Cultural Entropy, Innovation, and Growth

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Abstract
According to the Culture-Based-Development (CBD) paradigm, culture is the amalgam of attitudes how to value the world from which the order of preferences emerges. CBD handles the local cultural complexity by meaningfully reducing this complexity to two components— cultural heritage (CH) and living culture (LC). CH encompasses the attitudes valuing the 'I' local inherited identity, celebrating itself as an insider winner. LC encompasses the attitudes that celebrate the 'we' adaptive valuation of the newly co-created local identity where all present locally, not only the incumbents, participate in what is valued as art and beauty, and meaning. CBD defines Cultural Entropy as a Shannon Entropy index capturing the balance between LC and CH in a locality. In other words, Cultural Entropy is the measure of the ratio between the 'I' and 'we' component in local culture. The aim of the study is to establish whether localities with more even balance between CH and LC are more successful in innovation. Using two panel datasets for EU NUTS2 regions (2002–2017), I find that lower cultural entropy is associated with the local proto-institution culture establishing more extractive formal institutions (i.e., levying higher taxes) which stifle innovation and economic growth. Thus, cultural entropy is the tool to capture the cultural root of how social capital emerges in a way that can foster the flourishing or emergence of left behind places that lead to radical voting and socioeconomic demise.

Keywords: cultural entropy, extractive institutions, cultural capital, social capital, innovation

Entropía Cultural, Innovación y Crecimiento

Según el paradigma del Desarrollo Basado en la Cultura (DBC), la cultura es la amalgama de actitudes que valoran el mundo, de la cual emerge el orden de preferencias. El DBC gestiona

la complejidad cultural local reduciéndola significativamente a dos componentes: patrimonio cultural (PC) y cultura viva (CC). La CC abarca las actitudes que valoran la identidad local heredada del «yo», celebrándose como un ganador interno. La CC abarca las actitudes que celebran la valoración adaptativa del «nosotros» de la identidad local recién co-creada, donde todos los presentes localmente, no solo los residentes, participan en lo que se valora como arte, belleza y significado. El DBC define la Entropía Cultural como un índice de entropía de Shannon que captura el equilibrio entre la CC y la CC en una localidad. En otras palabras, la Entropía Cultural mide la relación entre los componentes «yo» y «nosotros» en la cultura local. El objetivo del artículo es determinar si las localidades con un equilibrio más equilibrado entre capital social y capital local tienen mayor éxito en la innovación. Utilizando dos conjuntos de datos de panel para regiones NUTS2 de la UE (2002-2017), observo que una menor entropía cultural se asocia con la cultura protoinstitucional local, que establece instituciones formales más extractivas (es decir, con impuestos más altos), lo cual frena la innovación y el crecimiento económico. Por lo tanto, la entropía cultural es la herramienta para captar la raíz cultural del surgimiento del capital social, de manera que pueda fomentar el florecimiento o la emergencia de lugares rezagados que conducen al voto radical y al declive socioeconómico.

Palabras clave: entropía cultural, instituciones extractivas, capital cultural, capital social, innovación

文化熵、创新与增长

根据基于文化的发展 (CBD) 范式，文化是各种态度的融合，这些态度决定了偏好的顺序，并由此产生。CBD 通过将地方文化的复杂性有效简化为两个组成部分——文化遗产 (CH) 和生活文化 (LC)。文化遗产包含重视 "我"——当地传承身份的态度，将自身视为内部赢家。生活文化包含推崇"我们"——适应性地评估新共同创造的地方身份的态度，在这种身份中，所有在当地生活的人，而不仅仅是在位者，都参与到被视为艺术、美和意义的活动中。CBD 将文化熵定义为香农熵指数，它捕捉了一个地方生活文化与文化之间的平衡。换句话说，文化熵衡量了地方文化中"我"和"我们"成分之间的比率。本文旨在确定文化遗产和生活文化之间更均衡的地区是否在创新方面更成功。运用欧盟NUTS2地区的两组面板数据集（2002-2017），我发现较低的文化熵与当地原制度文化建立更具榨取性的正式制度（例如征收更高的税收）相关，而这些制度会抑制创新和经济增长。因此，文化熵是捕捉社会资本如何以某种方式出现的文化根源的工具，这种方式既可以促进繁荣，也可以促进落后地区的崛起，最终导致激进投票和社会经济的衰落。

关键词：文化熵、榨取性制度、文化资本、社会资本、创新

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1. Introduction

In his most recent masterpiece, 'The Upswing' (2020), Robert Putnam—together with his co-author Shaylyn Romney Garrett—highlight the importance of culture for local socioeconomic and political development. The book is focused on the predictive power of the ratio between individualistic 'I' relational attitudes and pro-collective 'we' relational attitudes in local culture at a given time. The highest the 'we' share is in this ratio, the better off and more flourishing the United States seems to have been over the course of history. This ratio, as Putnam and Garrett (2020) show, predicts socioeconomic evolution, the emergence of left-behind people and places, as well as the radicalisation of voters in the United States over the course of history. But what drives the 'we' and 'I' ratio and its emergence is not clear in Putnam's book. This article aims to answer this question by introducing the Culture Based Development (CBD) notion of Cultural Entropy.

CBD is a cultural economics paradigm that exists and evolves for the last about 20 years (see literature overview in Tubadji 2023a, 2025). The main take of CBD is that local culture is a code of attitudes about what is valuable in the world which is used for the cultural filtering of the information from the world and transforms this information into an order of preferences about the things around us. This cultural code can be learned and observed either by self-reporting the attitudes or by observing what kind of culture people buy and participate in. If the attitudes or objects and experiences are related to the inherited past culture in the locality, CBD terms this cultural heritage (CH). CH captures part of the cultural code in the locality which values higher—and thus predicts ranking higher—in terms of preferences the local inherited identity. If the local people consume culture created today by anyone currently present in the locality, this CBD labels as living culture (LC). Depending on whether CH or LC consumption is higher in the locality, we can understand whether the people in the locality attribute higher valuation to their currently acquired identity, whether they considering all present locally as a 'we' or they stick more to their inherited identity 'I'. After being consumed, unlike normal goods, CH and LC can affect further the socioeconomic development. The power of the local CH and LC to affect the socioeconomic development is termed local cultural capital.

The first thing that the evaluative CH and LC attitudes affect is the creation of relation attitudes; i.e., cultural capital derives the social capital. Social capital is the way we build relations in the world. Social capital is derived from the 'I' and 'we' ratio in the book of Putnam too. It is also, of course, previously studied in his wealth of work under the framework of distinguishing between bonding social capital (valuing and relating with the closest circle of people) and bridging social capital (being able to value and relate with

wider range of people and members of various identities in the community). In other words, CBD explains why social capital is at a particular level as a function of the structure and composition of local cultural capital. Put differently, CBD explains the relational attitudes (termed social capital) as a function of the code of attitudes of valuation in a locality which has the power to influence socioeconomic choice by creating a cultural bias[1] in choice.

I use the CBD framework in this study to address the most crucial question in Putnam's new book—why the 'I' and 'we' ratio emerges in a particular level in a particular time and place and then what the consequences of its rebalancing are. I focus on the consequences for innovation which we know from endogenous growth theory to be most important for economic welfare. Innovation and growth can be trapped in unfavorable developmental trajectories by the local institutions if the latter are extractive (i.e., if they levy higher taxes; see Acemoglu and Robinson 2012; Akcigit et al. 2022; Diemer et al. 2022). What determines whether the local institutions will be extractive?

To sum up the above, this study suggests the hypothesis that local institutions are determined by the local proto-institution: culture that underpins local innovation and growth. In line with Hofstede and Hofstede (1991), CBD treats culture as the programming of the mind with a valuation code of attitudes. Building on this, in a given time and place, local culture can be thought of as a complex mix of the inherited and the contemporaneously 'programmed' cultural attitudes of the local population. To quantify and analyze accurately and precisely this mix, the notion of Cultural Entropy is proposed here.

Cultural Entropy is coined in this study to define the balance between local inherited attitudes (CH) and contemporaneously created ones (LC). Entropy is a measure for the variety of sub-classes of a complex entity.[2] The complexity of culture can clearly be thought of in many ways, but depending on how culture is proxied by variables, very divergent results can be obtained (Desmet et al. 2017). To justify the choice of reducing the complexity of local culture to living culture and cultural heritage, we employ the Culture Based Development (CBD) paradigm. It uses the temporal divide to delineate the CH and LC parts of local culture and it focuses on the balance between them because this balance

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[1] This cultural bias is called in Gary Becker (1957) 'taste for discrimination'.

[2] The notion of entropy has underpinned the related and un-related variety of industries stream of literature. This study can be seen as a study of the unrelated variety of the two main components of culture: cultural heritage and living culture. Thus, cultural unrelated variety is studied as a factor for local institutional quality (esp. the formation of the extractive institutional type) that impacts local innovation.

explains whether the local culture will be more or less prone to be adaptive in its choices to the current changing realities.

For over a decade now, CBD has accumulated a substantial body of empirical evidence.[3] CBD's key contribution is its methodological innovation to quantify culture as a complex form of local capital (called cultural capital). Namely, CBD exhaustively and precisely quantifies the entity local cultural capital through its special complexity reducing methodology and thus models and tests empirically economic choice in a manner that saves the economic model from under-specification due to incomplete measurement of culture as a component of choice (Tubadji 2014).

To overcome the measurement challenge, CBD has been employing various econometric techniques to quantify local cultural capital, such as: principal component factor analysis, partial least square path modeling (PLS-PM), and k-mean clustering (Tubadji and Pelzel 2015; Tubadji and Nijkamp 2015; Tubadji 2023a). The bottom line of all these techniques is that they employ a massive number of observations to reduce the complexity to fewer factors that can conservatively but statistically meaningfully and fully express the variation in culture. These empirical explorations have confirmed the presence of CH and LC as the two main components that always emerge in the data, across different time horizons and geographies. Importantly, these two components are well documented to have consistently opposite signs of impact on local innovation, growth, and inequality in space (Tubadji et al. 2022).

In a club theory sense, CH and LC represent two local clubs. The CH club celebrates the bonding social capital where only inherited identity is considered an insider. LC instead is a club with wider definitions of its identity, it accepts the acquired identity of anyone locally present as an insider in the local development. As we know from identity economics, whether one will be an insider and an outsider determines how they will interact locally with others, and this affects local productivity in every aspect (Akerlof and Kranton 2010). CBD claims that behind the social theory allocation of people into various general identities, there is the local division into CH and LC that creates a bias on how a person is valued in his/her various identities. A doctor may be a valued identity, but the CH club values a non-local doctor differently than a local doctor, while the LC club values foreign doctors higher. Thus, the balance between a CH and LC club locally will determine how

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[3] This CBD evidence is mainly about three things: (i) living culture is positively associated with local innovation and growth; (ii) cultural heritage is associated with more clubistic than open-minded cultural milieu, while the latter would be conducive for innovation; (iii) culture is a persistent but dynamic and nonlinearly developing entity (see Tubadji et al. 2022). These findings are in line with much of the modern empirical literature on culture and economics (see Rose 2018 for an excellent compact summary of this literature). See the book on CBD (Tubadji, 2025) for a structured comparative summary of the CBD and related economic literature and evidence.

many non-local doctors are likely to encounter taste for discrimination locally in Gary Becker's (1957) sense due to the balance between CH and LC. That is how CBD unpacks the why behind the emergence of taste for discrimination and the 'I' and 'we' ratio in a place. Put differently, CBD shows that social capital and local taste for discrimination emerge not exogenously but as a function of local cultural capital and the CH and LC composition of this complex entity.

Technically, since culture is exhaustively reduced to cultural heritage (CH) and living culture (LC), and these two components have opposite-in-direction effects, it is indeed of paramount importance to account for the balance between them from a statistical point of view. Theoretically, since cultural heritage is marked with the inherited identity and living culture is associated with the contemporaneously acquired identity, CBD has argued that consumption of CH more likely associates with conservative attitudes among the incumbent population and a mind-coding closed to change or novelty. Meanwhile consumption of LC is associated with openness to acquiring new identity, including openness to immigrants and to those locals who have new ideas and like new people of 'a different feather' (see Tubadji et al. 2022). Thus, two local clubs (the pro-CH one and the pro-LC one) emerge as always present in places. The cultural entropy measure can be thought of in this context as a measure of balance between the two clubs in the local collective programming of the mind, where both clubs of CH and LC could be equally represented locally and either could have the power to dominate over the other group and prevent its impact on innovation and growth.

CBD assumes here that each club achieves impact on innovation by creating local institutions that are either extractive (if the pro-CH club dominates) or super-open and inefficiently locally strategic (if the LC club dominates). By mathematical necessity, the entropy measure is highest (in an entity with two subcomponents) when the subcomponents are 50:50 represented in the entity. Hence, the CBD Cultural Entropy proposition here is the testable hypothesis that the highest 50:50 balance between the CH and LC locally creates the optimal conditions for innovation and growth, by ensuring equal likelihood for CH and LC to be culturally discriminated, i.e. ensures a random selection of ideas from any club in the locality. Put differently, CBD argues that the maximum cultural entropy allows the optimal wisdom of crowds (Page 2008) to be gained. In a nutshell, CBD suggests that maximum cultural entropy ensures being open to all innovative agents of any cultural type and ensures remaining strategically sufficiently locally focused on agglomerating around past knowledge and being innovative, agile and reinventing one's strategy. In line with Binmore's (1994) claim that game theory is an appropriate tool for

modelling ethical matters, a game theoretical sketch and an empirical exploration of the meaning of this balance are offered for the first time in this study.

The aim of this article is to measure the impact of Cultural Entropy between CH and LC on local innovation and growth across the EU NUTS2 regions. Namely, it explores how Cultural Entropy affects the "extractiveness" of local institutions and through this channel determines the local innovation and growth. Using a specially collected dataset for the EU NUTS2 regions for the period 2007-2017—including data from Eurostat, cultural indicators from the European Social Survey (ESS) and historical indicators about Franciscan and Cistercian monks in 1000-1600 Europe (obtained from Boranbay and Guerriero (2019))—the current study carries a series of regional economic explorations. Next, it triangulates these findings using the data from Muringani et al. (2021) for the period 2002–2016. The triangulated empirical results suggest that: (i) low Cultural Entropy does indeed associate with more extractive local institutions; (ii) higher Cultural Entropy is conducive to growth (through the channel of increasing local innovation); (iii) interestingly, the current centers of high Cultural Entropy are negatively associated with historical centers of prosperity. The latter[4] can be interpreted as evidence that the moving centers of economic gravity are associated with the dynamic changes in the local proto-institution culture which evolutionary self-corrects.

The rest of this study is structured as follows. Section 2 offers a brief overview of the literature on: (i) innovation, growth, and extractive institutions; (ii) culture as a proto institution and (iii) entropy as a measure in economic analysis. Section 3 presents: (i) the CBD game theoretical model of cooperation between the CH and LC clubs with implications for innovation, and (ii) translates the meaning of this game for local cultural dominance in terms of the notion Cultural Entropy. Section 4 describes the data and summarizes the estimation strategy employed for analyzing the data. Section 5 presents the results and discusses their implications. Section 6 concludes.

2. Literature review

2.1 Innovation, growth, and extractive institutions

In a massive recent data collection endeavor for the United States, Akcigit et al. (2022) find that taxation in USA harms innovation across time and space—in terms of quantity, quality, and location. The same authors have a series of papers that offer extensive literature reviews with modern findings that agree with their results. Levying taxes is arguably an

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[4] These findings are consistent with earlier CBD findings by Tubadji and Nijkamp (2018) for South-East Europe.

extractive behavior of the modern institutions. The current study cross-checks the validity of these findings for Europe. In addition, Acemoglu and Robinson (2012) are one of the cornerstones in the economic history stream who report consistently that extractive institutions in the past are associated with more inequality and flourishing in places today. Hence, extractive institutions in the past and today are associated with lower innovation and economic flourishing in the present with persistent consequences for the future as well. That is why, besides cross-checking the results for Europe, the current article asks the even more important question: What makes institutions extractive?

Extensive literature on clubs and rent seeking (that can be highly relevant for innovation) has argued that the parochialism of societies is associated with more extractiveness as a commitment proportional to the gain from membership (McChesney 1997; Birch 2020). This literature however asserts that the extractiveness of the clubs toward their members is associated with higher gains for the members. Geographical and social sciences, entrepreneurship, and network science have not been so deterministic in their views on the worthwhile effects from parochial social capital (see Rodriges-Pose and Storper 2006). Rather, numerous studies show that social capital (i.e., the club-power that a person begets the allowance to tap on once they become members of the club) can be used with both positive and negative aftermaths for local development (Pede 2011; Beugelsdijk et al. 2019). The negatives of social capital and bonding clubs' parochialism has been demonstrated as harmful for local development with the case of the mafia in southern Italy for example (Putnam 1993). Recent work about the regions of Europe extends Putnam's take and has confirmed that only bridging social capital is the one that is beneficial for local development and growth (Muringani et al. 2021). Thus, it seems that the extractiveness of the clubs (associated with the competitive game for power between the clubs) can spoil local flourishing in terms of innovation and growth. So, it is most relevant to ask: when is the strong club membership beneficial for the club and when does its parochialism become harmful for the club and its surrounding context? And finally, is not the choice whether to be extractive essentially a cultural choice by the policy makers behind the institutions?

2.2 Culture

Economics has attempted on numerous occasions to document and understand better the impact from culture on economic development more generally (Guiso et al. 2006; Ottaviano & Peri, 2006; Berliant and Fujita 2012; Alesina and Giuliani 2015) and specifically on

innovation (Benabou and Ticchi 2015; Nathan, 2015; Brunow and Nijkamp 2018). That 'culture matters' has been agreed in what is now known as the field of New Cultural Economics (NCE) (Hahn 2014). This field also tries to measure culture in innovative ways – such as genetic-distances (Spolaore and Wacziarg 2009; Galor 2011, 2022) or indices for cultural fractionalization (Alesina et al. 2003; Alesina and Ferrara 2005). Some NCE studies define culture as institutions (Alesina and Giuliani 2015), others define it as a common good related to cooperation (Rose 2018). This leads us to the global methodological concern, raised by Guiso, Sapienza and Zingales (2006) that accurately defining culture is needed in order to quantify culture correctly in its complex entirety. Culture has to be correctly defined and quantified in its entirety, because, as stated by Tubadji (2014), otherwise we run into an under-specification of the model by including only partial aspects of the important determinant culture. In line with this concern, Desmet et al. (2017) report that measuring cultural attitude and ethnic diversity leads to two very different maps of local culture. Yet, as we know, just amassing a large number of highly correlated cultural variables in a regression is not the answer as this can create various multicollinearity issues. Thus, the question what culture is and how to properly quantify it is most pivotal to capturing the cultural impact on innovation and growth. Many economists for decades have avoided this task, claiming that culture is an entity to be defined by other disciplines. Arguably, Cultural Theory is such a discipline.

Cultural Thery is best known in policy related literature through the work of anthropologist Mary Douglas (1966) and its extension in the work of Aaron Wildavsky and others (Wildavsky & Douglas 1983; Wildavsky 1988). This stream of literature importantly studies the here relevant link between culture and risk in group decision making. However, its typical grid-ground theorization of culture by type is deterministic in its explanations rather than looking in the dynamic transition between types. Instead of this, Cultural Theory is also a field heavily informed by the work of Pierre Bourdieu, Jacques Derrida, and

Thorstein Veblen, who all approach culture as dynamically changing attitudes expressed through behavior (see Edgar and Sedgwick 2002).

Inspired by the latter key contributions from the Cultural Theory field, the Culture Based Development (CBD) paradigm tailors its local cultural capital definition in specific based on Bourdieu's notion of cultural capital. This definition reduces the complex entity culture into living culture (contemporaneous attitudes) and cultural heritage (inherited attitudes).[5] CBD also clarifies why the bulk of the relational cultural attitudes (social capital) has to be isolated and extracted from the measure of local cultural capital, for statistical reasons. Namely, social capital is a part of cultural attitudes that are derived on the basis of the pure core of the rest evaluative attitudes (see Tubadji and Huang, 2023). Also, social capital can have an impact different in direction than the rest of the cultural attitudes (see Tubadji et al. 2022).

Furthermore, the philosophical constructionist view echoed in Cultural Theory[6] has proposed that what is good and bad (to be trusted or not) is only culturally defined and then the institutions guard for the cultural definition to be applied by the agents in society.[7] Therefore, CBD clarifies the link between culture and institutions as follows. Culture is a proto institution that gives rise to all other institutions in a hierarchical manner (Tubadji et al. 2016). Next, this proto institution is relatively persistent and is able to change only ever so slowly because culture is an important psychological shield from uncertainty (North 1991; Tubadji and Pattitoni 2022; Alesina et al. 2013; Guiso et al. 2016). Risk avoidance (the fear of uncertainty) is exclusively important psychologically for people (double in importance than gain, as reported by Prospect Theory (Kahneman and Tversky 1992). Thus, bounded rationality with affinity to risk avoidance explains the persistence of the proto-institution culture and its norms as derived institutions and laws reduce the uncertainty in the operation of society. Generally, people would prefer that their guardian from uncertainty is not destabilized. Uncertainty is a main component in the decisions on investment in innovative ideas (Shackle 1949; Bloom et al. 2007; Tubadji and Nijkamp 2016). That's why culture affects innovation. But culture does not fix innovation locally forever at a certain level. Because local culture itself can also change under the influence of

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[5] In Tubadji (2023b), CBD, in the spirit of the constructionist and deconstructionist schools of thought in philosophy, suggests that there are no intrinsic meanings or values in the world. Meaning is based on values which are randomly culturally defined and redefined across space depending on the free-will of people and their critical masses driving the marginal value change over time. Thus, all our attitudes boil down to the attitudes we inherited and how we and our contemporary agents manage to modify this inherited identity of how we think through some new acquired identity which is obtained through living culture.

[6] This part is mostly based on Wittgenstein and Derrida as representatives of the Cultural Theory school.

[7] This is also in line with Douglas North (1991) and the distinction between informal and formal institutions.

modern agency. Culture is a time and place varying man-made categorization of the world, serving as a fundament for the meaning making process - as constructionism asserts (Derrida 1967; Akerlof and Rayo 2020). Culture drives economic development only because it evolves slower than economic development.

It is also important that while identifying individualism as a type of culture coincides with Putnam's 'I' dimension, the 'we' dimension in Putnam's work is not the same as with the Douglas-Wildavsky stream of literature. While the latter emphasize institutional hierarchies as opposed to individualism, for Putnam 'we' has a much more community related emotive aspect of relation and social capital.

Meanwhile, again in Cultural Theory, and especially Veblen and Bourdieu, has provided a wealth of conceptualization about the link between cultural capital and how it affects the social capital (see Bourdieu 1986). Veblen asserts that consumption behavior (conspicuous consumption) can be used as a means to access an aspired membership into a club. Bourdieu explains how cultural capital (as the cultural consumption per se of parents and the individual herself) is the driver for socioeconomic mobility across social clubs (see Trigg 2001 for a comparison between Veblen and Bourdieu). The membership in a club is essentially a guarantee for the acceptance in the club and by extension the acceptance of one's proposals for innovation (Durlauf 2000).

Thus, Cultural Theory in its Bourdieu-Veblen-Derrida stream can teach us that cultural capital is what dynamically changes and affects institutions, the social capital, and the movement between clubs with different innovation potentials. So, we need to approach accurately and precisely this complex entity cultural capital if we are to understand correctly its influence on social capital and innovation. Complexity theory has long used the classical measure of entropy to quantify a complex entity.

2.3 Entropy

The notion of entropy originated in the 1970es in the realms of statistics and physics, being used to describe the degree of disorder in a diverse system. Whether used in physics, information theory, or economics, entropy can be measured as the probability of an equilibrium in a system composed of i-number of various stochastic in state sub-components. This measure is known as Shannon Entropy. Static and dynamic versions of the notion were studied theoretically, in both physics and economics ever since (Webber 1976; Nijkamp and Reggiani 1988; Richmond, Mimke, Hutzler 2013; Juhasz, Broekel and Boschma 2021).

In economics, the notion of entropy entered almost immediately, thanks to the groundbreaking contributions of Nicholas Georgescu-Roegen, a Romanian mathematician, statistician, and economist, who was first to use entropy as an econ-o-physics notion applied for the study of the exploitation of ecological and natural resources in economic production, thus pioneering the field of ecological economics. His magnus opus, *The Entropy Law and the Economic Process* (Georgescu-Roegen 1986), was interpreted to essentially suggest that resources are scarce and over time entropy can capture how they will be exhausted and demolished through economic exploitation and the waste in production. The widely celebrated pioneership by Nicholas Georgescu-Roegen was however seriously theoretically criticized (Khalil 2004). The essence of the criticism is that the analogy suggested by Georgescu-Roegen between the process of entropy and the economic production process was too imprecise. Namely, Khalil (2004) points out that the entropy process requires that the second level entities in the process are able to assume stochastically different states. Georgescu-Roegen was applying the Second Law of Thermodynamics on the economic process, by assuming the second level is stochastic, yet this entity is not always a subject of stochastic states.

To salvage the Georgescu-Roegen argument, Khalil (2004) proposes to apply the statistical notion of entropy in a conceptually different manner by exploring the ideas of microscopic fluctuations and macroscopic states through the lens of the economics of resources. The economics of resources (Dewey and Bentley 1973) suggests that the use of resources depends on the institutions and the context. Thus, Khalil's take on entropy is an entropy dependent on the institutional use of resources and not solely on the availability of these resources.

Regional economics seems to have partially surmounted the objection of Khalil (2004) in terms of its approach to entropy. Regional economics treats localities as different components of the economic system that can be thought as entities with dynamic internal stochastically changing composition of resources or industries inside them. Nijkamp (1994) initially distinguished between macro entropy and micro entropy in a sense of mechanistic entropy of the system versus a political economy take of entropy which can be viewed as an optimization problem by a decision maker on policy level employing a discrete choice model and linear programming. In the latter context, optimization of entropy in linear programming was argued to be similar to a general state of optimization of any function in linear programming. This general equilibrium application of entropy for the entire economic output has been extensively used in the regional literature (see for example Czyz and Hauke 2015).

Meanwhile, evolutionary economic geography has pioneered two concepts—related and unrelated variety—which are derivatives of the notion of entropy (see Frenke et al. 2007; Boschma and Frenke 2011). Related variety concerns the diversity of a system, while unrelated variety measures the diversity of each component of the diverse system. Two competing schools of thought exist on what would be the mechanisms that can explain the role of related and unrelated variety for the evolution of the economic system. The Marshall-Arrow-Rome (MAR) argument is based on the idea of specialization and localization economies. The Jacobean argument is based on variety of industries and inter-industrial knowledge spillovers (see Glaeser et al. 1992). Most notably, and closest to Khalil (2004) concerns, the work on the role of the endogenous R&D investment has been studied through the notion of entropy to explain local research and development (R&D) (see Broekel and Brachert 2015; Mewes and Broekel 2020; Juhasz, Broekel and Boschma 2021). Yet, the endogeneity of R&D is expressed as dependence of R&D on technology and location. Thus, the question remains unclear how one can use the entropy notion to articulate correctly the endogeneity of the R&D process and its dependence on the culturally shaped political institutions.

Consumer theory and lately NCE and some game theoretical approaches have engaged with entropy in a slightly different manner. Namely, Paul Samuelson, who himself argued that Georgescu-Roegen had to be recognized for his contributions to economics, suggests that the low system entropy can be thought of as a source of reduction of uncertainty in the system, enabling price stabilization that benefits the consumer (see Samuelson 1972). This idea has been lately evolved in game theoretical studies of reduced uncertainty that enables faster decision making (Koszegi and Matejka 2020; Ravid 2020) and in relation to investment decisions (Cabrales, Gossner and Serrano 2013). Meanwhile, Beaudreau (2006) has analyzed culture and entropy from political economy point of view as part of the question of consumer behavior with regard to identity.[8] Similarly, numerous political economy contributions have studied the effect of racial diversity and share of public investment in a locality (Echonique and Freyer 2007; Trounstine 2013; 2016). The current study aims to incorporate this latter take on entropy as a determinant for the uncertainty of the local context for decision making from political and institutional milieu. Thus, instead of the predominant applications of entropy for modelling the structure of the economy, this study applies alternatively the physics notion of entropy in order to model

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[8] Within the cultural field, Alexander (1996) has used entropy to measure the diversity within the popular music recording industry.

the internal dynamics of local culture[9]. Then on, the dynamics of local culture is hypothesized to affect the economy. Therefore, CBD coins and introduces the novel notion of local Cultural Entropy.

3. Cultural Entropy
3.1 Definition

CBD reduces the complex entity culture to living culture (LC) and cultural heritage (CH) components. Thus, CBD proposes here the following definition of local Cultural Entropy (CE):

Cultural Entropy (CE) is the measure of the balance in the variety between living culture and cultural heritage within the local cultural capital.

The CBD formula for calculating the CE is therefore the following interpretation of the Shannon Entropy formula (Shannon 1948):

$$CE = H(p_i) = -\sum p_i \, log(p_i) \tag{1}$$

where the elements of the Shannon Entropy are reinterpreted according to the CBD definition of cultural capital as follows:

i – identifies with a number of the class among the classes within the complex entity; in our case, there are two classes: living culture (LC) and cultural heritage (CH), which are assumed to be independent from each other, for simplicity[10];

p_i – stands for the probability of a cultural activity in the locality to belong to a given class, in our case—the probability of the activity to be classifiable as living culture or cultural heritage;

H – Shannon Entropy, which here measures the variability of the elements within cultural capital; i.e., how differently represented the two elements living culture (LC) and cultural heritage (CH) are within the entity local cultural capital;

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[9] Local culture is here defined in CBD terms as the amalgam of all local attitudes, giving the code of the local order of preferences (see Tubadji 2025).
[10] In more detailed handling, clearly culture has a memory, or path dependence, and what is currently LC in the next historical periods (if it survives existing in the locality) it will be CH for the same place. These detailed handling is available to read about in the CBD main reference book Tubadji (2025).

Shannon Entropy usually varies between 0 and infinity, depending on the number of classes and their distribution. Since in our case we have only two classes, it can be easily shown that the CE will vary between 0 and 1, where 1 is the maximum CE. This means that when CE is 1, the uncertainty whether the locality will engage (i.e., value and consume) with an activity of living culture (LC) or cultural heritage (CH) is the highest because the probability of each event is 50%. When the CE is 0, it is either LC or CH that dominates the cultural milieu of the locality. If any of the types: CH or LC is predominant in the local cultural milieu, CE will be between 0 and 1.

Translated in Putnam and Garrett's (2020) terms, when the CBD CE is closer to 1 the ratio of 'I' and 'we' is at its peak. When CE is dominated by CH, the 'I'/'we' ratio is growing in its 'I' component and when CE is dominated by LC, the 'we' component dominates the 'I' and 'we' ratio. The 'I' and 'we' ratio can be max 1 in value. In all disbalanced proportions of 'I' or 'we' dominating the other club there is always a suboptimal number representing the balance between 'I' and 'we.' The economic meaning of this statistical and mathematical fact is that whenever there is a discriminated club – be it the CH or the LC club—there always will be a taste for discrimination toward a club in the locality, which has been shown by Gary Becker to lead to inefficiencies for the market. Only when both CH and LC clubs are equally respected, the local taste for discrimination will be held best at bay (equal to 0) and so too the cultural bias and its distortion of the efficiency of local cooperation and productivity will be eliminated.

Thus, CE can serve as a measure to detect when the local cultural milieu will be strongly driven by only one dominant component (and discriminating the other component) in the local cultural capital, and this can serve as an alert for timely policy interventions. Yet, that highest cultural entropy, the most efficient equilibrium for the system, is here only statistically defined[11]. The reasoning why this highest Cultural Entropy (allowing for

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[11] Shannon (1948) demonstrates statistically and mathematically the Source Coding Theorem that suggests that maximum entropy represents an absolute mathematical limit on the success of decoding data from the source without noise and loss of information due to compression in the transmission process. Put differently, a message can be safely correctly and fastest transmitted when entropy is at its maximum level. So, when the innovative idea can come with either CH or LC type of signal because talent is distributed equally among incumbent (CH type) and newcomers (LC type), the innovative ideas will percolate fastest, if entropy between LC and CH types is highest (i.e., equal to 1 which is statistically possible only when LC and CH are 50:50 distributed in the system). If the society is biased toward either CH or LC in its attitude where it expects the innovation signal to be worthwhile, and has a taste for discrimination for CH or LC and avoids the other type of signal, the speed with which the innovative ideas will be decoded successfully will be lower, as the decoder will wrongly allocate lower expected probability to the less preferred type than the probability with which it actually occurs. This can be thought of as a different version of Shacklean unknown-unknowns truncation, where uncertainty in knowledge is modelled as the love of artificially creating certainty through biased choice toward some of the innovative ideas

highest cultural uncertainty which of the two classes (CH or LC) will dominate in the local milieu) leads to the most efficient outcome in economic sense needs to be further theoretically formalized and clarified. The following game theoretical sketch serves this purpose.

3.2 A CBD cooperation game for local cultural dominance in innovation

The CBD cooperation game for local cultural dominance explains how Cultural Entropy serves as a filter for the redistribution of economic growth by modifying the uncertainty about which innovative ideas will be invested in. The cultural gravity setup of this game is presented formally in Appendix 1 and can be reinterpreted here from the point of view of Cultural Entropy as follows. Player 1 is the decision maker with money to invest (can be thought of as the incumbent on the market), Player 2 is the investor with an idea (the new entry). Player 1 can be one of two types according to their cultural taste for discrimination of investors—they can either have a parochial clubistic mindset (i.e., prone/committed to accept only ideas from their own club) or they are likely to have an open mindset to ideas from both their own club and outside of it (i.e., to acquis to investment also in foreigners'/strangers' to their club good ideas).[12] CBD assumes here that people with more clubistic parochial mindset are incumbent investors who prefer their own identity as a club and hence are proud of their cultural heritage. That is why they can be labelled the CH type. The other type has a love for diversity and other identities, prone to accept the change in one's own identity through the interaction with other identities manifested in the local living culture. Hence, this type is labelled LC. When Player 1 is culturally biased type (i.e., is culturally programmed by a local cultural capital dominated by CH), he is likely to invest in Player 2 only if Player 2 is also of local identity type CH. If Player 1 is CE = 1 type (i.e., culturally unbiased), then he will invest in any Player 2 of any identity (local CH or newcomer LC).

As apparent from Appendix 1, using backward induction, depending on whether Player 1 is culturally biased or unbiased type, given that innovative talent is 50:50 distributed in both the incumbent population and among newcomers, assume the populations are equal in size, it is easily seen that when the game is culturally biased it will end in cooperation only with inventors from the same local identity as the investor and this

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based on a cultural marker (such as their LC or CH identity) which truncates away (into non-realization) part of the innovative ideas (see Tubadji and Nijkamp 2016; Tubadji et al. 2017, 2021).

[12] I assume that the CH type of Player 1 is a cultural taste for discrimination and is correlated with the general cultural taste of Player 1 to consume art products and services related to their own CH. Thus, the 50% percentage of consumption of CH in a locality corresponds to the 50% decision makers of CH type.

will be twice lower as amount of investment in innovative ideas in comparison to when the investment process is unbiased and both incumbents and locals are equally likely to be invested in.[13]

The higher the consumption of CH locally is, the higher the share of people mentally coded as CH type investors. The higher the concentration of CH investors in a locality, the lower will be the overall sum of investments in innovative ideas in the locality. Similarly, when LC is the predominant investor's type, the loss for innovation will be driven by the discrimination of the CH type who when unsuccessful but have a feeling of entitlement as incumbents to be successful locally will gradually accumulate a growing mass of dissatisfied and jealous local population who will feel overpowered. This dissatisfied group will grow into social unrest which will destabilize the local developmental trajectory and will create indirect barriers for the innovators from non-local identity to enter the market. Also, while the propensity to invest will be higher when the LC type dominates the local cultural milieu, the supply of innovative ideas will be lower in the locality (due to its hostile incumbent climate which will be less attractive for creative people with non-local identity to concentrate in this locality; see also the cultural gravity mechanism in Tubadji and Nijkamp 2015). Put differently, the interest to invest will be higher, but indirectly the number of outsiders' ideas will be lower due to endogenously triggered self-selection toward system with CE closer to 1.

Player 1 can be thought of either as a private investor or as a local policy maker. In both cases the effect for innovation will be the same since the decision made by the investor will decide whether and how innovations of foreign type will be harvested locally. If Player 1 is an individual, he will affect a smaller pool of innovative ideas which are directly dependent on his investment decision. If Player 1 is a policy maker, his culturally biased type can lead to the creation of general rules that will benefit only the incumbent inventors. Player 1 as a policy maker is also likely to be less trusting to the diverse taxpayers and hence more punitive and extractive institutions will be established locally. This is in line with the results of Becker (1957) on the consistency of the result that taste for discrimination leads to inefficiency of the system, no matter if discrimination is exercised on the demand or the supply side.

4. Operationalization
4.1 Data

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[13] Formally, this can also be shown through a Bayesian extension of the proof in Appendix 1.

This study uses two datasets. The first is amassed by the author and is referred to as the "own dataset". The second dataset is obtained from Muringani et al. (2021) as it contains very similar measures to the ones in the "own dataset," which were previously used to estimate the relationship between productivity and socio-cultural factors in the EU. The two datasets are used to triangulate the findings.

The "own dataset" is a unique panel compilation of indicators for the EU NUTS2 regions, containing 3005 observations for the period 2007–2017. The panel is not balanced but it contains a host of previously unavailable or rarely used variables. The sources of the dataset are: Eurostat (for the growth and innovation variables and most of the economic control variables), European Social Survey (for the social capital approximation), and Boranbay and Guerriero (2019) for the historical variables approximating the non-extractive types of institutions in 1000–1600 across Europe.

Innovation and growth are the main outcome variables in the study. An OECD data collection effort[14] has obtained from Eurostat the number of granted patents (economic innovation) and community designs (local social innovations). Local economic growth is approximated with gross value added in million euros.

Eurostat tax data is available as a percentage of income both with and without social contributions. It is assumed here that the higher the local tax, the more extractive the modern institution that levies it is.

Cultural Entropy is the main explanatory variable. It is also measured using proxies from the same OECD data collection based on Eurostat. The sum of local monuments and local businesses in the cultural and creative industries (CCIs) is considered as a proxy for local cultural capital. A proxy for CH is the percentage of monuments in the sum of total cultural capital. A proxy for LC is the percentage of CCIs in the total sum of local cultural capital. This information serves to calculate the Unrelated Variety Index (based on Shannon Entropy) that quantifies Cultural Entropy, as defined in the previous section.[15]

Social capital is in this study the mediator of the cultural impact on local development. Put differently, cultural capital shapes the local social capital by programming the preferences according to which people in a locality shape their choice to cooperate. Following Muringani et al. (2021), I select a group of variables approximating social capital (such as attitudes to cooperation, trust in various institutions and the

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[14] Related to the OECD Report on Culture and Creative Sectors for Regional Growth and Well-Being.

[15] Please note that using a proxy for CH and a proxy for LC satisfies what CBD called the First and Second CBD Laws for Quantification of Culture to the effect of having the model just-culturally identified. Put differently, this fulfils the minimum conditions postulated by CBD as sufficient to avoid cultural under-specification of the model (see Tubadji 2025 for all the relevant details).

characteristic for Muringani et al. (2021) approach—membership in political party). In total 14 variables are used for conducting a factor analysis with the data from ESS. Four factors were identified: trust, bonding social capital, bridging social capital type (1) (based on expressive behavior and need for acclaim from the wider audience), and bridging social capital type (2) (associated with membership in a political party). The original Muringani et al. (2021) dataset was also obtained and the measures for social capital from this second dataset are used as an alternative quantification of social capital to the factor variables described above. (See Appendix 2 and Muringani et al. 2021 for all details on this second dataset).

Cultural persistence is captured quantitatively in our dataset by three historical variables. These are firstly the provided by Boranbay and Guerriero (2019) geographical concentrations of Cistercian and Franciscan monks[16] in the period 1000–1600 across Europe. Both types of monastic orders were associated with flourishing and less extractive institutions. Second, Boranbay and Guerriero (2019) also provide an index of democratic propensity of the locality.

As further controls, the study derives from the Eurostat data the location quotients as proxies for the local specialization of the economy (in line with the MAR hypothesis) and a Shannon index of the unrelated variety of the 10 industries tracked by Eurostat for each locality (as a proxy for the Jacobean spill-overs approach to innovation). The standard determinants of GVA are also sourced from Eurostat. These are namely: share of tertiary educated people (human capital HC), total employment as a measure for labor (L), and physical capital formation (K). Muringani et al. (2021) has a similar set of controls which were also tried across the different specifications. For a list of all variables see Appendix 2, for the derivation of social capital see Appendix 3, and for the derivation of Cultural Entropy – Appendix 4.

4.2 Estimation Strategy

The estimation strategy of this study entails four steps. These are: (i) descriptive exploration of the data; (ii) empirical test for the impact of Cultural Entropy (CE) on innovation; (iii) empirical test to verify the full CBD mechanism implying that the impact of CE on innovation passes through the channel of social capital; (iv) empirical test for the impact of CE on regional growth.

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[16] We present the results with Cistercian monks the results with Franciscan monks are similar.

First, the dependencies between CH, LC, Cultural Entropy, and the outcomes of interest: innovation and economic growth are descriptively mapped out as direction of impact and trends over time. Both statistical and geographical impressions of the relationships are visualized and considered here.

Second, a pooled OLS estimator is employed to regress local innovation on Cultural Entropy in a horse race with the MAR within-industry specialization and Jacobean between-industry spill-over theories. Controls for the impact from the determinants of endogenous growth are also used. Two specifications are estimated using alternatively the two available proxies for the outcome of interest: innovation in terms of local patents or innovation in terms of community designs (i.e., local social innovations).

Third, a three stage least square (3SLS) method estimates a hierarchical model representing a recursive system of equations expressing the full CBD mechanism. Namely, the first equation expresses Cultural Entropy as an amalgam of the relationship between current social capital (captured through our factor variables obtained from the ESS data or through their Murangani et al. (2021) alternatives) and cultural persistence (captured through our historical variables). This clearly assumes that social capital is only a moderating factor, but the historical component overrides the causality effect of what determines culture. The second equation explains the contemporaneous extractiveness of the local institutions (in terms of the taxes that they levy) as a function of Cultural Entropy and controlling for the local endowment of the economy with physical capital. The third equation in the system explains local innovation as a function of the type of local institutions and the economic growth determinants (which approximate the financial capacity of investment in innovation). The latter is used as the most parsimonious specification in order to preserve degrees of freedom. Two specifications are again estimated – alternatively measuring innovation as: patents or community designs.

Fourth, again using OLS, local productivity is explained as a function of the main determinants of the endogenous growth model (L, K and HC). Three alternative specifications cross-check the impact from (i) Cultural Entropy (the CBD specification); (ii) extractiveness of the local institutions (Acemoglu-Akcigit specification), and (iii) the impact of local cooperation (the Muringani et al. specification). These three specifications allow us to compare the effect from Cultural Entropy, applying the chain rule, with what we already know from the literature about the effect from taxation on innovation and about the impact of social capital on economic growth across the EU regions.

Both datasets are rich but there are missing values in some variables. Therefore, we use the pooled cross section employing region and year fixed effects across all the above empirical tests.

5. Results

5.1 Descriptive Statistics

The first step of the empirical strategy entails the statistical and geographical characterization of the main dependent and independent variables of this study. This descriptive analysis covers: (i) the geography of culture and innovation, (ii) the correlation between cultural and innovation, (iii) the correlation between Cultural Entropy and innovation, and (iv) the relationship between cultural capital and social capital.

Figure 1 shows the geography of culture (CH, LC and Cultural Entropy) and the geography of innovation (patents and community designs, separately). The patents and community designs are presented as a count.
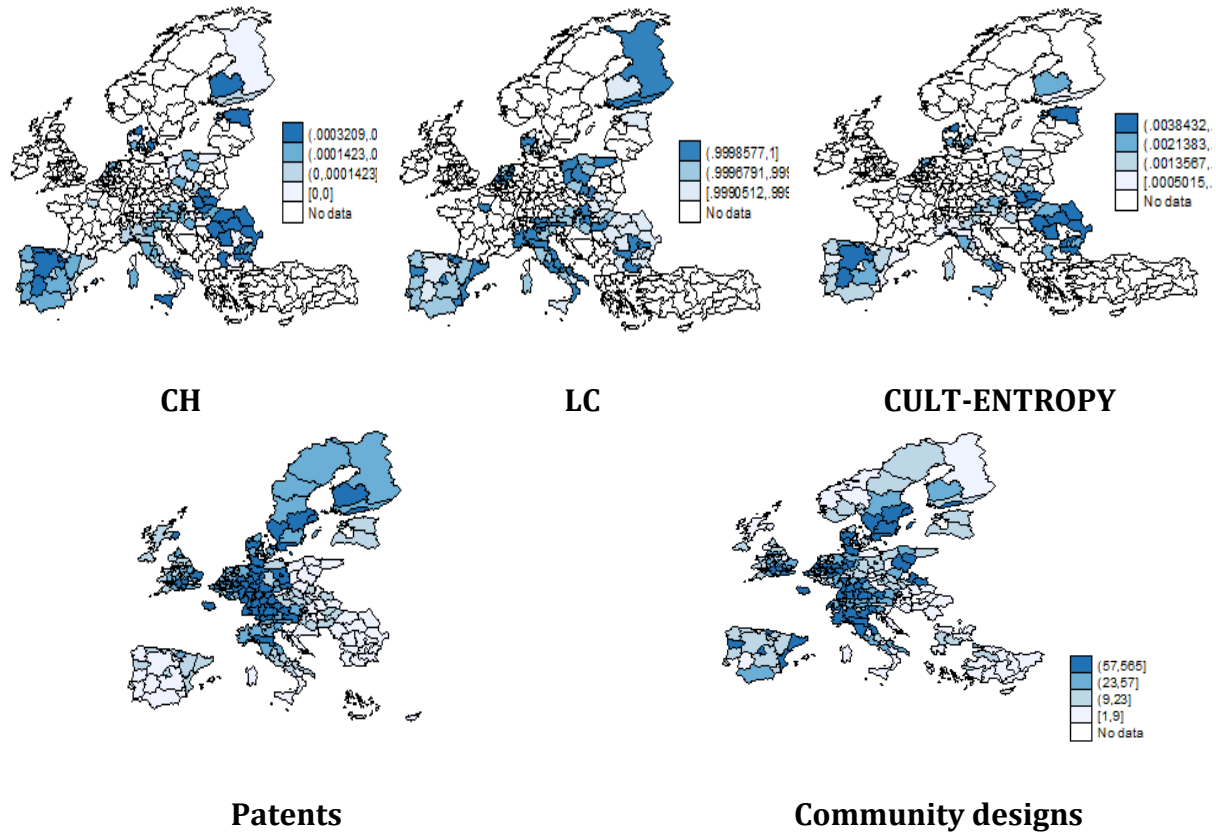

CH   **LC**   **CULT-ENTROPY**

Patents   **Community designs**

Figure 1: Geographical distribution of cultural entropy, its components and innovation
Note: CH and LC are represented as count of respectively monuments and businesses in the cultural and creative industries. Patents are a proxy for economic innovation; community designs - for social innovation.

Two main spatial dependencies are clearly visible from the maps in Figure 1. Firstly, the geography of CH, LC, and Cultural Entropy are different. Thus, clearly, Cultural Entropy measures an entity importantly driven by the balance between the CH and LC and is not overlapping with either of these two subcomponents of culture as local endowments.

Secondly, innovation (in terms of patents) and LC are positively associated, as previously reported and expected by CBD. CH has a negative relationship with innovation in space. The relationship between innovation and cultural entropy is less immediately obvious with patents, yet cultural entropy is clearly related to community designs.

To deepen this descriptive analysis, one can explore the association of CH and LC with the balanced presence of both types of innovation—economic and social (patents and community designs). For this, it is calculated here what is the unrelated variety between these two types of innovation. Figure 2 offers insights into the correlation of CH and LC with the unrelated variety of innovation in a region.
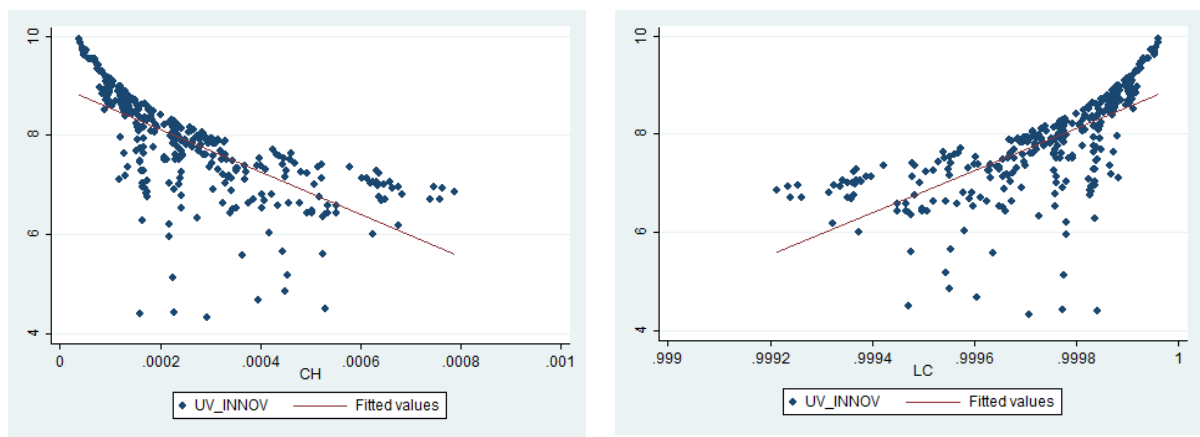

Figure 2: Relationship between Diversity of innovation, Cultural Heritage (CH) and Living Culture (LC)
Note: Diversity of innovation is measured as the unrelated variety between percentage of patents and community designs in total count and is labeled as UV_INNOV. CH and LC are in counts.

Figure 2 shows that regions with higher LC have a more balanced mix of economic and social innovation. The reverse is also strongly valid as a relationship with regard to CH.

A further detailed descriptive analysis can be carried out with regard to the main anthropocentric channel through which the cultural impact is inflicted—the concentration of highly skilled workers. Figure 3 offers this as a basic analysis and delves into its meaning for the developmental trajectories of regions.
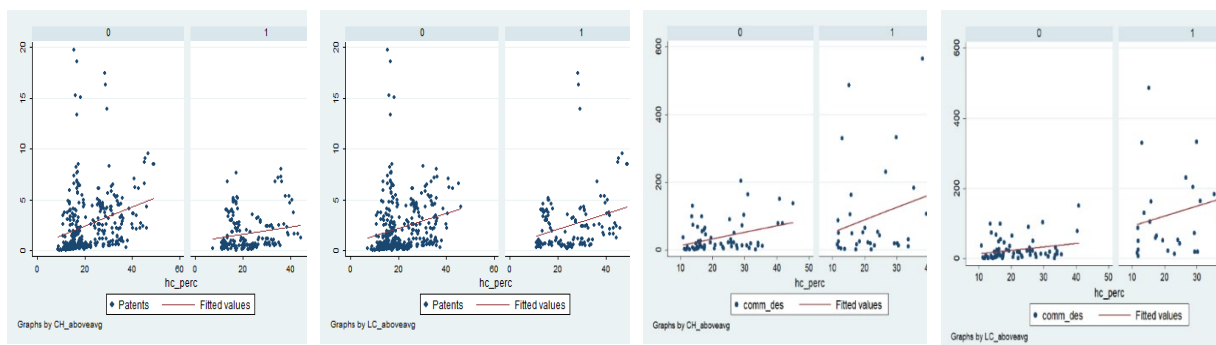
Figure 3: Human Capital, Culture and Innovation
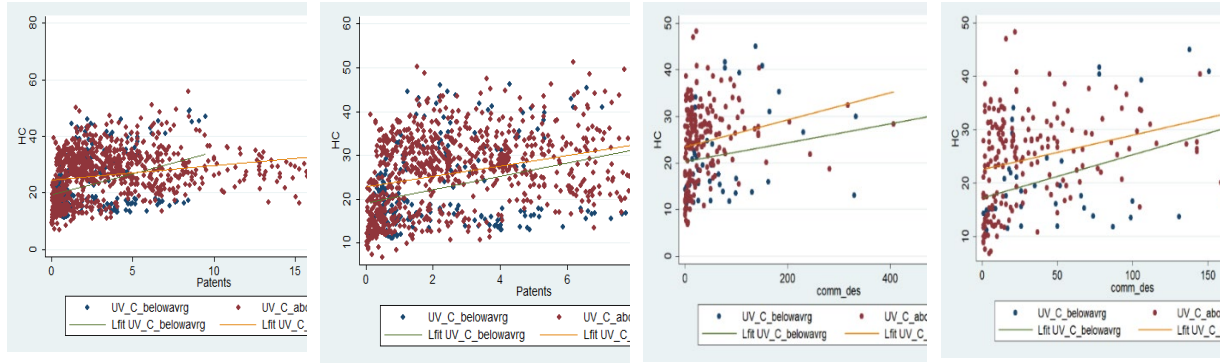*Note: The first row presents the utilization of human capital for innovation (their correlation) in respectively places specialized in CH (as opposed to those not specialized in it) and regions specialized in LC (as opposed to all the rest). The second row presents directly innovation output and cultural entropy (the balance between CH and LC in a region). The first two columns refer to patents as a proxy for innovation. The last two columns approximate innovation with community designs.*

The first row of Figure 3 shows a comparison for the fit between innovation and concentration of human capital in respectively: (i) regions with above average level of CH (coded as 1) (as opposed to all the rest regions (denoted as 0) and (ii) regions with above average for the EU level of LC (coded as 1) (as opposed to the rest of the regions of Europe). The main take of these plots is the clear worse fit between human capital and innovation only in the regions with above average concentration of CH. This means that human capital is less efficient in being economically creative in patenting in areas where the cultural milieu is most heavily endowed with CH. Social innovation is least efficiently achieved in places poor of LC.

The second row of Figure 3 demonstrates the relationship between Cultural Entropy (i.e., the balance between CH and LC in a locality) and local innovation. As clearly seen from the plots, especially when outliers are excluded, regions with above average levels of Cultural Entropy seem to be associated with more patents and more community designs.

Finally, it is interesting to look descriptively also at the relationship between Cultural Entropy and the main channel of the here proposed CBD mechanism—the relational cooperation channel. Figure 4 explores on the one hand the correlation between Cultural Entropy and bonding and bridging (both types of bridging social capital that we obtain, following Muringani et al. (2021)). On the other hand, it also shows the correlation between Cultural Entropy and our proxy for the extractive propensity of local institutions – the level of taxes (including social contributions).
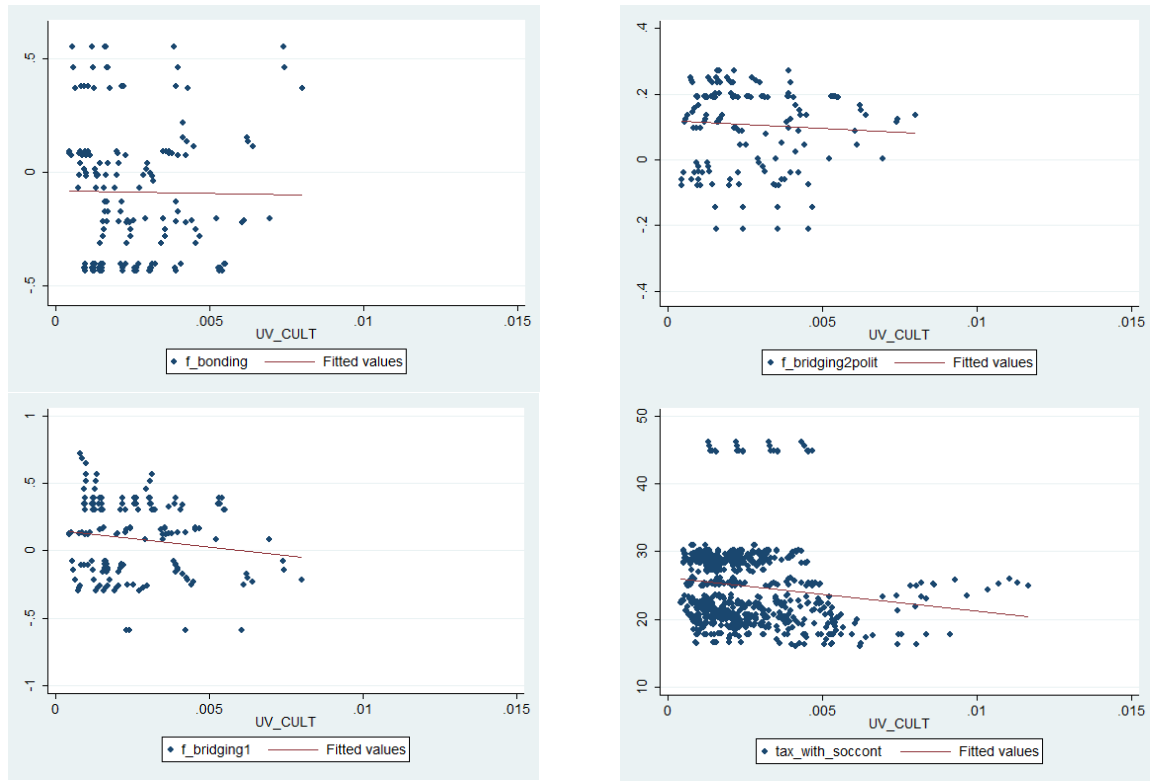
Figure 4: Relationship between Cultural Entropy and Social Capital
Note: The figure presents the correlation of Cultural Entropy (CULT-ENTROPY = UV_CULT) and clockwise, from top-left: (i) bonding social capital, (i) bridging social capital (measured according to Putnam's definition); (ii) bridging social capital (measured according to party membership); (iii) extractive institutions (measured with the level of tax, on income and profit, including obligatory social contributions).

The dependencies shown in Figure 4 are in line with the CBD expectations. Namely, we see that Cultural Entropy associates with the less clubistic in nature, bridging social capital (whichever measure for it we use). Also, taxation and extractive behavior of the institutions is less aggressive in places with higher Cultural Entropy.

5.2 Empirical results

Table 1 shows the implementation of the second step of the empirical strategy. Regional innovation is explained through the location quotients for the 10 types of industries available from Eurostat (approximating the MAR theory) and the unrelated variety between these same 10 types of industries (the Jacobean theory), in the presence of controls for the determinants of endogenous economic growth (K, L, HC).

Table 1: Cultural Entropy vs. Jacobean & Marshall-Arrow-Romer Drivers of Innovation

Dataset		Own dataset		Muringani et al. (2021) dataset	
		(1)	(2)	(3)	(4)
Motivation	Variables	Patents	Comm_designs	share_patents	share_comm_des
CULT-ENTROPY	CULT_ENTROPY	0.004***	0.019*	0.009**	-0.003

(CBD)					
Econ. unrelated variety (Jacob)	UV	0.0001***	0.001**	0.001***	0.001*
Specialization (Marshall-Arrow-Romer)	LQ_1	-0.0001***	0.0001	-0.000***	-0.000
	LQ_2	-0.0001**	-0.0001	-0.000***	-0.000
	LQ_3	0.0000	0.0000	-0.000	0.000
	LQ_4	0.0000	0.0000	0.000	-0.000
	LQ_5	-0.0001***	-0.0001	-0.000***	-0.000
	LQ_6	0.0000	0.0000	-0.000	-0.000
	LQ_7	0.0000	0.0000	-0.000	0.000
	LQ_8	-0.0001***	-0.0001	-0.000**	0.000
	LQ_9	-0.0001*	-0.0001	-0.000	0.000
	LQ_10	-0.0001*	0	-0.000	0.000
Endogenous growth input (Own dataset)	HC	0.0000	0.0000		
	L	-0.0001	0.0001**		
	K	0.0000	0.0000		
Endogenous growth input (Muringani et al. (2021) dataset)	HC (ed)			0.000	0.000
	L (ln_popd)			-0.000	0.000
	K (ln_av)			0.000*	-0.000
	Iinvest_RND (rd)			-0.000	-0.000
	Constant	0.0000	-0.001	-0.000	0.000
Controls	FE region	YES	YES		
	FE year	YES	YES		
	Observations	358	604	195	315
	R-squared	0.961	0.958	0.964	0.960

*** p<0.01, ** p<0.05, * p<0.1

Note: Results are based on pooled OLS with time and region fixed effects. LQ stands for location quotients per industry. UV stands for the unrelated variety between these industries in the locality

The results shown in Table 1 indicate that cultural entropy matters for both economic innovation (patents) and social innovation (community designs), in a manner that outperforms both the MAR and Jacobean hypotheses in terms of the magnitude of the coefficient. Yet, Cultural Entropy seems to be even more relevant for social innovation. Meanwhile, the two types of innovation—economic and social—seem to be slightly differently associated with the standard determinants of innovation, as we know them from the literature. Apparently, while patents do depend on the specialization of regions, social innovation is boosted by cultural and economic structural diversity. The latter is seen from the fact that in Specification 2 (where outcome is community designs), both cultural and industry entropy measures are significant, but not the location quotation measures for specialization. This is in a way consistent with the findings of Nathan (2015) and raises questions as to what innovation is. And still, it relates in an interesting manner to the degrowth literature because it shows that social innovation seems not to depend on the

economic structure but to depend on the size of the economy captured by L (labor). Combined, these results can be interpreted as a sign that socioeconomic development requires nurturing of the cultural capital and is different from strict economic specialization and efficiency, but is not entirely disconnected from economic endowments and growth.

Tables 2 a and 2b show the results from implementing the third step of the empirical strategy. It examines the full CBD mechanism where Cultural Entropy relates to social capital, and thus plugs into the extractiveness of the institutions which ultimately affect local innovation. Table 2a examines the economic innovation in terms of patents. Table 2b addresses the same mechanism operationalized for the case of social innovation (approximated through community designs).

Table 2a: Innovation as a Function of a Cultural-Entropy-Driven Extractive Behaviour of the Local Institutions - Patents

Dataset	Own dataset			Muringani et al. (2021) dataset					
	(1)			(2)			(3)		
VARIABLES	CULT_ENTROPY	Tax_with_soccont	Patents	CULT_ENTROPY	Tax_with_soccont	Patents	CULT_ENTROPY	Tax_with_soccont	Patents
f_bonding	-0.001								
f_bridging2polit	0.000								
bo_networks				-0.003*					
br_networks				0.001					
bo_practices							-0.002**		
br_practices							0.001		
culture_cistercians	-0.044***			-0.036***			-0.033***		
democracy	-0.001*			0.000*			0.000		
CULT_ENTROPY		-574.696***			-1,164.567***			-1,102.579***	
K		0.000			0.000			0.000	
tax_with_soccont			-0.0001*			0.000			0.000
HC			0.0000						
K			0.0000						
L			-0.0001*						
HC (ed)						0.000			0.000
L (ln_popd)						0.000			0.000
K (ln_av)						0.000*			0.001
Iinvest_RND (rd)						-0.000**			-0.000
Constant	0.004***	23.251***	0.000***	0.002***	27.208***	-0.006*	0.002***	27.048***	-0.021
FE region		YES			YES			YES	
FE year		YES			YES			YES	
Observations	74	74	74	121	121	121	121	121	121
R-squared	0.145	0.099	0.91	0.094	0.066	0.900	0.108	0.071	0.382

*** p<0.01, ** p<0.05, * p<0.1

Note: Results are based on a three stage least square (3SLS) with time and region fixed effects.

Table 2b: Innovation as a Function of a Cultural-Entropy-Driven Extractive Behaviour of the Local Institutions – Community Designs

Dataset	Own dataset			Muringani et al. (2021) dataset					
	(1)			(2)			(3)		
VARIABLES	CULT_ENTROPY	Tax_with_soc	Comm_des	CULT_ENTROPY	Tax_with_soc	Comm_des	CULT_ENTROPY	Tax_with_soc	Comm_des
f_bonding	-0.001								
f_bridging2polit	0.000								
bo_networks				-0.001					
br_networks				0.000					
bo_practices							-0.001**		
br_practices							0.000		
culture_cistercians	-0.044***			-0.034***			-0.032***		
democracy	-0.001*			0.000**			0.000		
CULT_ENTROPY		-750.979***			-1,011.931***			-958.791***	
K		0.000			0.000**			0.000**	
tax_with_soccont			-0.0001**			-0.000**			-0.000*
HC			0.0000						
K			0.0000						
L			0.0000						
HC (ed)						-0.000			-0.000
L (ln_popd)						-0.001			-0.001
K (ln_av)						-0.001***			-0.001*
Iinvest_RND (rd)						-0.000			-0.000
Constant	0.004***	23.587***	0.003*	0.002***	26.972***	0.020***	0.002***	26.832***	0.020**
FE region		YES			YES			YES	
FE year		YES			YES			YES	
Observations	73	73	73	197	197	197	197	197	197
R-squared	0.163	0.147	0.936	0.072	0.054	0.942	0.096	0.058	0.942

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Note: Results are based on a three stage least square (3SLS) with time and region fixed effects.

The main results in Table 2 a & b can be best read in reverse from equation three toward equation one, as follows. It seems that we cannot reject the detrimental effect of taxes and extractive behavior of the local institutions on local innovation (especially for social innovation). This finding is in line with Akcigit et al. (2022). The negative effect from the extractive institutions is clearly associated with lower local Cultural Entropy, which is in line with our main CBD expectations and shows that the main hypothesis of this study cannot be rejected. Ultimately, interestingly local Cultural Entropy is related to local social capital (in its political dimension, as found by Muringani et al. (2021)). Yet, the most curious finding is that Cultural Entropy is negatively associated with cultural persistence (captured by our historical measures of the concentration of Cistercian monks and the geography of democracy in the 1000-1600). This provides two interesting insights: (i) Cultural Entropy is associated with change and transformation of the local cultural milieu over time; and (ii) it is likely that the changing gravity centers of economic development might as well be associated with changing cultural gravity achieved through the rebalancing of CH and LC in space over time. This reminds previous CBD results related to shifting centers of gravity (see Tubadji and Nijkamp, 2018). Both insights are worth exploration with more data in future research.

Table 3 offers the results from implementing the last fourth step of the empirical strategy. It seeks to compare the impact of Cultural Entropy, extractive institutions (higher taxes) and social capital (bonding and bridging) on local productivity and economic growth (approximated with the local gross value added).

Table 3: Endogenous Growth – Impact of Cultural Entropy, Extractive Institutions and Social Capital

Data	Own dataset			Own dataset & Muringani et al. (2021) dataset	
VARIABLES	(1) GVA	(2) GVA	(3) GVA	(4) GVA	(5) GVA
HC	239.390***	237.104***	47.72	235.823***	242.147***
L	0.022***	0.022***	0.008	0.019***	0.018***
K	0.068**	0.038**	0.040*	0.043**	0.048***
CULT_ENTROPY	816,583.894***				
tax_with_soccont		-401.213***			
f_bonding			-1,675.92		
f_bridging2polit			7,981.832**		
bo_networks				-3,434.464*	
br_networks				3,713.025*	
bo_practices					-1,737.236
br_practices					2,091.362
Constant	18,340.417***	10,295.815***	-1,159.78	250.023	-141.471

FE region	YES	YES	YES	YES	YES
FE year	YES	YES	YES	YES	YES
Observations	770	1,122	230	443	443
R-squared	0.99	0.99	0.99	0.99	0.99

Robust standard errors

*** p<0.01, ** p<0.05, * p<0.1

Note: Results are based on pooled OLS with time and region fixed effects

As seen from Table 3, small increases in Cultural Entropy seem to generate the most massive impact on local economic growth. Taxation is confirmed as a negative factor for growth as well, which is to be expected based on its negative impact on innovation that is crucial for economic growth. And ultimately, the social capital channel (whether approximated through the "own dataset" factor variables or the Muringani et al. (2021) measures of social capital) is confirmed to be most significant and positively associated when approximated by the bridging political social capital measure, in line with the previous findings in Muringani et al. (2021). These findings mainly concord with the main narrative proposed in this study—that Cultural Entropy is a positive agent for economic growth, it is found in higher quantities where social capital of bridging type is also higher; and places that are poor of Cultural Entropy have more extractive institutions which harm local flourishing.

6. Conclusion

Cultural Entropy is coined and tested in regional economics and innovation setting for the first time in this study. It is defined as the measure of variety in the complex entity cultural capital, when its complexity is reduced to the two classes: cultural heritage and living culture. Cultural heritage is assumed to associate with parochialism, while living culture with local attitudes of openness to new people and new ideas, a reasoning relying on the body of empirical literature in the field of Culture-Based Development (CBD). This notion of Cultural Entropy is quantified employing the standard measure of Shannon Entropy. The impact of Cultural Entropy on innovation, passing through the channel of cultural impact on social capital and local institutions, is empirically explored with data for the regions of Europe at NUTS2 level for the period 2002 – 2017. Historical variables from Boranbay and Cuerriero (2019) (about Cistercian and Franciscan monks in the 1000-1600 and their geographical spread across Europe) are used as instrumental variables.

The results of this study point to several important insights. First, apparently, the balance between living culture and cultural heritage has a geography different than the mere endowment with the two sub-types of culture taken separately. The Cultural Entropy

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between these two subcomponents of culture is also statistically strongly associated with the extractive propensity of local institutions and thus ultimately with the local innovation output of the EU regions—both in terms of economic innovation (patents) and social innovation (such as community designs). Second, the empirical explorations of this study confirm that cultural capital affects social capital. This adds to the literature the insight that it is not just the stock of local culture, but the rebalancing between the positive and negative attitudes toward openness in local culture that ultimately determines how the local stock of cultural capital will affect social capital and by extension innovation and growth. Third, Cultural Entropy seems to be a factor associated both with innovation and with local economic growth. While we know that innovation is a main component for growth, it is useful to note that not any diversity but the balance between the subcomponents of culture affects growth. This insight can be a useful starting point in disentangling the long-lasting disagreement in the literature whether local diversity is beneficial or detrimental for economic growth. Fourth, through the use of the instrumental variables, the current study captures an interesting cultural and economic dynamics over time and space. Apparently, places that used to be central in economic development in the past are nowadays associated with less balanced local culture, while the favorable balance, closer to maximum Cultural Entropy, is found in the second runner places of the past. Thus, an evolutionary aptitude of local culture to be prone to rebalancing itself in order to allow more favorable growth is captured in this result. Also, this is in line with treating culture as a stochastic filtering agent in the redistribution of growth across space (Rossi-Hansberg and Wright 2007, Tubadji et al. 2022). Ultimately, we can see this finding from the point of view of changing centers of gravity across space that have been previously documented to be associated with cultural gravity redistribution (Tubadji and Nijkamp 2015, 2018; Quah 2011).

The limitations of the here presented work are related to the limited data availability. The data used here is the first OECD data collection attempt to amass a dataset that can allow the study of cultural industries. This OECD effort has been further enriched by the author with relevant ESS and historical variables to allow for the current exploration. The results were triangulated with the use of the Muringian et al. (2021) dataset. The construction of a better dataset for the quantification of cultural complexity in the manner demonstrated here is however possible. Data extraction based on lower NACE classification is possible from the entire European Union, which can allow for work with bigger data and further insights on the importance of Cultural Entropy in the process of regional innovation. Applying the same methodology for data collection in other

geographies, such as the United States or China, can yield readily comparable results (see Tubadji 2023a, showcasing examples for China).

In short, this study serves to demonstrate that checking the entropy of local culture is like checking the temperature of the water in which local innovation and economic growth will be cooking. Many known tendencies have been aligned here together through the use of this notion. Even more avenues for future exploration have been outlined in what seems to shape as a promising research agenda for exploring culture, innovation, and economic growth at the regional level.

The broader implications of this study are most relevant for unpacking the 'I' and 'we' ratio emergence that Robert Putnam and Shaylyn Romney Garrett (2020) have flagged out as an important predictor of socioeconomic development in the long run. The modern literature has already shown that having relative deprivation and left behind people and places leads to political radicalization and socioeconomic demise in places (see Muringani et al. 2021; Tubadji et al. 2021; Tubadji 2022; Rodríguez-Pose et al. 2024). The current study shows the important addition to clarify the source of emergence of cultural dynamics—Cultural Entropy. The paper sheds light on how the Cultural Entropy (i.e., the balance between CH and LC in a locality) is the mechanism behind the emergence of the 'I' and 'we' ratio that indeed affects the becoming left behind or prospering through innovation and growth also in the context of European regions, as the data demonstrated. This equips the Putnam's 'I' versus 'we' hypothesis with a powerful statistical tool, much stronger than the simple illustrative ratio between the frequencies of the words 'I' and 'we.' The Cultural Entropy measure is also much more actionable by policy makers through cultural policy interventions targeted at balancing the consumption between the CH or LC type of local cultural capital through increasing the one of the two types that is smaller as percentage locally. Therefore, it would be highly beneficial to replicate the Cultural Entropy methodology of this study and test for the USA and every other context whether the results for the cultural emergence of the 'I' and 'we' ratio can be predicted by Cultural Entropy. If that Cultural Entropy mechanism is confirmed for other geographies as well, a natural next step is to explore how the re-balancing of the cultural consumption of CH and LC can be utilized as a tool for maintaining the 'I' and 'we' local balance that can foster socioeconomic flourishing and avoid self-inflicted cultural-bias-driven demise.

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Appendices

Appendix 1: The Finite Dynamic Full Information CBD Game of Cooperation
Cultural Openness as a Function of Local Cultural Entropy

A foreigner's decision to immigrate in a particular locality can be presented as a game, where the decision will be taken in sequence of determining whether the foreigner wants to go into the locality and next, how the incumbent population will cooperate with them if the foreigner moved in. The incumbent (which may be any local agent such as co-workers, employers, investors, or local institutions already operating on the recipient locality) will always have one of two strategies—either to cooperate or to enter into conflict with the foreigner (the latter is labelled below as the 'fight' strategy). In this sense, the CBD cooperation game is set very much similar to a market entry game, as shown below. As life is finite, the game is finite. Full information is assumed for simplicity, but is also realistically enforced in human behavior by the presence of knowledge of the heuristics about cultural stereotypes regarding the local behaviors.

Game set-up:
Player 1 (P1) – Foreigner
- o A foreign agent who considers entering a country's (primary (goods and services) or derived (labor)) market in competition against the incumbents for a share of the local output (local GDP per capita).
- o Strategy: in vs. out

Player 2 (P2) – Incumbent
- o An agent already operating on the local markets at which a potential foreigner decides to enter (this can be a local co-employee, a local employer/investor, or a local policy maker)
- o Strategy: fight vs. cooperate

Outcomes & Pay-offs:
- o Best pay-off Player 1 – (P1 in, P2 cooperate)
- o Best pay-off Player 2 – P1 out
- o Worst pay-off for both – (P1 in, P2 fight)

Normal Form:

Incumbent

Foreigner		Cooperate	Fight
	In	(2 , 1)	(0 , 0)
	Out	(1 , 2)	(1 , 2)

Solution for Nash Equilibrium:

Incumbent

Foreigner		Cooperate	Fight
	In	(2 , 1)	(0 , 0)
	Out	(1 , 2)	(1 , 2)

Yet, the game is dynamic, hence we need to find the Sub-game Perfect Nash Equilibrium(s) for the game.
This can be done through backwards induction, i.e., considering the sub-games in reverse temporal sequence and finding the optimal strategies of the player who chooses in the particular sub-game (round) of the game.

Extensive Form with Solution for Sub-game Perfect Nash Equilibrium:
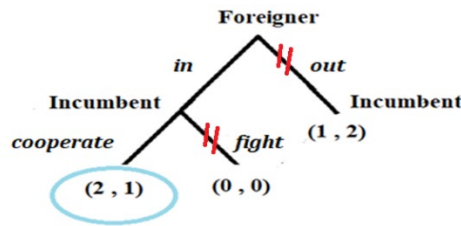
Commitments:
-   Foreigner – has **economic commitment** to strategy 'in' – due to sending country econ incentives to emigrate —this econ commitment reinforces the above derived SPNE outcome equally for any given recipient country

-   Incumbent—has **cultural commitment** to fight due to commitment/loyalty to the club of incumbents

   o   _Local Culture as a signal for the incumbent's COMMITMENT to cooperate (or fight)_
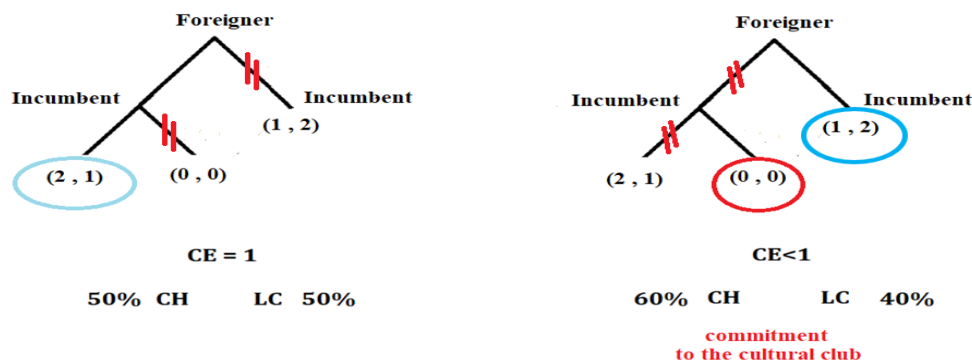
As the cultural commitment of the Incumbent to choose 'fight' increases, the probability of the foreigner's choice to choose 'in' decreases.

The cultural commitment of the Incumbent to fight for his club is _reversely proportional_ to the local **cultural entropy.** Local cultural entropy is highest when the local clubs are equal size. If smaller clubs exist, they are potential sources of higher clubism. Higher clubism means increased probability of Incumbent's commitment to 'fight' strategy, motivated by their higher commitment to their club. The lower the cultural entropy, the higher the probability to stick to the commitment to the club. Hence, there is higher likelihood for the Foreigner to choose strategy 'out,' the lower cultural entropy is. The latter is termed by CBD as the _'part of the CBD cultural gravity effect due to cultural openness,' i.e. the cultural propensity to cooperate. This is next weighted by the cultural distance between Foreigner and Incumbent. Thus, we can capture the precise ranking of the preferences of the Foreigner over different localities given their local cultural openness to cooperation in order to choose where to immigrate._

Appendix 2: Descriptive Statistics

Variable	Source	Obs	Mean	Std. Dev.	Min	Max
culturec	Boranbay & Guerriero (2019) J Comparative Econ	2206	0.04	0.02	0.001	0.07
culturef	Boranbay & Guerriero (2019) J Comparative Econ	2206	0.08	0.08	0.02	0.29
democracy	Boranbay & Guerriero (2019) J Comparative Econ	2206	1.82	0.36	1	2.62
f_trust_institutions	ESS - factor analysis	821	-0.02	0.37	-1.19	0.89
f_bonding	ESS - factor analysis	821	-0.08	0.22	-0.55	0.63
f_bridging1	ESS - factor analysis	821	0.07	0.37	-0.77	0.73
f_bridging2polit	ESS - factor analysis	821	0.05	0.12	-0.42	0.27
tax_with_soccont	Eurostat	2980	25.67	5.25	15.4	48.8
tax_without_soccont	Eurostat	2980	37.02	5.24	22.1	50.8
patents	Eurostat	512	0.00	0.00	4.87E-07	0.0016277
comm_designs	Eurostat	846	0.00	0.00	8.97E-06	0.0021539
CULT-ENTROPY	author's calculation—Shannon's entropy-based index for CH & LC- based on Eurostat data	794	0.00	0.00	0.0004	0.012
UV	unrelated variety of firms—author's calculation based on Eurostat data	1161	2.06	0.09	1.691	2.208
GVA	Eurostat	3005	39567.41	45346.93	958.260	631947.800
HC	Eurostat	3152	26.77	10.36	3.2	74.7

Appendix 3: Factor Analysis with ESS Data to obtain Social Capital

Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
Trust in country's parliament	0.8387	-0.0149	0.021	-0.0795	0.2895
Trust in the legal system	0.7927	-0.0475	0.0544	-0.0143	0.3662
Trust in the police	0.7102	-0.1224	0.129	0.0107	0.4639
Trust in politicians	0.8636	0.0074	0.0191	-0.1128	0.2411
Trust in political parties	0.8524	0.0159	0.0079	-0.1227	0.258
Trust in the European Parliament	0.7512	0.0154	-0.1146	0.1113	0.4099
Trust in the United Nations	0.7341	0.0079	-0.0257	0.1391	0.4411
Member of political party	-0.0674	0.008	0.0104	0.9674	0.0595
Important to help people and care for others	-0.0272	0.7332	0.1298	-0.0028	0.4448
Important to be successful	0.0144	0.0737	0.8294	-0.0179	0.3062
Important to get respect from others	0.0264	0.1469	0.8054	0.0372	0.3276
Important to be loyal to friends and close people	-0.0453	0.7516	0.1134	-0.0183	0.4199
Important to care for nature and environment	-0.0048	0.7488	0.0175	0.0067	0.439
Important to follow traditions and customs	0.0294	0.5494	0.2232	0.111	0.6351
	f_trust	**f_bonding**	**f_bridging_1**	**f_bridging2polit**	

Appendix 4: Cultural Entropy Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
monuments	3310	1.08	1.24	0	7
art_firms	1161	9857.26	10424.23	209	79583

gen CC = (art_firms + monuments_num)

gen LC = art_firms/CC

gen CH = monuments_num/CC

gen ln_1_CH = ln(1/CH)
gen ln_1_LC = ln(1/LC)

gen S_CH = (CH * ln_1_CH)
gen S_LC = (LC * ln_1_LC)

gen UV_CULT = (S_CH + S_LC)