma_A = \gamma_H = \gamma_Y \equiv \gamma = \sigma(1-u) + \varphi\gamma \quad \Rightarrow \qquad \gamma = \frac{\sigma(1-u)}{(1-\varphi)}. \tag{A12}$$

With $\gamma_C = \gamma_A \equiv \gamma$, from (A8) in the end it follows that:

$$\gamma = \frac{\sigma - \rho}{\theta - \varphi}. \tag{A13}$$

To find out $(1-u)$, we equate (A12) and (A13) and obtain:

$$(1-u) = \frac{(\sigma - \rho)(1-\varphi)}{\sigma(\theta - \varphi)}, \tag{A14}$$

or:

$$u = \frac{\sigma(\theta - 1) + \rho(1-\varphi)}{\sigma(\theta - \varphi)} \tag{A14'}$$

By combining (A6') and (A13) one gets:

$$r = (\sigma + \delta_A) + \varphi\gamma = \frac{\theta(\sigma + \delta_A) - \varphi(\rho + \delta_A)}{(\theta - \varphi)}. \tag{A15}$$

Given $r$ and $u$, from (A7) we finally obtain:

$$\frac{H_t}{A_t}=\left[\frac{r}{\beta(1-\alpha)}\right]^{1/\alpha}\left(\frac{1}{u}\right)=\left[\frac{r}{(1-\alpha)\left(\frac{A_t}{H_t}\right)^{\phi}}\right]^{1/\alpha}\left(\frac{1}{u}\right) \qquad \Rightarrow$$

$$\frac{A_t}{H_t}=\left[\left(\frac{r}{1-\alpha}\right)^{1/\alpha}\cdot\frac{1}{u}\right]^{\frac{\alpha}{\phi-\alpha}}=\left\{\left[\frac{\theta(\sigma+\delta_A)-\varphi(\rho+\delta_A)}{(1-\alpha)(\theta-\varphi)}\right]^{\frac{1}{\alpha}}\cdot\frac{\sigma(\theta-\varphi)}{\sigma(\theta-1)+\rho(1-\varphi)}\right\}^{\frac{\alpha}{\phi-\alpha}}.\blacksquare \qquad \text{(A7')}$$

## APPENDIX B

In this Appendix we prove the results stated in Proposition 4 in the main text.
Using Eqs. (9) and (10) into (11) gives:

$$A_t=\left(\frac{r}{1-\alpha}\right)^{\frac{1}{\phi-\alpha}}u^{-\frac{\alpha}{\phi-\alpha}}H_t \qquad \text{(B1)}$$

From Eq. (1'):

$$Y_t=\left(\frac{A_t}{H_t}\right)^{\phi}A_t^{1-\alpha}H_{Yt}^{\alpha}=u^{\alpha}A_t^{1+\phi-\alpha}H_t^{\alpha-\phi}, \qquad H_{Yt}\equiv u_tH_t, \qquad \alpha\in(0,1), \qquad \phi\neq\alpha, \qquad \phi\neq 0 \qquad \text{(B2)}$$

Recall that along the BGPE $u$ is constant (see Eq. 9). By plugging (B1) into (B2) one obtains:

$$Y_t=u^{-\frac{\alpha}{\phi-\alpha}}\left(\frac{r}{1-\alpha}\right)^{\frac{1+\phi-\alpha}{\phi-\alpha}}H_t. \qquad \text{(B3)}$$

Since we are interested in computing the effects of changes in the GDP share of cultural capital ($1-\alpha$) on real per-capita income ($Y$), we define $1-\alpha$ and $\alpha$ respectively as:

$$(1-\alpha)\equiv s\in(0;1) \qquad \text{(B4)}$$

$$\alpha\equiv 1-s. \qquad \text{(B5)}$$

Thus, (B3) can also be recast as:

$$Y_t=H_tu^{-\frac{1-s}{\phi-1+s}}\left(\frac{r}{s}\right)^{\frac{\phi+s}{\phi-1+s}}. \qquad \text{(B6)}$$

Note that $u$ and $r$ are both independent of $\alpha$ and, thus, of $s$. We are interested in evaluating: $\frac{\partial Y_t}{\partial s}$, for given $H_t > 0$.[11] After some algebra, in the end we obtain:

$$\frac{\partial Y_t}{\partial s} = H_t \left(\frac{r}{s}\right)^{\frac{\phi+s}{\phi-1+s}} \frac{u^{-\frac{1-s}{\phi-1+s}}}{(\phi-1+s)} \left[ -\frac{1}{(\phi-1+s)} \ln\left(\frac{r}{s}\right) - \left(\frac{\phi+s}{s}\right) + \frac{\phi \ln(u)}{(\phi-1+s)} \right]. \tag{B7}$$

Using the definition of $s$ (B4) into (B7), the latter equation can be re-written as:

$$\frac{\partial Y_t}{\partial(1-\alpha)} = H_t \left(\frac{r}{1-\alpha}\right)^{\frac{\phi+1-\alpha}{\phi-\alpha}} \frac{u^{-\frac{\alpha}{\phi-\alpha}}}{(\phi-\alpha)} \left[ -\frac{1}{(\phi-\alpha)} \ln\left(\frac{r}{1-\alpha}\right) - \left(\frac{\phi+1-\alpha}{1-\alpha}\right) + \frac{\phi \ln(u)}{(\phi-\alpha)} \right]. \tag{B8}$$

Clearly, the sign of $\frac{\partial Y_t}{\partial(1-\alpha)}$ crucially depends on whether $\phi$ is higher or lower than $\alpha$. Consider first the case $\phi > \alpha$.

**Case 1:** $\phi > \alpha$.

With our parameter values (in particular $r > 1$, $\alpha \in (0;1)$ and $u \in (0;1)$), $H_t > 0$ and $\phi > \alpha$, the term outside the square brackets in Eq. (B8) is unambiguously positive, whereas the term inside the square brackets is unambiguously negative. We conclude that in this case $\frac{\partial Y_t}{\partial(1-\alpha)}$ is always negative. Consider now the case $\phi < \alpha$.

**Case 2:** $\phi < \alpha$.

This restriction now implies that $\phi$ can be either positive or negative. The case $\phi = 0$ is ruled out by our analysis. When $\phi < \alpha$, the term outside the square brackets in Eq. (B8) becomes negative, whereas the term inside the square brackets has ambiguous sign. We conclude that in this case the sign of $\frac{\partial Y_t}{\partial(1-\alpha)}$ is also ambiguous. However, we can find a simple condition for $\frac{\partial Y_t}{\partial(1-\alpha)}$ to be positive. According to this condition what is contained into the square brackets should be definitely negative, implying:

$$\ln\left(\frac{r}{1-\alpha}\right) < \frac{(1+\phi-\alpha)(\alpha-\phi)}{(1-\alpha)} + \phi \ln(u). \tag{B9}$$

[11] Since $A$ and $H$ are both state variables in the model, what we can determine in equilibrium is the value of their ratio, but not the value of each stock in isolation.

Since the LHS of (B9) is strictly positive, for this condition to be meaningful we should impose that the RHS is positive, too:

$$\frac{(1+\phi-\alpha)(\alpha-\phi)}{(1-\alpha)}+\phi\ln(u)>0 \qquad \Rightarrow \qquad \frac{\eta-\sqrt{\eta^2+4\varepsilon}}{2}<\phi<\frac{\eta+\sqrt{\eta^2+4\varepsilon}}{2}<\alpha \qquad \text{(B10)}$$

where:

$\eta \equiv (2\alpha-1)+(1-\alpha)\ln(u)$

$\varepsilon \equiv \alpha(1-\alpha)$.

We conclude that, when $\frac{\eta-\sqrt{\eta^2+4\varepsilon}}{2}<\phi<\frac{\eta+\sqrt{\eta^2+4\varepsilon}}{2}$, the condition

$$\ln\left(\frac{r}{1-\alpha}\right)<\frac{(1+\phi-\alpha)(\alpha-\phi)}{(1-\alpha)}+\phi\ln(u)$$

is not only meaningful but also ensures that an increase in the share of cultural capital in GDP is always associated to an increase of real per-capita income, that is $\frac{\partial Y_t}{\partial(1-\alpha)}>0$. ■