Physical Capital Mobility, the Educational and Quality Aspects of Creative Capital, and Output Production[1]

by

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Abstract

We analyze two theoretical models of the connections between physical capital mobility, education in and the quality of creative capital, and the production of output in a region that is creative in the sense of Richard Florida. Our first model focuses on a *single* region which produces a knowledge good with perfectly mobile physical capital. We trace through the effect that *education* has in converting raw creative capital into acquired creative capital and then study how physical capital mobility affects the impact of the change in education on the output of the knowledge good. Our second model is similar to the first one but the focus now is on *two* creative regions and on the *quality* of creative capital. We show how to decompose the difference in the logarithm of the output of the knowledge good per raw creative capital unit between the two regions into the contributions of education and all other factors.

Keywords: Creative Capital, Creative Region, Education, Knowledge Good, Quality

JEL Codes: R11, I21, D20

1. Introduction

1.1. The two research questions

Researchers working in the fields of regional and urban economics now frequently come across the terms *creative class* and *creative capital*. These two terms are due to Richard Florida who first used and popularized them in his now well-known tome titled *The Rise of the Creative Class*. According to Florida (2002, p. 68), the creative class "consists of people who add economic value through their creativity." This class is made up of professionals such as medical doctors, lawyers, scientists, engineers, university professors, and, remarkably, bohemians such as artists, musicians, and sculptors. With regard to regional economic growth and development, the creative class is significant because its members possess creative capital which is the "intrinsically human ability to create new ideas, new technologies, new business models, new cultural forms, and whole new industries that really [matter]" (Florida, 2005, p. 32).

Florida has pointed out on numerous occasions that the creative class is important because this group routinely gives rise to ideas, information, and technology, outputs that are salient for the economic growth and development of cities and regions. Therefore, in this era of globalization, cities and regions that want to be successful need to do all they can to attract members of the creative class because this class is the principal driver of economic growth.

How is the concept of creative capital different from the more traditional notion of human capital? To answer this question, first note that in empirical work, the notion of human capital is generally measured with education or with education based indicators. Even so, Marlet and Van Woerkens (2007) have rightly pointed out that the accumulation of creative capital does not have to depend on the acquisition of a formal education. Put differently, while the creative capital

accumulated by some members of Florida's creative class (medical doctors, engineers, university professors) does depend on the completion of many years of formal education, the same is not necessarily true of other members of this creative class (artists, painters, poets). Individuals in this latter group may be innately creative and hence possess raw creative capital despite having very little or no formal education.

Given this state of affairs, we agree with Marlet and Van Woerkens (2007) that there is little or no difference between the notions of human and creative capital when the accumulation of this creative capital depends on the completion of many years of formal education. In the remainder of this paper, we call this kind of creative capital *acquired* creative capital. In contrast, there can be a lot of difference between the notions of human and creative capital when the accumulation of this creative capital does not have to depend on the completion of a formal education. In what follows, we refer to this second kind of creative capital as *raw* creative capital. Since creative capital is of two types (raw and acquired), it is a *more* general concept than the notion of human capital. Having said this, it is important to understand that the division of creative capital into a raw part and an acquired part is not hard and fast. Therefore, it is certainly possible---and this is a key point that we model and analyze at length in what follows---for a raw creative capital unit to turn into an acquired creative capital unit as the result of one or more years of schooling.

There now exists a sizeable literature on the creative class and creative capital but this literature is mainly empirical or based on case studies.[4] In particular, the theoretical study of creative capital and its accumulation is still very much in its infancy. Given this state of affairs, the general purpose of this paper is to shed *theoretical* light on two important questions about creative

[4] This literature is discussed briefly in section 1.2 below.

capital that have received *no* attention in the literature thus far.

To this end, we analyze two formal models of the connections between physical capital mobility, education in and the quality of creative capital, and the production of output in a region that is creative in the sense of Richard Florida. Our first model focuses on a *single* region which produces a knowledge good with perfectly mobile physical capital. We trace through the effect that education has in converting raw creative capital into acquired creative capital and then study how physical capital mobility influences the impact of the change in education on the output of the knowledge good. Our second model is similar to the first one but the focus now is on *two* creative regions and on the *quality* of creative capital. We show how to decompose the difference in the logarithm of the output of the knowledge good per raw creative capital unit between the two regions into the contributions of education and all other factors. Before proceeding to the analysis itself, we first briefly summarize the literature on the two questions that we have just discussed.

1.2. Review of the literature

We begin by considering the linkage between education and creative capital. Marlet and Van Woerkens (2007) studied employment growth in Dutch cities and towns. They showed that local education levels and the existence of a large creative class are joint predictors of the growth in employment. They also point out that relative to education levels, Richard Florida's idea of the creative class is a better predictor of human capital. Communian *et al.* (2010) focus on individuals with high levels of education in the creative disciplines. These researchers point out that the economic reward accruing to these "bohemian graduates" is low and hence these graduates cannot possibly be the agents of knowledge spillovers.

Marrocu and Paci (2012) ask whether education or creativity matters more for total factor

productivity in a variety of regions in Europe. They show that highly educated people working in creative occupations are the most important determinant of increases in total factor productivity. Allen and Hollingsworth (2013) study aspirations as a key target of education policy in England and show that there is a geographical dimension to young people's aspirations for careers in the creative industries. Subroto (2013) contends that college curricula ought to focus on entrepreneurship education because this kind of education helps in comprehending the creative economy which, in turn, is a key driver of economic growth.

Moving on to the nexus between quality and creative capital, Throsby (2006) studies the production of artistic output. Specifically, he shows that it is possible to model the relationship between the quantity and the quality of creative output on the one hand and labor, physical, and human capital on the other. Wojan and McGranahan (2007) point to the importance of quality of life factors in attracting creative workers to a particular location who are then involved in creative occupations. In addition, these researchers show that the local employment share in these creative occupations is a significant determinant of entrepreneurial manufacturing plants.

Liu *et al.* (2010) focus on post-Katrina New Orleans and argue that for economic redevelopment to enhance the quality of life of residents in this region, it will be necessary to promote the creative media cluster. Finally, in a recent paper, Batabyal and Beladi (2015) mention the importance of theoretically studying the quality of creative capital but they do *not* actually conduct such a modeling exercise themselves.[5]

The remainder of this paper is organized as follows. Section 2.1 delineates the theoretical framework that is used in our first model of a *single* creative region that produces a knowledge

[5] For more empirical and case study based analyses of the creative class and creative capital, see Nathan (2007), Florida *et al.* (2008), Andersen *et al.* (2010), Hatcher *et al.* (2011), Gabe *et al.* (2013), and Sands and Reese (2013).

good with perfectly mobile physical capital. Section 2.2 computes the marginal product of physical capital. Section 2.3 uses this computation to derive an analytic expression for the equilibrium level of physical capital. Section 2.4 derives an expression for the derivative of the logarithm of the output of the knowledge good with respect to a change in the level of *education* that is received by the raw creative capital units. Section 2.5 explains exactly how the assumed perfect mobility of creative capital influences the impact that the change in education has on the output of the knowledge good.

Section 3.1 describes the theoretical framework that is used in our second model of *two* creative regions in which the focus is on the *quality* of creative capital. This theoretical framework implicitly assumes that there is a one-to-one, strictly monotonic functional relationship between the quality of education received by a raw creative capital unit and the resulting quality of the creative capital that is acquired. Therefore, it does not really matter whether we talk about the quality of education or the quality of the creative capital since one notion connects to the other in a very clear manner. Section 3.2 discusses the properties of a measure that shows how one can decompose the difference in the logarithm of the output of the knowledge good per raw creative capital unit between the two regions into the contributions of education and all other factors. Section 3.3 shows how the measure of section 3.2 can be improved upon. Section 4 concludes and then discusses two ways in which the research described in this paper might be extended.

2. Education and Creative Capital

2.1. The theoretical framework

Consider a stylized regional economy that is creative in the sense of Richard Florida. Suppose that the output Q of a knowledge good such as a laptop computer or a smartphone is

produced in accordance with a production function that has the following Cobb-Douglas form[6]

$$Q = K^{\alpha}(e^{\phi E}R)^{1-\alpha}, \tag{1}$$

where K is physical capital, R is raw creative capital, E is the amount of education---or the years of schooling---the various raw creative capital units receive, α and ϕ are parameters with $\alpha \in (0,1)$ and $\phi > 0$. The price of this knowledge good is normalized to unity, i.e., it is set equal to one.[7]

We assume that the available physical capital in our creative region is perfectly mobile. This means that K always adjusts so that the marginal product of physical capital equals the external or "world" interest rate denoted by r^w. Our next task is to find an expression for the marginal product of physical capital in the creative region under study.

2.2. The marginal product of physical capital

We know that the production function is given by equation (1). Therefore, differentiating this equation with respect to physical capital K gives us the expression we seek. That expression is

$$\frac{\partial Q}{\partial K} = \alpha K^{\alpha-1}(e^{\phi E}R)^{1-\alpha}. \tag{2}$$

Let us now use equation (2) to derive a closed-form expression for the equilibrium level of physical capital as a function of the world rate of return r^w, education E, raw creative capital R, and the parameters of the production function α and ϕ.

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[6] Also see Griliches (1979).

[7] The reader should note that because we are interested in studying the working of a region that is creative in the sense of Richard Florida, the two factors of production we concentrate on in equation (1) are physical and creative capital and not labor *per se*. Instead, if we focused on labor as a primary input then we would *not* be modeling a key aspect of a creative region, namely, the possession of creative capital by members of the so called creative class in this region. Having said this, observe that creative capital can also be thought of as labor augmented with skills that an individual either possesses innately or through the acquisition of education.

2.3. The equilibrium level of physical capital

Because there is perfect mobility of physical capital in our creative region, it is clear that the marginal product of physical capital must equal the world or external rate of return. In symbols, we have $\partial Q/\partial K = r^w$. So, setting the right-hand-side (RHS) of equation (2) equal to r^w and then simplifying the resulting equation gives us the expression we seek. We get

$$K = \{\frac{r^w}{\alpha}\}^{1/(\alpha-1)} R e^{\phi E}. \quad (3)$$

Inspecting equation (3), we see that the equilibrium level of physical capital in our creative region is given essentially by the product of (i) the ratio of the world rate of return r^w to the scale parameter α, (ii) the raw creative capital input R, and (iii) the exponent of the amount of education E. Now, recall that a key objective of ours in this section is to study the effect that education has in converting raw creative capital into acquired creative capital. To this end, let us derive an expression for the derivative of the logarithm of the output of the knowledge good with respect to a change in the level of education received by the raw creative capital units.

2.4. The derivative

We want to find an expression $\partial lnQ/\partial E$, where ln denotes the natural logarithm. To this end, let us substitute the expression for K from equation (3) into the equation for the production function in equation (1), and then take the natural logarithm of both sides of the resulting expression. This gives us

$$lnQ = \frac{\alpha}{\alpha-1} \ln\left(\frac{r^w}{\alpha}\right) + lnR + \phi E. \quad (4)$$

Differentiating the RHS of equation (4) with respect to the amount of education E received by the various raw creative capital units, we get an expression for the derivative we seek. That expression is

$$\frac{\partial lnQ}{\partial E} = \phi > 0. \qquad (5)$$

Let us now comprehend the impact that perfect physical capital mobility has on the effect of the change in education on the output of the knowledge good.

2.5. The impact of education

Inspecting equation (5), we see that consistent with our intuition, an increase in the amount of education or, alternately, the number of years of schooling, has a positive impact on the logarithm of the output of the knowledge good in our creative region. However, the more important point to note is that perfect physical capital mobility *raises* the impact of the change in the amount of education on the output of the knowledge good.

We now explain why the claim in the last sentence of the previous paragraph is valid. In this regard, observe that with perfect physical capital mobility, more education raises the marginal product of physical capital as shown in equation (2). This tells us that for the marginal product of physical capital to remain equal to the world rate of return r^w, the physical capital stock in our creative region must rise. This last assertion follows because from equation (3) we know that K is an increasing function of E. The increase in the level of the physical capital stock causes the output of the knowledge good to rise *even more* than if there had been no increase.[8] In this regard, it is straightforward to confirm that without this response of the physical capital stock, we have

[8] The magnitude of this increase depends in part on α.

$\partial lnQ/\partial E = (1-\alpha)\phi$ which is clearly *less* than ϕ because $\alpha \in (0,1)$. This completes our discussion of the nexuses between education, creative capital, and the production of the knowledge good in our stylized regional economy.[9] We now proceed to the second and final research question of this paper. This involves theoretically analyzing the quality of creative capital in a model with two creative regions.

3. The Quality of Creative Capital

3.1. The theoretical framework

Consider an aggregate economy made up of two regions that are creative in the sense of Richard Florida. Suppose that the output Q_i of the knowledge good in creative region $i, i = 1,2,$ is given by the production function

$$Q_i = A_i U_i e^{\phi E_i} R_i, \tag{6}$$

where A_i is a shift variable, U_i is the *quality* of education, E_i is the amount of education or the number of years of schooling received by the raw creative capital units, R_i is raw creative capital, and $\phi > 0$ is a parameter. As in section 2, the price of the knowledge good is normalized to unity.[10]

We assume that higher output of the knowledge good per raw creative capital unit raises the quality of education. Mathematically, this means that

$$U_i = B_i (Q_i/R_i)^{\gamma}, \tag{7}$$

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[9] Note that the explanation given in this paragraph does not depend on equation (5) alone. Instead, this explanation utilizes equations (2), (3), and the related analysis.

[10] As noted in section 1, our primary objective in this section is to show how one might decompose the difference in the logarithm of the output of the knowledge good per raw creative capital unit between the two regions into the contributions of education and all other factors. In particular, our goal in this section is *not* to study how interactions between the two regions affect the logarithm of the output of the knowledge good per raw creative capital unit. This is why we do not account for interactions in our analysis. Having said this, the reader should note that recently, Batabyal and Nijkamp (2014a, 2014b) have analyzed trade interactions between regions. Therefore, if we want to analyze interactions between our two regions then the methodology utilized in these two papers can be used to analyze certain kinds of inter-regional interactions.

where the shifter B_i>0 and the parameter $\gamma \in (0,1)$. Our primary goal now is to show that it is possible to decompose the difference in the logarithm of the output of the knowledge good per raw creative capital unit between the two creative regions, 1 and 2, into the contributions of education and all other factors. To this end, we suppose that we have data on the variables Q, E, and R in the two regions and that we know the parameters γ and ϕ.

3.2. A measure of output decomposition

Suppose we assign the amount $\phi(E_2 - E_1)$ of $\ln(Q_2/R_2) - \ln(Q_1/R_1)$ to education and the remainder to all other factors associated with the production of output per raw creative capital unit in the two regions under study. The question before us now is the following. Does our proposed measure $\phi(E_2 - E_1)$ accurately reflect the contribution of education to the difference in log output per raw creative capital unit in the two regions or does it overstate or understate this contribution? Let us investigate.

The ith creative region's output of the knowledge good is given by equation (6) and the quality of the amount of education received by the individual raw creative capital units is given by equation (7). Let us solve for the output of the knowledge good per raw creative capital unit and then take the natural logarithm of the resulting expression. This gives us

$$\ln\left(\frac{Q_i}{R_i}\right) = lnA_i + lnB_i + \gamma \ln\left(\frac{Q_i}{R_i}\right) + \phi E. \qquad (8)$$

Given equation (8), we can compute the difference in the log output of the knowledge good per raw creative capital unit between the two creative regions or $\ln(Q_2/R_2) - \ln(Q_1/R_1)$. After a few steps of algebra, we get

$$\ln\left(\frac{Q_2}{R_2}\right) - \ln\left(\frac{Q_1}{R_1}\right) = lnA_2 - lnA_1 + lnB_2 - lnB_1 + \gamma\left\{\ln\left(\frac{Q_2}{R_2}\right) - \ln\left(\frac{Q_1}{R_1}\right)\right\} + \phi(E_2 - E_1). \quad (9)$$

Inspecting equation (9), we see that assigning the amount $\phi(E_2 - E_1)$ of the difference in the log output of the knowledge good per raw creative capital unit to education would capture *only* the direct effect of a higher level of education---additional years of schooling---on output per raw creative capital unit. The above measure would *omit* the fact that a higher level of education results in higher output per raw creative capital unit. This last effect results in a higher *quality* of education that, in turn, raises output of the knowledge good per raw creative capital unit even more. Put differently, the measure $\phi(E_2 - E_1)$ *underestimates* the contribution of education to the difference in the log output per raw creative capital unit in the two regions under study. Given this finding, we now discuss how the $\phi(E_2 - E_1)$ measure of this section can be improved upon.

3.3. An improved measure of output decomposition

We begin by solving equation (9) for the difference in the log output of the knowledge good per raw creative capital unit or $\ln(Q_2/R_2) - \ln(Q_1/R_1)$. This gives us

$$\ln\left(\frac{Q_2}{R_2}\right) - \ln\left(\frac{Q_1}{R_1}\right) = \frac{lnA_2 - lnA_1}{1-\gamma} + \frac{lnB_2 - lnB_1}{1-\gamma} + \frac{\phi(E_2 - E_1}{1-\gamma}. \quad (10)$$

Inspecting equation (10), we see that relative to the section 3.2 measure, a more accurate measure of the contribution of education to the difference in the log output of the knowledge good per raw creative capital unit is given by the last term on the RHS or by $\phi\,(E_2 - E_1)/(1-\gamma)$. In this regard, note that the parameter γ captures the impact of the output of the knowledge good per raw creative capital unit on the *quality* of education. Given this interpretation, the following point is

worth emphasizing. The larger is γ, the larger is the ratio $\phi/(1-\gamma)$ and hence the greater would be our underestimate of the true impact of education if we simply used the measure $\phi(E_2 - E_1)$ to denote the contribution of education to the difference in the log output of the knowledge good per raw creative capital unit in the two regions that we are studying.

We now briefly emphasize the three ways in which our analysis thus far in this section is significant for the future theoretical and empirical study of creative regions. First, we have provided what we believe is the *first* decomposition of the difference in the logarithm of the output of the knowledge good per raw creative capital unit between the two regions into the contributions of education and all other factors. Second, we have demonstrated the *two ways* in which education influences the output of the knowledge good per raw creative capital unit. Finally, we have provided explicit functional relationships---see equations (9) and (10)---that an empirically minded researcher might in principle want to *estimate*.[11] This completes our discussion of the two research questions of this paper.

4. Conclusions

In this paper, we analyzed two theoretical models of the nexuses between physical capital mobility, education in and the quality of creative capital, and the production of output in a region that was creative in the sense of Richard Florida. Our first model focused on a *single* region which produced a knowledge good with perfectly mobile physical capital. We traced through the effect that *education* had in converting raw creative capital into acquired creative capital and then we studied how physical capital mobility influenced the impact of the change in education on the output of the knowledge good. Our second model was similar to the first one but the focus was on *two* creative regions and on the *quality* of creative capital. We showed how to decompose the

[11] Also see the last sentence in the paragraph immediately before section 3.2.

difference in the logarithm of the output of the knowledge good per raw creative capital unit between the two regions into the contributions of education and all other factors.

The analysis in this paper can be extended in a number of different directions. In what follows, we suggest two possible extensions. First, it would be useful to study the impact that varying degrees of physical capital mobility has on the working of a creative economy in which a knowledge good is produced with physical capital, education independent raw creative capital and education dependent acquired creative capital. Second, it would also be instructive to explicitly introduce greater spatial variation and study a model with $n \in \mathbb{N}$ creative regions in which the quality of education stochastically and differentially affects the quality of the raw creative capital input in the n regions. Studies that analyze these aspects of the underlying problem will provide additional insights into the connections between the use of creative capital, the production of knowledge goods, and the functioning of creative regional economies.

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