Talk: Inequality in the Age of Pseudonymity

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Abstract. Inequality measures such as the Gini coefficient are used to inform and motivate policymaking, and are increasingly applied to digital platforms. We analyze how measures fare in pseudonymous settings that are common in the digital age. One key challenge of such environments is the ability of actors to create fake identities under fictitious false names, also known as "Sybils." While some actors may do so to preserve their privacy, we show that this can hamper inequality measurements: it is impossible for measures satisfying the literature's canonical set of desired properties to assess the inequality of an economy that may harbor Sybils. We characterize the class of all Sybil-proof measures, and prove that they must satisfy relaxed version of the aforementioned properties. Furthermore, we show that the structure imposed restricts the ability to assess inequality at a fine-grained level, and apply our results to prove that popular measures are not Sybil-proof, with the famous Gini coefficient being but one example out of many. Finally, we examine dynamics leading to the creation of Sybils in digital and traditional settings.

Keywords: Inequality Measurement Theory · False-name-proofness · Sybil-proofness · Decentralized Finance · Digital Platforms.

1 Introduction

The measurement of economic equality is a cornerstone of social science, and is used to inform public discourse and motivate government policy [6,3]. Thus, it is

unsurprising that inequality measures are used to study digital platforms. One famous measure is the Gini coefficient (GC), which ranges between a value of 0 (all individuals have equal wealth) and 1 (one entity holds all wealth).

Alarmingly, some claim that the inequality of a prominent digital platform, Bitcoin, is "more unequal than any other human society" [13] and "like North Korea" [14], owing to a GC of 0.88 (see Fig. 1). Similar findings have been used to argue for a need to change the power distribution and governance structures of cryptocurrencies and decentralized finance (DeFi) platforms to ensure they do not succumb to centralization [12,9].

However, applying classical measures to pseudonymous platforms overlooks the potential disconnect between observable identities and true individual actors. This is not a mere technicality but a first-order feature of pseudonymous settings that invalidates the core assumptions of traditional inequality analysis. Thus, before we can answer how unequal pseudonymous platforms are, we must first tackle a fundamental question:

Can one reliably measure inequality in pseudonymous settings?

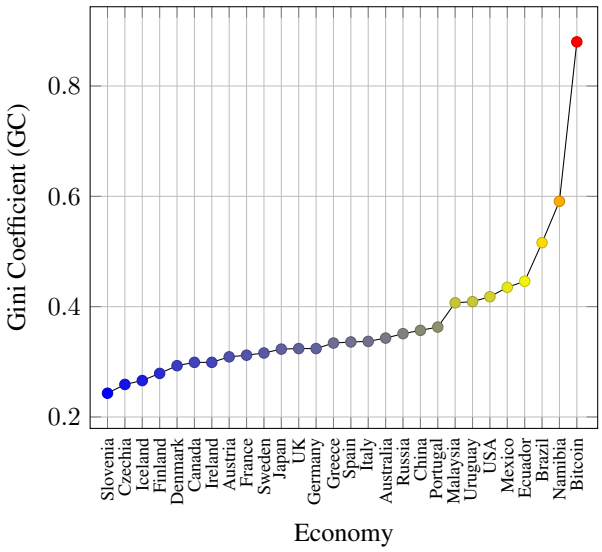

Fig. 1. Some argue that Bitcoin's GC equals 0.88, a value larger than that of any other global economy, and thus also alarmingly indicative of extreme inequality [13,14]. Country-level data obtained from [15].

2 This Work

We provide the first axiomatic answer to this question by establishing theoretical foundations for inequality measures for pseudonymous settings. Thus, our work nicely several bodies of work, including the literature on the axiomatic approach to inequality measures [2,8], empirical analyses of inequality [12,4], and the impact of pseudonymity on various economic mechanisms [5,10].

We show that reliable measurement is inherently challenging to carry out under the pseudonymous settings common to digital platforms. This is due to actors possibly holding their wealth across several Sybil identities, i.e., using multiple fictitious false names [11]. In fact, such considerations are generally applicable even to traditional settings: consider how individuals may hold wealth across seemingly disparate shell corporations to avoid taxes [1].

To analyze the impact of Sybils, we build upon the literature's canonical desiderata [7]. Thus, measures receive a vector representing the distribution of wealth over an economy's population, and should ideally satisfy several axioms: 1. the transfer principle (i.e., given a population ordered by wealth, order-preserving transfers from rich individuals to poorer ones reduce inequality), 2. symmetry (i.e., invariance to permutations), 3. insensitivity to population size, and 4. scale independence (i.e., invariance under uniform scaling).

Our first main result is an impossibility: no Sybil-proof inequality measure can satisfy the transfer principle. We follow by showing the general difficulty of measuring inequality in pseudonymous settings. Our analysis highlights the tension between Sybil-proofness and each of the literature's standard desired properties. Moreover, we extend our results by both relaxing some properties, and considering additional alternative properties proposed by the literature.

We augment our impossibilities with a full characterization of the class of Sybil-proof inequality measures. As we show, this class is exactly the family of metrics which are *sum-dependent*, meaning that given an input wealth distribution, its inequality is calculated solely based on the sum of wealth. This family is a natural companion to the impressive line of work published in Econometrica characterizing decomposable measures, i.e., measures that, given aggregate information on two sub-populations, can calculate the inequality of their union. In a way, our sum dependent family considers a further condensed form of aggregation. As we prove, this is not only a feature, but also a necessity.

In total, we offer a toolbox of results and techniques that encompass a large class of measures, including the GC, the coefficient of variation (CV), the Herfindahl-Hirschman (HH) index, the Atkinson measure (AM), the Theil L (TL) index, the Theil T (TT) index, and the family of generalized entropy (GE) metrics. Moreover, our constructive characterization maps the complete design space of robust metrics, showing not just what is impossible, but also the precise structure of everything that is possible.

The aforementioned results (and additional ones) are provided in the paper's conference version [17]. That version is further augmented by the paper's extended version [16], which includes full proofs for all results and a comprehensive overview of the related literature.

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