Market Diversity and Market Churn

Measures of Competitive Structure

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Measuring competitive intensity is a crucial endeavour in competition law and policy. Structural metrics are those which quantify the degree of competition present in a market based off of market shares. The most commonly used structural metrics are those that measure market concentration. This paper argues that measuring market concentration is unsatisfactory, and proposes an alternative suite of metrics drawn from theoretical ecology which measure market diversity. It is split into three parts. The first part outlines flaws in commonly used concentration metrics. The second part introduces a suite of metrics to measure diversity. These metrics share a common theoretical framework, and include a metric to measure diversity within a single market, a metric to measure diversity within a group of markets, a metric to measure market dynamism, and ways to account for heterogeneity between firms and between products. The last part makes descriptive, theoretical and normative arguments for why competition law, regulation and policy should prefer diversity metrics over concentration metrics.

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Contents

1. Introduction

Measuring competition is a crucial endeavour in competition law. Evidence that frames the intensity of competition incorrectly may significantly alter the course of a case, terminate it altogether, or even prevent it from being brought in the first place. In the context of Article 101 of the Treaty of the Functioning of the European Union (TFEU), the effect of an agreement or concerted practice must be determined within the "actual context in which it would occur in the absence of the agreement in dispute", for which a comparison between the intensity of competition on the actual market and a counterfactual one must be made.[1] The application of Article 102 TFEU meanwhile, requires establishing whether an undertaking holds a dominant position, which in turn, involves determining whether it operates from a "position of economic strength" that would enable it to "prevent effective competition being maintained" and thereby "behave [...] independently of its competitors, customers, and ultimately of its consumers."[2] There too, measuring the intensity of competition is crucial to making any such determination. Finally, the measurement of competitive intensity is perhaps most vital in merger control, where mergers are deemed incompatible with the common market if they would result in a significant impediment to effective competition.[3]

Given the above, competition authorities and academics have long wrestled with the challenge of coming up with metrics to quantify the degree of competition on a market. The fruits of these labours have included conduct measures like the Lerner index,[4] consumer focused measures like the diversion ratio,[5] and structural measures, such as the Hirschman-Herfindahl Index (HHI) or CR4 metrics,[6] among others.

This contribution focuses on structural measures of competition, particularly market concentration metrics. In the words of Adelman, such metrics aim to "to sum up [the distribution of firm sizes into] one meaningful number".[7] The HHI is perhaps the most commonly used measure of market concentration,[8] and is defined as the sum of the squared of the market shares of the firms in a market ($HHI = \sum_{i=1}^{n} s_i^2$). The metric was put forward independently by both Alfred Hirschmann[9] and Orris Herfindahl[10] in the middle of the 20th century,[11] and places markets on a spectrum from 1 in the case of a perfectly uncompetitive monopoly, to 0 in the case of a perfectly competitive market (for a market of N firms, the market

[1] *Case C-307/18* Generics (UK) Ltd and Others v Competition and Markets Authority *ECLI:EU:C:2020:52* Case C-307/18, paras 118-120.

[2] *Case 27/76* United Brands Company and United Brands Continentaal BV v Commission of the European Communities *ECLI:EU:C:1978:22* (ECJ, 14 February 1978) para 65.

[3] See Article 2(3) EUMR. Council Regulation (EC) No 139/2004 of 20 January 2004 on the Control of Concentrations between Undertakings (the EC Merger Regulation) 2004.

[4] Dennis C Mueller, "The Persistence of Profits above the Norm" (1977) 44(176) Economica 369; AP Lerner, "The Concept of Monopoly and the Measurement of Monopoly Power" (1934) 1(3) The Review of Economic Studies 157.

[5] Christopher Conlon and Julie Holland Mortimer, "Empirical Properties of Diversion Ratios" (2021) 52(4) The RAND Journal of Economics 693.

[6] The CR4 metric measures the share of revenues in a market earned by the 4 largest firms. In general the CRX metric measures the share of revenues for the largest X firms. Matej Bajgar and others, "Industry Concentration in Europe and North America" [2023] Industrial and Corporate Change dtac059.

[7] MA Adelman, "Comment on the "H" Concentration Measure as a Numbers-Equivalent" (1969) 51(1) The Review of Economics and Statistics 99, 100.

[8] Chad Syverson, "Macroeconomics and Market Power: Context, Implications, and Open Questions" (2019) 33(3) Journal of Economic Perspectives 23, 25; For a recent use in the competition economics see Annika Stöhr, "Price Effects of Horizontal Mergers: A Retrospective on Retrospectives" (2024) 20(1–2) Journal of Competition Law & Economics 155.

[9] Albert O Hirschman, *National Power and the Structure of Foreign Trade* (University of California Press 1 January 1980).

[10] Orris C Herfindahl, "Concentration in the Steel Industry" (PhD thesis, Columbia University 1950) ⟨https://www.proquest.com/docview/304363163/citation/44879CEB88254353PQ/1⟩ accessed 10 December 2024.

[11] Herfindahl was inspired to research the topic in light of the "profound ignorance" of economics at the time when it came to how to conceptualise market concentration. ibid 1.

concentration cannot be less than $\frac{1}{N}$).

Concentration metrics are among the most practical measures of competition, because they rely only on the market shares of each firm, which are relatively easy to obtain.[12] This makes them useful for providing a preliminary overview of the level of competition in a market. They are particularly useful in the practice of merger review where competition authorities must judiciously choose which mergers to challenge under tight time constraints and with limited resources. Competition authorities commonly set soft law thresholds for the level of concentration in a market, beyond which additional competition law scrutiny will be triggered. For instance, The European Commission's 2004 Horizontal Merger Guidelines and the 2023 US Merger Guidelines indicate that mergers in markets with a HHI under 0.2 and 0.18 respectively are unlikely to raise competition concerns.[13] The use of the HHI as a yardstick against which to gauge the risk of a transaction was reaffirmed in the European Commission's recent guidance on the simplified treatment of mergers, where mergers are eligible for a streamlined approvals process if, among other conditions, the HHI increases by less than 0.015 as a result of the merger.[14]

These thresholds are hugely consequential because they serve to calibrate the level of scrutiny given to prospective mergers. As the literatures on killer acquisitions and industry rollups have demonstrated,[15] merger thresholds also act as discriminative filters, which when incorrectly calibrated, can contribute to anti-competitive mergers being erroneously approved or extra work for parties if mergers are unnecessarily scrutinised. As a consequence, the merger thresholds, and the assumptions which underlie them, are often re-visited by competition authorities, and are the subject of much scholarly debate.[16]

Principally through its use in merger guidelines, but also in providing a general measure of market concentration which provides useful context to decision-makers in non-merger cases, the HHI has long played an important role in competition law. Again, the fact that it relies only on market shares makes it an enticing measure to use. It is unreasonable, however, to expect that any measure based on market shares alone can give a comprehensive insight into competition on a market because, there are strict limits as to how much insight market shares can provide. This is for two reasons.

First, market shares will differ depending on how widely a market is defined, making structural measures of competitive intensity somewhat contingent on where one draws the line as to what the market is.[17] The question of market definition is complex,[18] and in this paper I

[12] Under EU competition law the Commission can submit a Request for Information under Article 18 of Regulation 1/2003. Council Regulation (EC) No 1/2003 of 16 December 2002 on the Implementation of the Rules on Competition Laid down in Articles 81 and 82 of the Treaty (Text with EEA Relevance) 2002; Syverson (n 8) 25.

[13] Guidelines on the Assessment of Horizontal Mergers under the Council Regulation on the Control of Concentrations between Undertakings 2004, p. 19; US Department of Justice and US Federal Trade Commission, Merger Guidelines (18 December 2023) ⟨https://www.ftc.gov/system/files/ftc_gov/pdf/2023_merger_guidelines_final_12.18.2023.pdf⟩ p. 5-6.

[14] Commission Notice on a Simplified Treatment for Certain Concentrations under Council Regulation (EC) No 139/2004 on the Control of Concentrations between Undertakings 2023/C 160/01 2023, 5(d)(i), 5(d)(ii).

[15] Colleen Cunningham, Florian Ederer, and Song Ma, "Killer Acquisitions" (2021) 129(3) Journal of Political Economy 649; Aslihan Asil and others, "Painful Bargaining: Evidence from Anesthesia Rollups" (November 2024).

[16] For an example, see Keith N Hylton, "Getting Merger Guidelines Right" (2024) 65(1) Review of Industrial Organization 213.

[17] Jan De Loecker, Jan Eeckhout, and Gabriel Unger, "The Rise of Market Power and the Macroeconomic Implications" (2020) 135(2) The Quarterly Journal of Economics 561, 563; Louis Kaplow, "Market Share Thresholds: On The Conflation of Empirical Assessments and Legal Policy Judgeemnts" (2011) 7(2) Journal of Competition Law & Economics 243, p. 253.

[18] See generally Miguel Sousa Ferro, *Market Definition in EU Competition Law* (Edward Elgar Publishing 2019); Magali Eben, "The Antitrust Market Does Not Exist: Pursuit of Objectivity in a Purposive Process" (2021) 17(3) Journal of Competition Law & Economics 586.

assume that a market has already been defined and market shares are readily available.

Second, and more importantly, the purely structural nature of market concentration measures does not provide insight into behaviour, consumer preferences, potential competition, business model specificities, or other factors relevant to competitive intensity. While in theory, the profitability of a market can be shown to be proportional to the HHI under Cournot competition,[19] this connection is often somewhat tenuous in practice.[20]

The flaws of structural metrics have been pointed out extensively in the literature on industrial organisation economics, especially during its turn away from the "structure, conduct, performance" paradigm,[21] which has resulted in them being largely been replaced in economic analysis with incentive-based models of competition. That said, structural metrics are still heavily used in competition law not only in merger guidelines but also as a general means to get a sense of how competitive markets are, despite the received wisdom in competition law and policy being that market concentration (alone) is not a good indicator of competitive intensity.[22]

Given these limits inherent to metrics based purely off market shares, it is unsurprising that such metrics has received little scholarly attention in recent decades. Yet the use of structural metrics should not be precluded because they can only reveal *some* aspects of competitive intensity should. Indeed, structural metrics can still provide important and convenient insights into market competition. The main issue with the current suite of concentration metrics lies not in their structural nature, but rather in their theoretical underdevelopment. This paper contends that the HHI is flawed in various ways, and that in light of the emergence of more robust alternative metrics in other fields, it should be retired. The purpose of this article is to propose superior alternatives based on the concept of diversity.

The article proceeds as follows: Section 2 outlines the limitations of the HHI. Section 3 introduces the concept of diversity as an alternative to concentration and explores a family of metrics from theoretical ecology to measure it. These metrics share a common theoretical framework, and can measure measure diversity within a single market, measure diversity within a group of markets, quantify market dynamism, and are able to account for both heterogeneity between firms and between products. Section 4 then considers the normative and policy implications of diversity measures, and finally, Section 5 offers concluding remarks.

2. Flaws in the HHI

Not least because it has received little theoretical theoretical attention since its introduction in the 1940's,[23] the HHI is a measure of market structure with several flaws. The following

[19] Ioannis Lianos and others, *Competition Law* (Oxford University Press 2019) p. 268.

[20] Timothy F Bresnahan, "Empirical Studies of Industries with Market Power" in *Handbook of Industrial Organization* (Elsevier 1 January 1989) vol 2, 1046; Steven Berry, Martin Gaynor, and Fiona Scott Morton, "Do Increasing Markups Matter? Lessons from Empirical Industrial Organization" (2019) 33(3) Journal of Economic Perspectives 44.

[21] Berry, Gaynor, and Scott Morton (n 20) 46; Bresnahan (n 20); Richard Schmalensee, "Inter-Industry Studies of Structure and Performance" in *Handbook of Industrial Organization* (Elsevier 1 January 1989) vol 2; Kaplow (n 17).

[22] "Our own view, based on the well-established mainstream wisdom in the field of industrial organization for several decades, is that regressions of market outcomes on measures of industry structure like the Herfindahl–Hirschman index should be given little weight in policy debates." Berry, Gaynor, and Scott Morton (n 20) 45-48.

[23] Kenneth R Ahern, Lei Kong, and Xinyan Yan, "The Anatomy of Concentration: New Evidence From a Unified Framework" (January 2024) p. 5; Adelman (n 7); Michael O Finkelstein and Richard M Friedberg, "The Application of an Entropy Theory of Concentration to the Clayton Act" (1967) 76(4) The Yale Law Journal 677.

sub-sections describe specific shortcomings in the HHI from the perspective of competition law,[24] in order to motivate the search for more capable alternatives.

2.1. Large firm bias

The HHI is defined as the sum of the squared market shares of each firm in a market. The squared term in the HHI amplifies the influence of larger firms, as the contribution of smaller firms to the index decreases quadratically with their market share. While this choice may be reasonable under some assumptions,[25] it can also obscure changes in market structure which primarily affect smaller firms.

This bias can be illustrated using a simple example.[26] Consider a market with 100 firms, where four firms collectively control 80% of the market, while the remaining 96 firms share the remaining 20% equally. This market would have a HHI of 0.16. Such a distribution of market share is not unthinkable in a sector such as news, where many small local news agencies exist alongside national outlets. Now, imagine that a large disruption hit the sector - similar to what occurred with the rise of digital advertising, where profits were shifted from small regional newspapers to big tech firms[27] - causing 90 of the smallest firms to fail. Consider that their market share were to be distributed equally between the surviving six small firms, leaving four firms with 20% market share, and six with just over 3%. Despite the fact that 90% of the firms in the sector would have collapsed, the HHI would rise only slightly in such a scenario, from 0.16 to 0.166, an increase of 0.006 or about 4%.

This example shows how the HHI's baked-in bias towards larger firms can serve to obscure important changes in market structure, and encode a relative blindness to small firms. The issue with this bias is not that exists, but rather lies in its nature as an implicit normative choice. Throughout the history of competition law, courts have been keen to emphasise that decision makers in competition law cases should play close attention to the legal and economic context in which they are making decisions.[28] Metrics which present a view of market competition which is somehow distorted may therefore lead courts and competition authorities astray.

The importance of firm size varies on a case-by-case basis. In some sectors, such as news and journalism, small firms are particularly important for civic life and local democracy.[29] In such situations, mergers or changes in market structure which affect small firms but do not change the HHI can have important consequences, and are therefore deserving of close scrutiny. In other sectors like network industries like railroads, small firms may be

[24] A host of specifically economic problems with the HHI have also been identified, including its lack of theoretical connection to the wider economic literature and lack of statistical power when applied to incomplete datasets. For more detail, see Ahern, Kong, and Yan (n 23) p. 22, 3.

[25] Notably the profitability of an industry can be shown to be proportional to the HHI under Cournot competition. Lianos and others (n 19) p. 268.

[26] For a similar example from Ecology, see Lou Jost, "Partitioning Diversity into Independent Alpha and Beta Components" (2007) 88(10) Ecology 2427, 2429.

[27] House Judiciary Committee, *Investigation of Competition in Digital Markets* (2022) ⟨https://judiciary.house.gov/news/documentsingle.aspx?DocumentID=5025⟩ accessed 16 October 2022, p. 57-62; Marcel Garz and Mart Ots, "Media Consolidation and News Content Quality" [2025] Journal of Communication jqae053.

[28] *Case 96/82 NV IAZ International Belgium and Others v Commission of the European Communities ECLI:EU:C:1983:310* Joined cases 96-102, 104, 105, 108 and 110/82, para 23-25; *Case 29/83* Compagnie Royale Asturienne Des Mines SA and Rheinzink GmbH v Commission of the European Communities *ECLI:EU:C:1984:130* Joined cases 29/83 and 30/83, para 26; *Case C-377/20* Servizio Elettrico Nationale SpA, *Opinion of Advocate General Rantos ECLI:EU:C:2021:998* (ECJ, 2020) para 6; *Case C-307/18* Generics (UK) Ltd and Others v Competition and Markets Authority *ECLI:EU:C:2020:52* (n 1) para 39.

[29] Committee (n 27) p. 48-49.

economically unviable. Ideally therefore, the sensitivity of structural metrics to smaller or larger firms should be explicit in the decision-making of competition authorities and courts.

Of course, other metrics such as entry/exit rates can supplement the HHI, as to make up for its intrinsic bias towards bigger firms. Yet such an approach is somewhat ungainly, since as discussed in the following section, these metrics use different units from the HHI and are therefore hard to commensurate with it.

2.2. Lack of interpretability

The HHI is unitless quantity. Its absolute values, and changes to those values (deltas), carry little intrinsic meaning beyond indicating the general level of concentration in a market. As Ahern et al. write, "[the] economic meaning of an industry with an HHI of [0.025] is not readily apparent"[30] and likewise, an increase in the HHI by 0.1 carries little practical meaning. While HHI values are hardly the most obscure pieces of evidence that decision-makers in competition law cases have to consider, they are nevertheless far from intuitive. Clear and easily understandable metrics are desirable because they help make the assumptions behind policy decisions like merger thresholds explicit, which should, in theory, feed into improved consistency in decision-making and higher levels of legal certainty. As Section 3 will demonstrate, it is possible to craft structural metrics which do have meaningful units.

To further complicate how the HHI should be interpreted, the effect of any given increase in the HHI depends on the context. In general, the same change in HHI reflects a more substantial shift in market structure when a market is deconcentrated than when it is already concentrated and the change affects one of the larger firms. This is because of the squared term in the HHI, which accords more weight to firms with higher market shares.

A simple example with equally sized firms illustrates this effect. With n equally sized firms, the HHI is $1/n$. Hence, moving from a monopoly (n = 1, HHI = 1) to duopoly (n = 2, HHI = 0.5) halves the index, but the next entry (n = 3) cuts it by only one-third, the fourth by one-quarter, and so on. Identical structural changes, in this case adding an equally sized entrant, produce progressively smaller absolute falls in HHI as the market becomes less concentrated. In other words, the "same" change in the structure of a market will cause a different amount of change in the HHI value depending on the existing level of concentration.

It is reasonable to argue that this behaviour is desirable. After all, a change in market concentration arising from a two-to-one merger is far more alarming than from a ten-to-nine merger. Yet such behaviour nevertheless encodes a normative assumption - one which emphasises changes in market structure when markets are already concentrated - into the metric. Furthermore, it makes HHI deltas unintuitively non-linear in practice. As will be discussed, this flaw can be remedied by converting the HHI measure into a "numbers equivalent" by taking its reciprocal,[31] although I will later describe other methods to approach the problem more holistically.

This paper contends that the opacity of the HHI is not inevitable, but is instead a product of under-theorisation. It is possible to build metrics of competitive structure which are both more interpretable than the HHI, and fit within a wider conceptual framework that neatly integrates other structural aspects of markets which are of interest, such as geographic and temporal (dynamic) variations.

[30] Ahern, Kong, and Yan (n 23) 3.

[31] Adelman (n 7).

2.3. Product differentiation is not considered

The HHI is a measure of market concentration, yet it is often used as a proxy for competition on the assumption that markets with fewer competitors are less competitive than those with more.[32] This 'jump' from concentration to competition is valid when all products in a market are perfectly substitutable, since under Cournot competition it can be shown that the HHI correlates directly with profitability of firms, which is itself a measure of competitive intensity.[33]

While competition law makes an assumption of substitutability within a given relevant market,[34] it is unreasonable in most cases to expect that the products of each competing firm will be *perfectly* substitutable with each other. The degree to which products within a market are less substitutable directly affects the degree to which concentration implies competition,[35] as lower substitutability reduces the likelihood that a given product is perceived by consumers as part of the same choice set as its rivals. The assumption of perfect substitutability which underlies the HHI being used as a proxy for competitive intensity may therefore lead to it providing an overestimate of the intensity of market competition, in cases where products are less than perfectly substitutable.

Furthermore, the fact that the HHI does not account for product differentiation, or indeed any kind of inter-firm heterogeneity, means that it is unsuitable for use as a metric to measure aspects of markets like consumer choice or product variety. Such parameters are relevant in many competition law cases, not least because product variety is understood by Union courts as a key parameter of competition and limitations on consumer choice are considered as restrictions of competition.[36]

2.4. Market dynamics are not captured

Changes in the HHI can be easily visualised over time by plotting it on a graph. Even so, the HHI remains is a poor metric to capture market dynamics, such as innovation-driven competition, firm turnover, or disruptive entry, because it does not provide insight into *which* firms gained or lost market share over time. For instance, a market characterised by Schumpeterian competition and rapid technological change may exhibit a high firm turnover, yet still retain a high HHI at any given moment by virtue of the market always remaining concentrated. In such cases, the competitive process could still be robust, despite persistent concentration.[37] To give a short example, if two firms had a market share of 70% and 30% respectively, yet their market shares flipped every calendar year due to each firm's innovations successively leapfrogging the other, then the HHI would remain constant at 0.58 while the market may actually be quite competitive in a dynamic sense. Conversely, an industry with a low HHI but very stable market shares could exhibit significant barriers

[32] Berry, Gaynor, and Scott Morton (n 20) p. 46.

[33] Lianos and others (n 19) p. 268.

[34] The court writes how the concept of the relevant market relies on implies "effective competition between the products which form part of it and this presupposes that there is a sufficient degree of interchangeability between all the products" on the market, and that these products should be "regarded as interchangeable or substitutable by the consumer". *Case T-340/03* France Télécom SA v Commission of the European Communities *ECLI:EU:T:2007:22* Case T-340/03, para 80-81.

[35] Bresnahan (n 20) 1046.

[36] *Case T-684/14 Krka Tovarna Zdravil Dd v European Commission ECLI:EU:T:2018:918* Case T-684/14, para 374; *Case C-439/09 Pierre Fabre Dermo-Cosmétique SAS v Président de l'Autorité de La Concurrence ECLI:EU:C:2011:649* Case C-439/09, para 19.

[37] "One of the chief objections to 'concentration ratios' as description of market structure is that high ratios may be consistent with considerable instability in the market shares of individual firms." Michael Gort, "Analysis of Stability and Change in Market Shares" (1963) 71(1) Journal of Political Economy 51, 91.

to entry, low consumer switching rates, entrenched market power and a low intensity of competition overall.

Responding to these issues, metrics to have been created such as the instability index (I), which measures the total amount by which the market shares of the firms changed over a given time period:[38]

$$I = \sum_{i=1}^{N} |s_{i,t} - s_{i,t-1}|$$

Yet aside from risking fragmenting our approach to measuring market structure by introducing a metric wholly unrelated to the HHI, the market instability index still does not tell the whole story. For instance, if two firms were to consistently and predictably trade the same amount of market share in each period, then the instability may appear as high, while if three firms were to trade the amount of market share over a three-cycle period, the same amount of market share would be traded every cycle and the metric would return the same value, despite the market being plausibly more competitive on account of there being more firms involved. The instability index also doesn't distinguish between an incumbent firm capturing a portion of the market from another incumbent, versus an entrant being able to do so (which may plausibly indicate a more disruptive and desirable form of competition).

3. Market Diversity

Taken in isolation, each of the above flaws is a relatively minor inconvenience, yet taken together, it is clear that the HHI metric is not satisfactory. Given that the measure has received little theoretical attention since its introduction in the 1940's,[39] this is understandable. In that light, however, it is high time for a conceptual refresh of structural metrics. This section puts forward an alternate framework for approaching market structure, which does not suffer from the flaws in the HHI outlined above.

The practice of assessing competitive situations by examining the relative fortunes of each competitor is not specific to competition law. Indeed, many disciplines which are interested in such questions have developed measures of competitive intensity which are "structural" in nature, in the sense that they are derived from market shares, or their equivalent. For the most part, these disciplines have settled on measuring diversity, rather than concentration. Ecologists, in particular, have created a number of diversity-based measures of competitive structure which may be cross-pollinated into competition law and policy.[40]

Intuitively, making the conceptual switch from concentration to diversity is simple: as markets become more concentrated, they also tend to get less diverse, and vice-versa. When concentration is measured using the HHI, concentration has a literal inverse relationship with diversity through the well known conversion from a HHI to its 'numbers equivalent', which is a measure of diversity, by taking its reciprocal.[41]

[38] Stephen Hymer and Peter Pashigian, "Turnover of Firms As a Measure of Market Behavior" (1962) 44(1) The Review of Economics and Statistics 82; See also Mariana Mazzucato and Willi Semmler, "Market Share Instability and Stock Price Volatility during the Industry Life-Cycle: The US Automobile Industry" (1999) 9(1) Journal of Evolutionary Economics 67.

[39] Ahern, Kong, and Yan (n 23) p. 5; Adelman (n 7); Finkelstein and Friedberg (n 23).

[40] Political scientists also have similar measures, see Grigorii V Golosov, "The Effective Number of Parties: A New Approach" (2010) 16(2) Party Politics 171, 173.

[41] Adelman (n 7).

Up until the early 2000s, ecological science relied on a variety of measures to quantify diversity.[42] Building on Hill's work from the late 1970s,[43] Lou Jost introduced a unified framework for measuring diversity, commonly referred to as *true diversity*,[44] which is described in the following section. Jost's work demonstrated that all existing diversity indices could be expressed as special cases of his metric through a simple algebraic transformation. This unified previous diversity metrics under a single coherent framework, and provided a consistent and interpretable approach for studying diversity. This contribution applies the literature on ecological diversity measures to competition law.[45]

Conceptually speaking, diversity is a broader and thicker concept than concentration, in the sense that there are several different ways in which a market can be diverse but only one way in which a market can be concentrated. For instance, while shifts in market share from smaller firms to larger firms will increase concentration, diversity can be increased by boosting the number of firms in a market, evening out the market shares of firms, adding product variety, or in yet other ways as will be discussed. Thus while measures of concentration can be related directly to measures of diversity, the same cannot be said in reverse.

This section introduces the concept of diversity and describes several metrics which may be of interest to courts, competition authorities and competition law academics. It is split into two parts, relating to intra-market and inter-market diversity respectively. Section 3.1 explains the basic measures of diversity as developed by ecologists, and considers how they may be applied to measure the diversity of a particular market. Section 3.2 then moves on to exploring measures of diversity that operate across several markets, and explores how such measures can be applied over space and over time. The normative content of diversity measures are dealt with later, in Section 4.

3.1. Intra-market diversity

Intra-market diversity refers to the diversity of competitors within a particular market. This may vary according to how many competitors there are, the relative commercial success of those competitors, and the differences between their competitive offers. The conceptual elasticity of diversity means that there are a family of metrics to measure it, which can take into account its various different aspects. These metrics are described below.

3.1.1. Measuring intra-market diversity

Diversity can be broken down into two independent components; richness and evenness.[46] Richness is how many different competitors there are. Hence, a market with one hundred competitors would be considered rich, regardless of the distribution of their market shares. Evenness, on the other hand, is how equally the market is spread between those competitors. An even market would be one in which most firms have a similar market share.

Diversity can be measured using the "true diversity" index ${}^{q}D$, also known as alpha diversity, which gives the "effective number of competitors" in a market. It returns a number from

[42] These included the Gini-Simpson Index and Shannon Diversity, among others.

[43] MO Hill, "Diversity and Evenness: A Unifying Notation and Its Consequences" (1973) 54(2) Ecology 427.

[44] True diversity is also known as the 'effective number of competitors', or the 'Hill number', and in economics as the 'numbers equivalent'. Lou Jost, "Entropy and Diversity" (2006) 113(2) Oikos 363; Adelman (n 7); Hill (n 43).

[45] This strand of the ecology literature was also recently, and independently, uncovered by Ahern et al., who applied it in economic settings to understand market concentration across the US labour market. Ahern, Kong, and Yan (n 23).

[46] Jost, "Entropy and Diversity" (n 44); Drawing heavily from Hill, as discussed below. Hill (n 43).

0 to infinity representing how many "effective" competitors there are in the market. The parameter q is known as the 'order' of diversity, and controls the relative importance of the richness and evenness components, which in turn, affects how effective each competitor is considered to be. Intuitively, the parameter q corresponds to the degree of bias towards larger firms, or in other words, how much more of an "effective competitor" is a larger firm than a smaller firm.

At lower orders, richness has more of an effect on the index, while at higher orders, evenness does. At the extremes, ${}^0D$ is known as the richness index, which is simply the number of competitors, while ${}^\infty D$ is known as the dominance diversity, which is equal to the reciprocal of the share of the largest competitor.[47] The index is defined as follows:[48]

$$ {}^qD(S) = \begin{cases} \left(\sum_{i=1}^{|S|} s_i^q\right)^{\frac{1}{1-q}} & \text{if } q \neq 1 \\ exp\left(-\sum_{i=1}^{|S|} s_i ln(s_i)\right) & \text{if } q = 1 \end{cases} $$

Where S is a list of the market share of each competitor,[49] s_i is the market share of competitor i and q is the order of diversity. Thus, ${}^qD$ constitutes a spectrum of different metrics to measure diversity, with each placing a different weight on richness or evenness depending on the value of parameter q.

The utility of this equation lies in how it can make the "unstated theoretical commitments"[50] encoded into other diversity and concentration metrics explicit. Hill showed how earlier diversity and concentration metrics can be expressed as ${}^qD$ for some value of q, thus exposing their underlying (normative) assumptions about the relative importance of richness and evenness when it comes to distilling them down to a single number. For instance, the HHI is equivalent to $\frac{1}{{}^2D}$.[51]

To demonstrate different orders of diversity, I return to the example of the news market given in Section 2.1, where the loss of true diversity in the market is vastly different depending on which value of q is used. As shown in the following table, as q is increased from 0 (weighting only on market richness) to ∞ (weighting only on market evenness), the magnitude of the concentration event according to its effect on market diversity changes massively:

q	${}^qD$ before event	${}^qD$ after event	% reduction in ${}^qD$
0	100	10	90.0%
1	12.46	7.15	42.6%
2	6.23	6.00	3.69%
∞	5.00	5.00	0.00%

[47] Tom Leinster and Christina A Cobbold, "Measuring Diversity: The Importance of Species Similarity" (2012) 93(3) Ecology 477, p. 480.

[48] Hill (n 43) 428.

[49] Note that market shares of 0 should be removed from S, as to ensure that ${}^qD(S)$ is well defined and to prevent ${}^0D$ from over-counting by including firms which did transact at all.

[50] Hill (n 43) 431.

[51] $HHI = \sum_{i=1}^{|S|} s^2 = \frac{1}{\left(\sum_{i=1}^{|S|} s^2\right)^{-1}} = \frac{1}{\left(\sum_{i=1}^{|S|} s^2\right)^{\frac{1}{1-2}}} = \frac{1}{{}^2D}$ See Anne Chao, Chun-Huo Chiu, and Lou Jost, "Unifying Species Diversity, Phylogenetic Diversity, Functional Diversity, and Related Similarity and Differentiation Measures Through Hill Numbers" (2014) 45(Volume 45, 2014) Annual Review of Ecology, Evolution, and Systematics 297, p. 306.

The question then arises as to which value of q to use, not least since they each give different answers to the question of how diverse a market is. Multiple authors, including Jost and Ahern et al. advocate for $q = 1$ as the best general measure of diversity, for a variety of reasons, including the fact that it evenly balances between market evenness and market richness without favouring either large or small competitors.[52]

Yet, as discussed by several authors,[53] is may not be necessary to commit to a single value of q. To get an intuitive and well rounded sense of the diversity of a market, it is possible to plot a *diversity profile* which shows the number of competitors for each value of q. This gives a curve which always slopes downwards from left to right, where the steepness of the slope indicates the degree of dominance (or conversely, the absence of evenness) and the height of the curve indicating more competitors. The diversity profile for the hypothetical news market above, both before and after the event in which most small firms were removed, is shown in Figure 1.

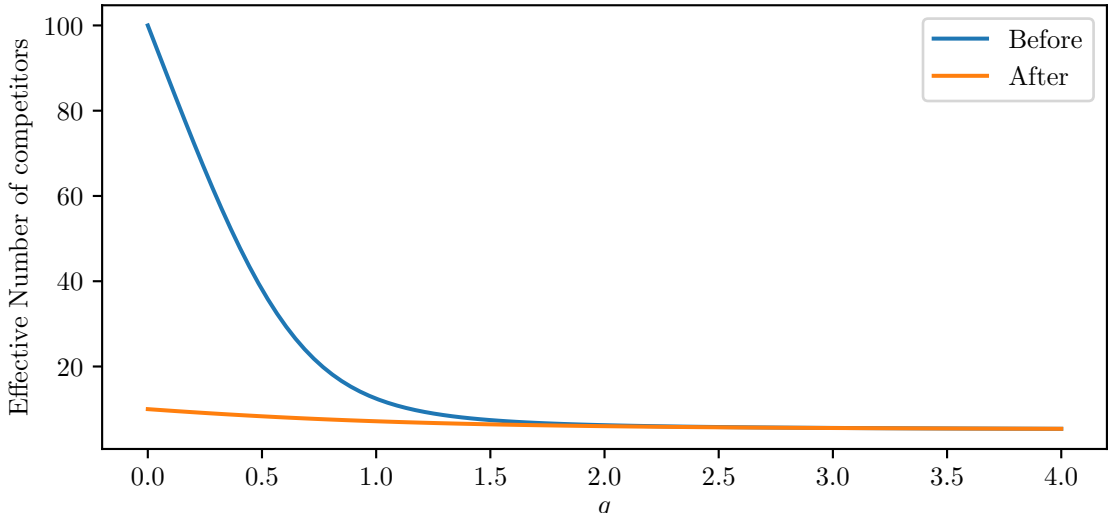


Figure 1: The diversity profile of the hypothetical news market before and after the concentration event. The diversity profiles clearly display how the distribution of firms changed over time. While for larger values of q, the true diversity barely changes, the change is dramatic for values of q closer to 0.

A comparison between the true diversity metric and existing concentration metrics will be made in Section 4.

3.1.2. Product differentiation

Both the HHI and the true diversity metric are based on an assumption that the contribution of a particular firm in a market to the 'diversity' of that market depends only on the size of its market share. This, in turn, rests upon another assumption, that of each firm producing perfectly substitutable products. Yet it may be desirable for diversity metrics to take into account the degree of difference between products;[54] surely the diversity of a

[52] Jost, "Entropy and Diversity" (n 44) p. 364-5; From a statistical point of view, Ahern et al. also note that $q = 1$ has superior statistical properties than $q = 2$. Ahern, Kong, and Yan (n 23) p. 26, Appendix 2.

[53] Ahern, Kong, and Yan (n 23) p. 20; Leinster and Cobbold (n 47) p. 483; Lou Jost, "The Relation between Evenness and Diversity" (2010) 2(2 2) Diversity 207, p. 215.

[54] See, for instance Thomas BLeary, "The Significance of Variety in Antitrust Analysis" (Federal Trade Commission, 18 May 2000) ⟨https://www.ftc.gov/news-events/news/speeches/significance-variety-antitrust-analysis⟩ accessed 1 July 2025.

market in which five firms produce five very different products is higher than one in which five firms produce perfectly identical products. From a competition policy perspective, product heterogeneity is important to take into account because first, it can help understand the actual amount of consumer choice in a market which is likely to be higher in the case that products are differentiated, and second, it can indicate when products are highly dissimilar and therefore less likely to provide a competitive constraint on each other as a result of their heterogeneity.[55]

Unsurprisingly, given that living species can co-exist with varying degrees of similarity, theoretical ecology has incorporated the notion of differentiation into the metrics described above. Leinster and Cobbold present a 'similarity-sensitive' true diversity metric which takes into account the amount of differentiation between competitors expressed as a matrix $\mathbf{Z}$, where $\mathbf{Z}_{i,j}$ gives the similarity of competitors i and j.[56] The output of their measure gives the equivalent number of effective totally dissimilar competitors.[57] Their metric is defined as follows:[58]

$$ {}^{q}D^{Z}(S) = \begin{cases} \left(\sum_{i=1}^{|S|} s_i \left(\sum_{j=1}^{|S|} \mathbf{Z}_{i,j} s_j \right)^{q-1} \right)^{\frac{1}{1-q}} & \text{if } q \neq 1 \\ \frac{1}{\prod_{i=1}^{|S|} \left(\sum_{j=1}^{|S|} \mathbf{Z}_{i,j} s_j \right)^{p_i}} & \text{if } q = 1 \end{cases} $$

While the method to determine $\mathbf{Z}$ for a selection of different product offerings out of scope for this discussion, demonstrating its application requires only a simple example. Imagine a market with three products, A, B and C, where each product has a market share of 33%. The effective number of competitors would then be ${}^{q}D = 3$. Now imagine that A has a similarity of 0 with B and C, but that B and C have a mutual similarity of 0.5. The similarity matrix $\mathbf{Z}$ would then look as follows:

$$ \mathbf{Z} = \begin{array}{c} \\ A \\ B \\ C \end{array} \begin{array}{c} \begin{array}{ccc} A & B & C \end{array} \\ \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0.5 \\ 0 & 0.5 & 1 \end{bmatrix} \end{array} $$

The order-1 effective number of totally dissimilar competitors in such a market would be 2.29, indicating that the market is less diverse when (the lack of) product differentiation between A, B and C is taken into account. The potential competition law and policy implications of taking heterogeneity into account will be considered in Section 4.

3.2. Inter-market diversity

An important question for ecologists is how diversity changes over a region, or between different environments. For instance, an ecologist may be interested in how a disturbance to

[55] Bresnahan (n 20) 1046.

[56] Competitors i and j are totally dissimilar if $\mathbf{Z}_{i,j} = 0$ and totally similar if $\mathbf{Z}_{i,j} = 1$. Leinster and Cobbold (n 47) p. 479.

[57] ibid p. 478.

[58] The quantity $\sum_{j=1}^{|S|} \mathbf{Z}_{i,j} s_j$ measures the relative abundance of competitors which are similar to i. In cases where the values of $\mathbf{Z}_i$ are all close to 0, indicating that all competitors are dissimilar from i, then this value will be also close to 0 (and vice versa). ibid p. 479.

the environment, such as a river or a road, affects the diversity of species around it. Likewise, they may wish to know how similar two different areas of rainforest are, such as one located in the Amazon, and another on the west coast of Britain.[59] To answer questions such as these, ecologists have developed the concepts of alpha, beta and gamma diversity. Alpha diversity is the true diversity defined as ${}^{q}D$ above, and measures the diversity within a given environment. Gamma diversity is the total diversity of a region, consisting of an assemblage of many sub-environments each with its own alpha diversity. Beta diversity, also known as aggregate diversity, is a measure of the relative change of diversity between the different environments in a region, or alternately, the effective number of distinct communities of species within an assemblage of sub-environments.[60] The relationship between alpha, beta and gamma diversity is shown in Figure 2.

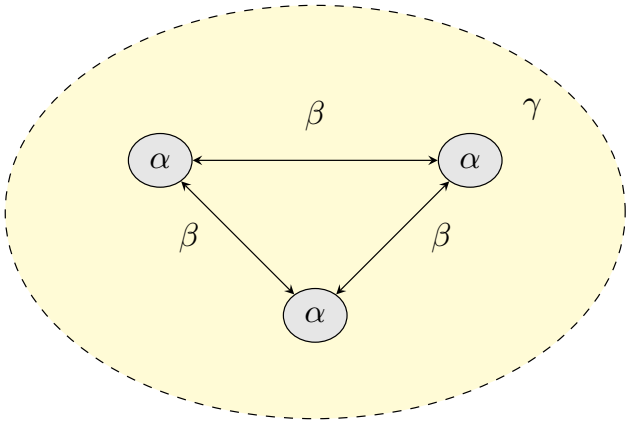


Figure 2: A graphical representation of the relationship between alpha diversity (${}^{q}D_{\alpha}$), beta diversity (${}^{q}D_{\beta}$) and gamma diversity (${}^{q}D_{\gamma}$).

The same concept can be applied in an economic setting, hence in the following I will refer to 'markets' as opposed to 'environments'.[61] In this context, ${}^{q}D_{\alpha}$ is the effective number of competitors in a single market, ${}^{q}D_{\gamma}$ is the total number of effective competitors across all markets studied, ${}^{q}D_{\beta}$ corresponds to the effective number of distinct market regimes across the markets. If, for example, there were n distinct markets which all had the same firms competing with roughly the same market shares, then the beta diversity would be 1 since there would be just one effective market repeated n times, but on the other hand, if there were the same number of markets but where each market had a distinct set of firms, then the value would be n since there would be n effective markets. The relationship between alpha, beta and gamma diversity is expressed as:[62]

$$ {}^{q}D_{\gamma} = {}^{q}D_{\bar{\alpha}} \times {}^{q}D_{\beta} \tag{1}$$

Where ${}^{q}D_{\bar{\alpha}}$ is the weighted average of the alpha diversity of each of the markets in the sample. Intuitively, this means that the total diversity of all the markets aggregated together is equal to the average diversity of each separate market multiplied by effective number of distinct markets in the sample.

[59] Indeed, many parts of the west coast of Britain have small parts vestigial rainforest which was not cleared over successive generations of industrial development. Guy Shrubsole, *The Lost Rainforests of Britain* (William Collins 2023).

[60] Jost, "Partitioning Diversity into Independent Alpha and Beta Components" (n 26) p. 2431.

[61] See also Ahern, Kong, and Yan (n 23) p. 31.

[62] Jost, "Partitioning Diversity into Independent Alpha and Beta Components" (n 26) 2431.

The value of ${}^{q}D_{\bar{\alpha}}$ can be calculated by assigning each market a weight, for instance, according to the total revenue of all firms in the market, and using the following equation to find the weighted average of their alpha diversities:[63]

$$ {}^{q}D_{\bar{\alpha}}(S) = \begin{cases} \left[\frac{\sum_{j=1}^{|S|} w_j^q \sum_{i=1}^{|S|} s_{ij}^q}{\sum_{i=1}^{|S|} w_i^q} \right]^{\frac{1}{1-q}} & \text{if } q \neq 1 \\ exp\left[\sum_{j=1}^{|S|} \left(-w_j \sum_{i=1}^{|S|} s_{ij} ln(s_{ij}) \right) \right] & \text{if } q = 1 \end{cases} \tag{2} $$

In the above equation, $s_{i,j}$ is the market share of firm j in market i. The gamma diversity can be calculated by taking the weighted average of the pooled data:[64]

$$ {}^{q}D_{\gamma}(S) = \begin{cases} \left[\sum_{i=1}^{|S|} \left(\frac{\sum_{j=1}^{|S|} s_{ij}}{|S|} \right)^q \right]^{\frac{1}{1-q}} & \text{if } q \neq 1 \\ exp\left[\sum_{i=1}^{|S|} - \left(\sum_{j=1}^{|S|} w_j s_{ij} \right) ln\left(\sum_{j=1}^{|S|} w_j s_{ij} \right) \right] & \text{if } q = 1 \end{cases} \tag{3} $$

Re-arranging Equation 1, we can then find the beta diversity:

$$ {}^{q}D_{\beta} = \frac{{}^{q}D_{\gamma}}{{}^{q}D_{\bar{\alpha}}} \tag{4} $$

These concepts can let us measure the average effective number of competitors across a group of markets (${}^{q}D_{\hat{\alpha}}$), the effective number of different markets (${}^{q}D_{\beta}$), and the total effective number of competitors across all markets (${}^{q}D_{\gamma}$). To demonstrate, imagine a trading bloc with four countries $C_1, \ldots, C_4$. Within the trading bloc, there are six firms active within the market with the following market shares (graphically visualised in Figure 3a):[65]

	Firm 1	Firm 2	Firm 3	Firm 4	Firm 5	Firm 6
C_1	74.8	0.0	23.2	1.6	0.3	0.0
C_2	0.0	64.4	35.6	0.0	0.0	0.0
C_3	0.0	0.1	0.0	0.4	33.4	66.1
C_4	0.0	0.0	5.3	63.8	30.9	0.0

Table 2: Market shares (in percentages) of six firms competing in the national markets of four fictional countries.

In this case, assuming for simplicity that the size of the market, and hence the weight, of each country is the same,[66] the order-1 diversities would be as follows:

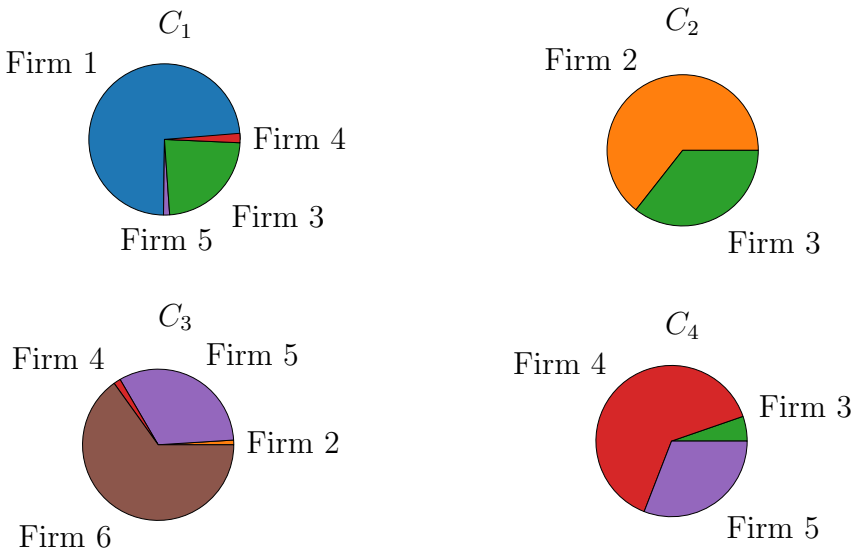
$${}^{1}D_{\bar{\alpha}} = 2.0$$
$${}^{1}D_{\beta} = 3.0$$
$${}^{1}D_{\gamma} = 6.0$$

As such, the bloc can be said to have 3.0 effective markets, each with 2.0 effective competitors, and all the countries in the bloc combined having a 6.0 effective competitors in total, as shown in Figure 3b.[67]

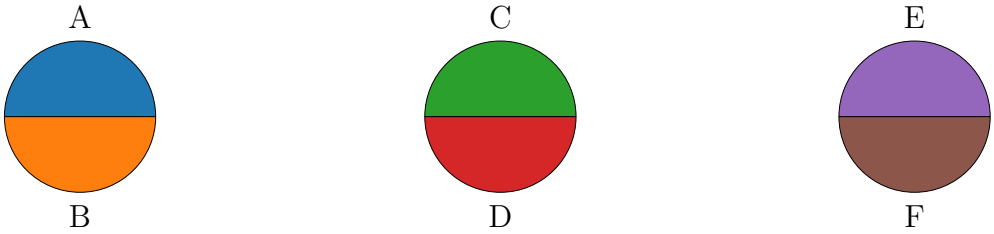
From a competition law perspective, there are several applications of beta diversity. The following two sub-sections will consider, from a methodological perspective, how beta diversity can be used to answer questions about how markets vary over geographic space, and over time.

[63] Jost, "Partitioning Diversity into Independent Alpha and Beta Components" (n 26) 2433.

[64] Note that the gamma diversity is only valid for $q \neq 1$ when all weights are equal, hence the weights are omitted when



(a) Market shares for C_1, C_2, C_3, and C_4.



(b) Three effective markets with two effective competitors each.

Figure 3: The market shares of firms in $C_1, \ldots, C_4$ and their effective equivalent markets.

3.2.1. Inter-market diversity over space

When applied to an assemblage of geographically distinct markets, beta diversity can be used to determine how many effective markets there are in the assemblage, and thus quantify the level of structural differentiation between those markets. In other words, how similar are those markets in terms of which firms are competing and their relative levels of success? Other applications are possible too, but they will be considered in Section 4.

Market integration is a core goal of EU competition law.[68] The recent Draghi report noted that despite the importance of the EU's single market as a "core building block" of European

$q \neq 1$. Jost, "Partitioning Diversity into Independent Alpha and Beta Components" (n 26) 2433.

[65] This example is inspired by that given in Ahern, Kong, and Yan (n 23).

[66] For instance, if the total value of sales in each country was the same.

[67] Aggregate diversity measures can also integrate product similarity as described in Section 3.1.2. These are not covered here in the interests of space, but the interested reader is directed towards Marcon et al. Eric Marcon, Zhiyi Zhang, and Bruno Hérault, The Decomposition of Similarity-Based Diversity and Its Bias Correction (20 May 2014) ⟨https://agroparistech.hal.science/hal-00989454⟩ accessed 3 March 2025, and; Reeve et al. Richard Reeve and others, "How to Partition Diversity" (8 December 2016).

[68] Or Brook, *Non-Competition Interests in EU Antitrust Law: An Empirical Study of Article 101 TFEU* (Cambridge University Press 2022) p. 36; "on a number of occasions the Court has held agreements aimed at partitioning national markets according to national borders or making the interpenetration of national markets more difficult, in particular those aimed at preventing or restricting parallel exports" as contrary to EU competition law. *Joined Cases C-468/06 to 478/06* Sot Lelos Kai Sia v GlaxoSmithKline *ECLI:EU:C:2008:504* Joined cases C-468/06 to C-478/06, para 65. See also paras 4 and 55-57. See also Consten & Grundig, where the Court held that agreements which "tend to restore the national divisions in trade between member states might be such as to frustrate the most fundamental objectives of the community". *Case C-56/64* Consten and Grundig v Commission ECLI:EU:C:1966:41, para. 8.

competitiveness,[69] it has remained stubbornly fragmented for decades.[70]

The report singled out the EU's telecoms market as being particularly segmented among the Member States due to regulatory constraints which serve to entrench boundaries between national markets and hamper free competition within the single market.[71] Yet while the report is likely directionally correct in saying that the "34 mobile network operator groups in the EU" are too many,[72] applying the concepts of alpha, beta and gamma diversity would allow an interested party to ascertain exactly how integrated the single market is by expressing in terms of the number of effective competitors across a number of effective markets. In other words, a relevant authority could determine that the single market is actually equivalent to ${}^{q}D_{\beta}$ effective markets, each composed of ${}^{q}D_{\bar{\alpha}}$ effective mobile operators, which in combination amount to ${}^{q}D_{\gamma}$ effective competitors across the whole bloc. This technique is applicable not only for the telecoms sector, but indeed in any market study or investigation where the amount and distribution of competition is relevant. The normative implications of this possibility, and further potential applications of aggregate diversity, are discussed in the Section 4.

3.2.2. Inter-market diversity over time

One issue with the HHI, as discussed in Section 2.4, is that its atemporal nature means that it may remain relatively stable over time despite large changes to the competitive structure of the market.[73] The degree to which a set of market shares changes over time is important, since it can indicate whether the market is *actually* contestable in practice. While market shares alone cannot definitively indicate competition problems, it is nevertheless the case that the longer that market shares are static for, the higher the likelihood that barriers to entry or other impediments to competition are present. As noted in Section 2.4, metrics like the Instability Index were created to address the atemporality of the HHI,[74] yet the metric struggles with scenarios involving consistent market share exchanges and lacks consideration for richness and evenness, leading to potentially misleading interpretations of competitiveness.

At first glance, true diversities cannot do any better. Just like the HHI, they are computed for a single time period and do not distinguish *which* firms contributed to the overall diversity, in what quantity those firms did so, and how the composition of market shares changes over time. For instance, if there was a market with two firms which spanned two time periods, where one firm had a monopoly in the first time period, while the other had a monopoly in the second time period, the effective number of competitors would be 1 in both time periods (irrespective of q).

To remedy this issue, we can compute alpha, beta and gamma diversity not for an assemblage of markets spread over the geographical dimension, but rather one spread over a temporal dimension. In other words, instead of considering markets which are distinct in geographical

[69] Mario Draghi, "The Future of European Competitiveness - In-depth Analysis and Recommendations" (September 2024) ⟨https://commission.europa.eu/topics/strengthening-european-competitiveness/eu-competitiveness-looking-ahead_en⟩ accessed 30 September 2024, 17.

[70] Mario Draghi (n 69) 8; Enrico Letta, *Much More than a Market* (2024) ⟨https://dorie.ec.europa.eu/en/details/-/card/8000605⟩ accessed 13 February 2025, p. 3.

[71] Mario Draghi (n 69) 31, 35.

[72] ibid 31.

[73] "One of the chief objections to 'concentration ratios' as description of market structure is that high ratios may be consistent with considerable instability in the market shares of individual firms." Gort (n 37) 91.

[74] Hymer and Pashigian (n 38); See also Mazzucato and Semmler (n 38).

or product space, the approach considers the same market at distinct points in time. In this case , ${}^{q}D_{\bar{\alpha}}$ is the average number of effective competitors over the whole timespan, ${}^{q}D_{\gamma}$ is the total number of effective competitors that existed over the whole timespan, and ${}^{q}D_{\beta}$ is equal the number of effective markets across the timespan (or the number of different market regimes which occurred). This approach allows for the consummation of market diversity (and market concentration) with (observed) market contestability under a single framework.

Assessing the diversity of a market over time also allows for the *rate* of that change to be assessed. The rate of change in the structure of a market - also known as its dynamism - is important for competition authorities to assess, because which competition policies or remedies may be prudent for a given market may depend on the 'stage' of the industrial lifecycle it is at, and whether markets are actually contestable in practice. Given such a metric, competition regulators could ask themselves questions such as: *Have firms been able to enter this market and successfully establish themselves as competitors? Or, are the largest firms in a market secure and stable incumbents, or are they constantly vying for market share?*

Structural metrics which can give an insight into these questions could be of great utility to competition authorities and courts, since using nothing more than market shares, they could give a first look at whether dynamic competition has occurred in markets. By dividing the beta diversity - the number of effective markets - by the time period over which the market was measured, we can derive the rate of change of the market's diversity, in market regimes per unit time, which I will call as the "churn rate". For a market with beta diversity ${}^{q}D_{\beta}$ occurring over time duration t, we can measure the churn rate C_q as:

$$C_q = \frac{{}^{q}D_{\beta} - 1}{t}$$

The rest of this section contains various examples to illustrate these concepts.

Example 1: Cycling monopolies. Imagine a scenario in which there are four firms, each of which holds a monopoly position in a market for one time period before passing it onto the next firm.

	Market Shares			
Time period	Firm 1	Firm 2	Firm 3	Firm 4
1	1	0	0	0
2	0	1	0	0
3	0	0	1	0
4	0	0	0	1

Table 4: The market shares of four firms in a hypothetical scenario where each of the firms holds the monopoly for one time period before it is passed to the next firm.

Finding the aggregate diversity of this market gives an average of one effective competitor (${}^{q}D_{\bar{\alpha}} = 1$), a total of four effective competitors overall (${}^{q}D_{\gamma} = 4$), and hence four effective

markets (${}^{q}D_{\beta} = 4$).[75] On account of the market shares of each firm active in the market being even (there is only ever one firm active), the effective number of competitors does not vary with q. Computing the churn rate (where the duration for which the market changed was $t = 3$) gives a rate of change of one regime per unit time, which is intuitively correct, since there was a new monopoly in every time period. Note that it is necessary to subtract 1 from the beta diversity because there is always at least one effective market in the sample (because by definition, ${}^{q}D_{\bar{\alpha}} \leq {}^{q}D_{\gamma}$).[76]

Example 2: Incumbent disruption. In the first scenario, firms either had a monopoly or were excluded from the market, which meant that the order of diversity used (q) did not affect the effective number of competitors, because the ratio of market richness to market evenness was the same (both were always 1). In the second scenario, we change the relative firm sizes such that the ratio between market evenness and richness is no-longer fixed, so as to demonstrate how the true diversity values of different orders vary. The scenario spans two periods, where initially, the market is dominated by a large player with 80% market share, with four laggard firms holding a 5% market share making up the rest. In the second period, the market moves to each firm having an equal market share, indicating that the incumbent has been disrupted:

	Market Shares				
Time period	Firm 1	Firm 2	Firm 3	Firm 4	Firm 5
1	0.8	0.05	0.05	0.05	0.05
2	0.2	0.2	0.2	0.2	0.2

As before, the q parameter adjusts the sensitivity of the metric to the size of the firm. This means that when q is larger, changes in market shares among larger firms will elicit larger shifts in ${}^{q}D_{\beta}$, and vice-versa when q is smaller. In this scenario, the order zero diversity remains constant throughout the scenario (since there are 5 firms in the market). As q is increased, the sensitivity to evenness increases such that the change in evenness between the two time periods is reflected in the metrics for values of $q > 0$. The true diversities for this scenario are given in the following table:

q	${}^{q}D_{\bar{\alpha}}$	${}^{q}D_{\beta}$	${}^{q}D_{\gamma}$	C_q
0	5.00	1.00	5.0	0.00
1	3.30	1.21	4.0	0.21
2	2.35	1.36	3.2	0.36

Note that the churn rate is higher for larger values of q, since the change in the market shares is more dramatic for the largest firm than for the smaller firms. Varying q allows us to discover the churn rate for larger and smaller firms respectively, as the next scenario will further illustrate.

[75] The beta diversity can also be interpreted as the amount of market regiemes that a market has transitioned through in the sample.

[76] Jost, "Partitioning Diversity into Independent Alpha and Beta Components" (n 26) p. 2428; Ahern, Kong, and Yan (n 23) p. 33.

Example 3: Challenger disruption. In the final scenario, we restrict the disruption only to small firms. This is akin to a market where an incumbent has a strong moat, but small challengers are nevertheless able to enter the market and compete with each other.

	Market Shares				
Time period	Firm 1	Firm 2	Firm 3	Firm 4	Firm 5
1	0.65	0.35	0.00	0.00	0.00
2	0.65	0.15	0.13	0.05	0.02

In this case, the level of churn is higher for lower values of q, since the stable market share of the largest firm stabilises the number of effective competitors for higher levels of q:

q	${}^qD_{\bar{\alpha}}$	${}^qD_{\beta}$	${}^qD_{\gamma}$	C_q
0	3.50	1.43	5.00	0.43
1	2.35	1.09	2.56	0.09
2	1.98	1.03	2.04	0.03

The difference between C_2 in examples 2 and 3 illustrates how the q value of the true diversity captures not only the magnitude of structural disruption in a market, but also where that disruption occurs: among established incumbents or among emerging challengers.

Example 4: Mobile operating systems. This section applies the diversity metrics given above to the market for mobile operating systems. This market was chosen because of its clear transition from a competitive market prior to around 2015 to a stable duopoly dominated by Google's Android and Apple's iOS afterwards. Figure 4 plots the market shares over time.[77]

Using the metrics in Equations 2-4, the alpha, beta and gamma diversities can be computed for the market over that time period, and are given Table 5. Churn is displayed in milliregimes per year.

Order	Alpha Diversity	Beta Diversity	Gamma Diversity	Churn (mr/y)
0	7.156	1.118	8.000	7.487
1	2.822	1.285	3.627	18.111
2	2.187	1.245	2.723	15.552

Table 5: The alpha, beta and gamma diversities, as well as the churn rate, for the mobile operating systems market between 2009 and 2025, as depicted in Figure 4.

The average order-1 alpha diversity over the time period was 2.82, meaning that there were on average just under three competitors in the mobile operating system market at a time. The order 1 gamma diversity was 3.63, indicating that throughout the whole period there was a total diversity of around three and a half competitors. The beta diversity, following ${}^qD_{\beta} = \frac{{}^qD_{\gamma}}{{}^qD_{\alpha}}$ was around 1.29, indicating a modest amount of disruption, despite the fact that the market remained essentially composed of the same players over the time period.

[77] Statista, "Market Share of Mobile Operating Systems Worldwide from 2009 to 2024, by Quarter" ⟨https://www.statista.com/statistics/272698/global-market-share-held-by-mobile-operating-systems-since-2009/⟩ accessed 17 February 2025.

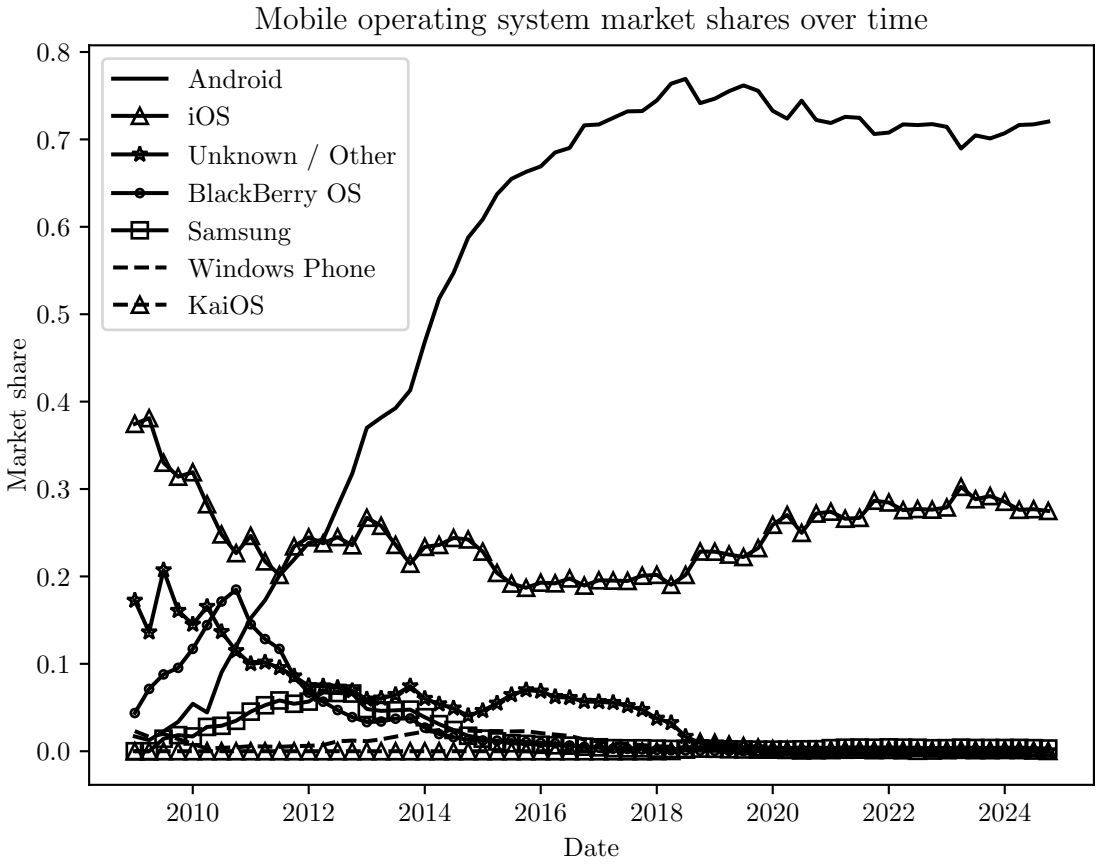


Figure 4: Market shares of mobile operating systems between the 2009 and 2025 (Source: Statista).

Yet these figures are statistics over a 20 year time period, over which the dynamics of the market changed a lot. For instance, we can see that the market undergoes a transition from a more competitive regime where market shares are relatively volatile (between 2009 and around 2015), to one where market shares are stable as the market settles into a duopoly (from around 2015 onwards). We can quantify the difference in these regimes by examining the alpha, beta and gamma diversities, as well as the churn rate at different times. The results are very different in the first five years when there was a lot of disruption versus (Table 6) in the last five years where there was not (Table 7).

Order	Alpha Diversity	Beta Diversity	Gamma Diversity	Churn (mr/y)
0	6.900	1.014	7.000	3.053
1	4.782	1.098	5.252	20.679
2	4.082	1.129	4.611	27.262

Table 6: The alpha, beta, and gamma diversities, as well as the churn rate, for the first five years in the mobile operating system dataset (shown in Figure 4).

Order	Alpha Diversity	Beta Diversity	Gamma Diversity	Churn (mr/y)
0	7.238	1.105	8.000	21.044
1	1.887	1.001	1.889	0.246
2	1.690	1.001	1.691	0.139

Table 7: The alpha, beta, and gamma diversities, as well as the churn rate, for the last five years in the mobile operating system dataset (shown in Figure 4).

The order 1 and 2 churn is at 20.7 and 27.3 milliregimes/yr respectively over the first five years, with an average diversity of 4.8 and 4.1 competitors respectively. This indicates that while the market may have been relatively concentrated, there was significant degree of churn among the players suggesting the presence of dynamic competition. However, the same metrics show almost zero churn for the last five years of the dataset, with an average effective number of competitors of 1.9 and 1.7 respectively, showing how the market later stagnated into a duopoly with little dynamism.

Interestingly, the order 0 metrics show a rather different picture, with the effective number of competitors being higher in the last five years than the first five years of the dataset and the churn rate being higher over the second period. This is the case because the order-0 metrics are sensitive only to market entries and exits. During the first five years, there were no exits, and only one entry which occurred towards the start of the sample (Samsung OS), meaning that the ${}^0D_{\bar{\alpha}}$ is almost equal to ${}^0D_{\gamma}$ resulting in an order-0 beta diversity of close to 1 (the lowest possible value). In contrast, the the last five years featured two market exits (BlackBerry OS and SeriesX0), which resulted in ${}^0D_{\beta}$ being higher.

This example illustrates two facets of true diversity metrics. First, that order-0 diversity metrics are highly sensitive to small firms which may not have a large impact on the actual competitive conditions in the market. Second, that the churn metric is a measure of the magnitude of change, but not the direction of change; the order-0 churn is high in the last five years of the sample despite firms exiting, not entering, the market.

4. Applicability to competition law

Having introduced the concept of market diversity and described metrics to measure it, this section now makes a descriptive and normative argument for why, on both a practical and conceptual level, diversity should be preferred to concentration as a structural measure of competitive intensity. It also outlines various ways in which diversity metrics may be of use in competition law, regulation and policy.

It is important to emphasise, before proceeding, the conceptual separation between the descriptive and normative aspects of diversity measures. The diversity metric outlined in the previous sections of this paper is, first and foremost, a descriptive measure of market structure. Alpha diversity can function as a drop-in replacement for the HHI and other concentration metrics, and as this section will argue, is a better alternative on a purely descriptive level. This application of market diversity has little to no normative content, or in other words, diversity is a metric rather than a goal. Indeed when $q = 2$, the true diversity metric encodes exactly the same degree of normative bias towards evenness over richness as the HHI does (as discussed in Section 3.1.1).

This section starts by arguing, on that descriptive basis, how market diversity measures are more intuitive than market concentration measures. It then moves on, however, to more

normative concerns. It highlights the value of the richness and evenness sub-components of diversity for competition policy. It then moves on to discuss how diversity metrics do not necessarily require market shares, and therefore could help competition law move away from the relevant market concept. The potential for diversity metrics to be used in assessments of media plurality is considered next, before finally, the section turns to the theoretical underpinnings and potential applications of aggregate diversity and market churn.

4.1. Simple and intuitive units

Perhaps the most obvious and immediate benefit of diversity metrics over concentration metrics is the unit by which they are measured. Concentration metrics are unitless, and as described in Section 2.2, return values which carry little intuitive or practical meaning. Diversity metrics, on the other hand, measure the effective number of competitors (or undertakings), which is the number of equally sized competitors that the market is equivalent to. Such a unit is useful for three reasons.

First, the effective number of competitors is easy to grasp.[78] Describing the expected structural effect of a merger using the HHI might show market concentration increasing from, for example, 0.2 to 0.23. Expressing that same effect using market diversity on the other hand, might show the effective number of competitors dropping from 5.4 to 4.5.[79] The diversity measure characterises the merger as losing almost one effective competitor, which is a far more tangible, informative, and intuitive measure than market concentration increasing by 0.03.

Second, the effective number of competitors is a normalised unit, which makes inter-market comparisons intuitive. As described in Section 2.2, the HHI delta generated by a merger in a concentrated market is typically smaller than the HHI delta of an equivalent merger in a less concentrated market. There is, therefore, potential for diversity measures to make merger guidelines more conceptually simple, both for undertakings and enforcers. Instead of specifying HHI thresholds, competition authorities could, for example, specify that any merger which drops the number of effective competitors in a market below 5, or which involves the loss of more than 0.5 effective competitors, will be scrutinised.

The quality of having normalised units also extends to aggregate diversity. Both alpha and gamma diversity are defined in terms of the effective number of competitors. Beta diversity, on the other hand, is defined in terms of the effective number of markets, each with n equal competitors where n is the mean alpha diversity of the ensemble of markets being analysed. Again, the *effective* number unit hence facilitates inter-market comparison. For instance, one could compare the number of effective regional markets and the number of effective competitors in those markets in one country, to those found in another country.

Third, existing measures of market concentration can be converted into true diversities through simple algebraic transformations (such as taking the reciprocal of the HHI to get ${}^2D$).[80] This means that existing thresholds can be easily converted from a concentration-based approach to a diversity based approach, without the content of the threshold changing at all.

While the HHI and other concentration metrics are easy to compute, one potential drawback

[78] Chao, Chiu, and Jost (n 51) p. 305-6; Ahern, Kong, and Yan (n 23) p. 6.

[79] The hypothetical merger in question takes the market shares from $[25, 25, 20, 15, 10, 5]$ to $[25, 25, 25, 20, 5]$.

[80] Chao, Chiu, and Jost (n 51) p. 306.

of diversity indices is that their formulae are a little more obscure. In my view, the choice of a simple formula which produces harder to interpret results, or a more complex formula which produces easier to interpret results, is a question about the distribution of interpretative labour. In other words, should the burden to understand market structure fall on the person computing the metric, or on the person interpreting the metric? There is no 'right' answer to such a question. Yet since structural metrics are likely to be computed just once, yet interpreted many times, and since the calculations themselves them can be easily automated by computers, it seems to me that there is a strong argument to favour the easy interpretation of diversity metrics, rather than easy computation of concentration metrics.

4.2. The value of richness and evenness

As described in Section 2, the HHI makes "implicit assumptions to compress [richness and evenness] into a single summary statistic of concentration" because its squared term is more sensitive to the market shares of larger firms, hence "the importance of evenness is overweighted and the importance of richness is underweighted".[81] The HHI's bias towards evenness likely made sense when it was formulated, after all, its originators were principally concerned with inter-firm inequality, not the number of competitors.[82] Yet the implicit assumption regarding the balance of richness and evenness currently encoded into the HHI is problematic because when it comes to market competition, both the evenness and richness aspects of market diversity are important, and both are relevant to competition policy.

One hardly needs to make an argument to for market evenness - that *ceteris paribus* markets without dominant firms are normatively preferable to those with dominant firms - especially considering that existing metrics already overemphasise it. The argument for richness, however, is worth re-stating.

Theoretically, richness is fundamental to the process which evolutionary economics describes as "parallel experimentation",[83] where firms continually "tinker"[84] with their competitive offering as they seek to continually find more effective business models. This is what makes markets, as famously argued by Hayek, a discovery procedure.[85] In brief, the argument for richness is that with only a few firms competing, only a small number of strategies can be tried and little of the 'search space' can be explored. That a *plurality* of firms is involved in the "parallel development" of competing offerings is vital from the perspective of markets being able to effectively discover and fulfil the needs of consumers,[86] which means that they are able to act as a means to aggregate information about society which can be used to coordinate consumption and production decisions.[87] The alternative, is move towards a centrally planned economy, which rarely works because it is almost always impossible to know which strategies will work best *ex ante*.[88] Again drawing from evolutionary economics, various authors have also concluded that diversity enhances the resilience of economic systems, as well

[81] See Ahern, Kong, and Yan (n 23) p. 1-2.

[82] See Herfindahl (n 10) p. 9-24.

[83] Simonetta Vezzoso and Wolfgang Kerber, "Competition and Innovation: Incorporating a More Dynamic Perspective into Enforcement" (Rochester, NY, 3 January 2025).

[84] Eric D Beinhocker, *The Origin of Wealth: Evolution, Complexity, and the Radical Remaking of Economics* (Harvard Business Press 2006) Chapters 9, 11.

[85] Friedrich A Hayek, "Competition as a Discovery Procedure" (2002 (1968)) 5(3) Quarterly Journal of Austrian Economics 9.

[86] Richard R Nelson, "Uncertainty, Learning, and the Economics of Parallel Research and Development Efforts" (1961) 43(4) The Review of Economics and Statistics 351, p. 353.

[87] Frederick A Hayek, "The Use of Knowledge in Society" (1945) 35(4) American Economic Review 520.

[88] Nelson (n 86) p. 353.

as their ability to respond to exogenous shocks, since in more diverse sets of competitors, there is more likely to be one such undertaking that is able to respond appropriately to the shock.[89]

Arguments like this have been made many times over in the competition law literature, such as by Joseph Farrell who advocated for "econodiversity" in order to facilitate "selection through the product market",[90] and more recently by McLean who argues that much innovation comes "from below", citing the break-up of AT&T as an example of small firms successfully spawning new product markets.[91] The benefits of market richness also transcends purely economic concerns. The concept of product variety was linked to democracy by the General Court's in its decision on *Google Android*, where it emphasised the importance of product variety not only as a means to facilitate innovation-based competition on the merits, but also as being "necessary in order to ensure plurality in a democratic society".[92] Similarly, the need for a diverse range of books, containing a diverse range of ideas, was cited in the Commission's decision to challenge the *Vivendi/Lagardère* merger.[93] This issue will be considered more deeply in Section 4.4.

More recently, link between consumer choice and economic democracy has been emphasised, in that consumers with a meaningful range of options are able to "vote with their feet", and in doing so, direct the development of markets.[94] Conversely, a lack of choice creates relations of domination, where consumers are subject to the arbitrary decisions of powerful firms, without recourse to being able to transact with alternative suppliers if those decisions are unacceptable to them.[95]

The ability of diversity metrics to integrate heterogeneity information as described in Section 3.1.2 could be particularly useful for measuring consumer choice, particularly to estimate loss of consumer choice resulting from a potential merger.[96] For instance, to go back to the three firm example in Section 3.1.2, where the products of firms B and C have a similarity of 0.5, but those of firm A is completely distinct, if the firms producing A and C merged and product C was discontinued the effective number of dissimilar competitors would drop from 2.29 to 2.00, as 12.6% reduction. If, on the other hand, product A was discontinued, then the effective number of dissimilar competitors would drop from 2.29 to 1.33, a 41.8% drop. These figures are visualised in Table 8.

[89] Elias Deutscher and Stavros Makris, "Sustainability Concerns in EU Merger Control: From Output-Maximising to Polycentric Innovation Competition" (2023) 11(3) Journal of Antitrust Enforcement 350, p. 381-2; Wolfgang Kerber, "Competition, Innovation and Maintaining Diversity through Competition Law" in *Competition Policy and the Economic Approach* (Edward Elgar Publishing 2011) ⟨https://www.elgaronline.com/downloadpdf/edcollchap/edcoll/9781848448841/9781848448841.00017.pdf⟩ accessed 4 July 2025, p. 178-9.

[90] Joseph Farrell, "Complexity, Diversity, and Antitrust" (2006) 51(1) The Antitrust Bulletin 165, p, 168.

[91] Andrew P McLean, "Innovation against Change" [2024] Journal of Antitrust Enforcement jnae002, p. 386-9.

[92] *Case T-604/18* Google Android *ECLI:EU:T:2022:541* Case T-604/18, para 1028.

[93] "Commission Opens In-Depth Investigation into the Proposed Acquisition of Lagardère by Vivendi" (30 November 2022) ⟨https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7243⟩ accessed 7 July 2025.

[94] Todd Davies and Spencer Cohen, "Error Costs, Platform Regulation, and Democracy" [2025] Journal of Competition Law & Economics nhaf008, p. 6.

[95] ibid p. 7.

[96] Note that integrating heterogeneity could also help cross the bridge between structural metrics and the actual intensity of competition, since more similar products can be expected to exert a greater competitive constraint on each other. Bresnahan (n 20) 1046.

Scenario	Market Shares	${}^1D(S)$	${}^1D^{\mathbf{Z}}(S)$
A, B, C	33% each	3.00	2.29
C discontinued	50% (A), 50% (B)	2.00 (−33.3%)	2.00 (−12.6%)
A discontinued	50% (B), 50% (C)	2.00 (−33.3%)	1.33 (−41.8%)

Table 8: The impact of mergers on the effective number of competitors, with and without product similarity. Percentages in rackets give the drop in the effective number of competitors (${}^qD^{\mathbf{Z}}$) versus the scenario where A, B and C are in the market.

4.3. Beyond the relevant market

Traditionally, competition law analysis starts by defining a relevant market. Courts have commented that where different relevant markets overlap, a conventional analysis based on product substitutability may no longer be sufficient.[97] Competition law cases are increasingly occurring across the boundaries of traditionally defined markets, or between undertakings which produce complementary products, and hence simultaneously cooperate in value creation but compete for value capture.[98] Market definition, as a result, has become an increasingly difficult task in competition law cases. Conventional market concentration measures do not fare well in such situations because computing market shares requires both a well defined market, and assume that sales by one undertaking are directly comparable with sales by another.

Unlike conventional metrics of market concentration, diversity measures do not necessarily require the definition of a relevant market. While the examples in this paper used market shares as a convenient measure of firm success when computing diversity metrics, there is no requirement to do so. As a result, diversity measures are promising as alternatives to concentration measures in cases where a relevant market is difficult to define.

Diversity measures require only two ingredients: a method to determine which undertakings should be included in analysis, and a metric according to which the relative weight can be assigned to each. The former should be assessed on a case by case basis, and the appropriate methods vary based on the context. With regards to the latter, any measure available for all competitors involved may be used, such as the revenue or sales numbers of the firms involved.[99] What follows are two concrete examples of aggregate diversity metrics; their application to digital ecosystems, and their application on a macroeconomic level.

4.3.1. Digital ecosystems

With the concept of ecosystems beginning to play a more important role,[100] especially since its inclusion in the Commission's latest guidance on market definition,[101] the practice of delineating the boundaries of interest in competition law cases has begun to change, and scholars have already begun searching for new methodologies to delineate the boundaries of digital ecosystems.[102] In that regard, there is potential for aggregate diversity to be used to

[97] *Case T-604/18* Google Android *ECLI:EU:T:2022:541* (n 92) para 116-7.

[98] *Case T-604/18* Google Android *ECLI:EU:T:2022:541* (n 92) para 116-7; Ioannis Lianos, "Value Extraction and Institutions in Digital Capitalism: Towards a Law and Political Economy Synthesis for Competition Law" (2022) 1(4) European Law Open 852, p. 863-867.

[99] Ahern et al. used the number of employees, for example. Ahern, Kong, and Yan (n 23).

[100] Michael G Jacobides and Ioannis Lianos, "Ecosystems and Competition Law in Theory and Practice" (2021) 30(5) Industrial and Corporate Change 1199.

[101] Commission Notice on the Definition of the Relevant Market for the Purposes of Union Competition Law C/2024/1645 2024, p. 31.

[102] Konstantinos Stylianou and Bruno Carballa-Smichowski, "'Market' Definition in Ecosystems" [2024] Journal of Antitrust Enforcement jnae046.

determine the degree to which two markets, or ecosystems are distinct from each other.

For example, the question of whether Google's Play Store and Apple's App Store are two separate ecosystems or a single large ecosystem was discussed at length in the Commission's decision in *Google Android*.[103] There, the Commission essentially engaged in what might be described as a comparative analysis of the diversity of different app stores,[104] which considered the size of each app store, the number of apps, the popularity of the apps, and the overlap between the app stores. Each of these questions is well suited to be addressed through the diversity framework outlined here. The Commission observed that most apps which are popular on the Google Play Store are also popular on Apple's App Store too, and concluded that the ecosystems are relatively similar.[105] Calculating the value of ${}^{q}D_{\beta}$ based off of the downloads of each app within each ecosystem could provide a principled methodology to make such a determination.

4.3.2. Macroeconomic analysis

While competition authorities typically assess competition on the microeconomic scale relevant to an individual case, recent years have seen competition authorities increasingly turn their attention to measuring levels of competition on the macroeconomic scale too. Discussions about the scale at which to measure concentration (i.e. on an inter or intra-industry basis) have existed since the HHI was first conceived.[106] Aggregate diversity offers a means to sidestep this decision entirely by simply doing both; alpha diversity permits an investigation of intra-industry diversity, while gamma and beta diversity allows us to quantify inter-industry diversity. Ahern et al. demonstrate this by computing the aggregate diversity of the employment market across the entire United States, and thereby estimate the effective number of competitors, and effective number of labour markets, across the whole US economy.[107] Such techniques are especially relevant since levels of local and national market diversity have been observed to be diverging in recent years, with local diversity increasing and national diversity falling.[108] Aggregate diversity could be applied to further analyse these trends, and tease out important insights about the development of national market economies, which would naturally feed back into competition law enforcement priorities.

An example of a national competition authority engaging in such an endeavour is the UK's Competition and Markets Authority's annual State of Competition Report.[109] In its latest report, the CMA examined structural measures of market concentration across the UK economy, calculating the average CR10 index and the average HHI across all sectors.[110] Notably, in computing these metrics, both of which focus on the largest firms as described in Section 2.1, the CMA risks overlooking the contributions of smaller firms to the econ-

[103] Other app stores were also considered in the analysis.

[104] *AT40099 - Google Android*, paras 590-614.

[105] The Commission found that " large percentage of Google Android developers already develop apps for both Google Android and iOS" ibid para 555, 669.

[106] Herfindahl justified his decision to focus on the latter on the grounds that "if there is danger that monopoly power is growing; it must lie in considerable part in the possibility of concerted action by firms that are related to each other." Herfindahl (n 10) p. 16.

[107] Ahern, Kong, and Yan (n 23) p. 34-37.

[108] Esteban Rossi-Hansberg, Pierre-Daniel Sarte, and Nicholas Trachter, "Diverging Trends in National and Local Concentration" (2021) 35 NBER Macroeconomics Annual 115.

[109] Competition and Markets Authority, *The State of UK Competition Report April 2024* (2024) ⟨https://www.gov.uk/government/publications/the-state-of-uk-competition-report-2024⟩ accessed 21 September 2023.

[110] The CR10 index is the share of total revenues taken by the ten largest firms to the rest of the firms. ibid Figures 14-5.

omy.[111] A methodological shift is clearly needed, not least since the Authority noted that the turnover share of small firms in the UK economy is declining,[112] while communicating a policy interest towards trying to ensure that "smaller, younger, innovative firms" are able to "[compete] effectively with larger high-markup incumbents", observing that academic research underlining how "small firms play an important role in employment creation", and calling out the risk that a "large [number] of small mergers in very segmented industries can cumulatively have a large impact on market power in an industry".[113] The use of diversity metrics could also help the Authority in its work to develop an industrial strategy,[114] particularly in terms of the connection between economic diversity and resilience or dynamism (as described in Section 4.2).

4.4. Media plurality

The media sector has long been of concern to competition authorities and academics because of the normative and structural role that media plurality plays in liberal democracies.[115] The idea, broadly speaking, is that media markets should boast a variety of different perspectives as to permit healthy competition in the market ideas,[116] and that the media sector functions as a 'public watchdog' with regards to the functioning of society.[117] Competition law enforcement, as a result, has historically involved close scrutiny of mergers that threaten the diversity of media markets.[118]

Until recently, EU merger regulation left the protection of media plurality to discretion of Member States. The recent passage of the European Media Freedom Act (EFMA), however, marked the start of an EU-wide harmonised approach, which itself describes media pluralism as a "pillar of democracy".[119] Article 22 EFMA sets out a framework for the assessment of media mergers by obliging Member States to enact national legislation to assess the impact of media market mergers on media pluralism and editorial independence. Article 22(2a) pertains directly to mergers, and stipulates that the impact of mergers in media markets should be assessed in terms of their impact on media pluralism.

A long history of scholarship on media diversity exists, particularly relating to how market power in media markets should be measured.[120] This history includes media market specific indicators of pluralism, which typically aimed to "not have to choose between a measure of market power (the HHI) or of pluralism (the number of voices) but ought to incorporate

[111] The CR10 index ignores the long tail of the smallest firms entirely. Herfindahl (n 10) p. 8.

[112] Competition and Markets Authority (n 109) Figure E.17.

[113] ibid.

[114] ibid.

[115] See generally Konstantina Bania, "The Role of Media Pluralism in the Enforcement of EU Competition Law" (Thesis, European University Institute 2015).

[116] Davies and Cohen (n 94) p. 4-6.

[117] Regulation (EU) 2024/1083 of the European Parliament and of the Council of 11 April 2024 Establishing a Common Framework for Media Services in the Internal Market and Amending Directive 2010/13/EU (European Media Freedom Act) (Text with EEA Relevance) 2024, recital 1.

[118] Josef Drexl, "Competition Law in Media Markets and Its Contribution to Democracy: A Global Perspective" (2015) 38(3) World Competition ⟨https://kluwerlawonline.com/api/Product/CitationPDFURL?file=Journals%5CWOCO%5CWOCO2015031.pdf⟩ accessed 18 November 2024, p. 378-382.

[119] Regulation (EU) 2024/1083 of the European Parliament and of the Council of 11 April 2024 Establishing a Common Framework for Media Services in the Internal Market and Amending Directive 2010/13/EU (European Media Freedom Act) (Text with EEA Relevance) 11 April 2024, recital 2.

[120] The Valcke report presents a good summary. Peggy Valcke, "Indicators for Media Pluralism in the Member States: Towards a Risk-Based Approach" [2009] Final Report and Annexes: User Guide, MPM, Country Reports Brussels: European Commission, p. 72-80.

both".[121] In the language of theoretical ecology, this would be equivalent to finding a balance between evenness and richness. These included the Diversity Index defined by the FCC in 2003 (and later rejected by the U.S. Court of Appeals for the Third Circuit),[122] the Noam Index,[123] and the Hill Index.[124]

As a result of these shortcomings, the media-specific diversity indices described above have not been widely accepted, and that most common measure used in the media plurality literature today is the CR4 index (the ratio of the market shares of the top 4 firms to the market shares of the rest of the firms in the market).[125] For example, the annual Media Pluralism Monitor Report, a gold standard report published by the Centre for Media Pluralism and Media Freedom, uses the CR4 index to measure media market concentration.[126] This is despite a critical shortcoming of the CR4 and HHI indices, which is that they are typically defined on national markets, and therefore prone to "understate concentration in local or regional markets where fewer competitors typically operate."[127]

Although the question of exactly how to apply true diversity measures to the context of media plurality would be a large undertaking in itself and is out of scope for this paper, there are three reasons why diversity has the potential for use in terms of measuring media plurality. First, it is variably sensitive to evenness and richness, and thus with the appropriate choice of q an appropriate and explicit trade-off between them can be made.

Second, aggregate diversity measures can be used to allow an analysis of both local and national media pluralism. This could work by collecting market shares on a local level for each region in a country, and then computing the alpha, beta and gamma diversities. The alpha diversity would be the average effective number of competitors for each local region, the beta diversity would be the effective number of media markets in the studied region, and the gamma diversity would be the total number of effective media firms over the whole region. A low alpha diversity would indicate that media market concentration is high in local markets.[128] A low beta diversity would suggest a high degree of homogeneity of media markets across the whole region. A low gamma diversity would suggest that there is a low level of media pluralism across the whole region.

Third, true diversity measures can account for heterogeneity between media firms, as described in Section 3.1.2, and would entail creating a similarity matrix to map how similar each outlet is to each other outlet on a scale of 0 to 1. While the method by which such a matrix could be calculated is out of scope for this paper, one could imagine using data on the share of common ownership, or ideological similarity, to do so. Such approaches could help authorities establish the effects of a merger on "the formation of public opinion" as

[121] Eli Noam, "How to Measure Media Concentration" (4 August 2004) ⟨https://web.archive.org/web/20090930144843/http://www.ft.com/cms/s/2/da30bf5e-fa9d-11d8-9a71-00000e2511c8.html⟩.

[122] Brian C Hill, "Measuring Media Market Diversity: Concentration, Importance, and Pluralism" (2006) 58(1) Federal Communications Law Journal 169 ⟨https://heinonline.org/HOL/P?h=hein.journals/fedcom58&i=181⟩ accessed 3 July 2025; *Prometheus Radio Project v Federal Communications Commission* 373 F.3d 372.

[123] Eli M Noam, "National Media Concentrations Compared" in Eli M Noam and The International Media Concentration Collaboration (eds), *Who Owns the World's Media?: Media Concentration and Ownership around the World* (Oxford University Press 1 January 2016) p. 1029.

[124] The Hill Index is unfortunately named, and bears no relation to Hill Numbers as defined above. It is defined as the sum of the square roots of the market shares. See Hill (n 122).

[125] Valcke (n 120) p. 73.

[126] Roberta Carlini, "Why Accurate Measuring of Media Ownership Concentration Matters" (4 March 2024) ⟨https://cmpf.eui.eu/why-accurate-measuring-of-media-ownership-concentration-matters/⟩.

[127] Valcke (n 120) p. 73.

[128] As the Valcke report noted that concentration indices often overlook. ibid p. 73.

prescribed by Article 22(2) EMFA, by quantifying the amount of diversity lost when two media companies combine.

4.5. Interpreting aggregate diversity

Finally, it is worth considering how the alpha, beta and gamma diversities should be considered from a normative point of view. Economic theory, experience of tacit collusion and common sense all indicate that oligopolistic markets, i.e. those which have an effective number of competitors below around four or five, are undesirable from a competition perspective. Hence alpha diversity values (on a local level) or gamma diversity values (on a national level) which indicate oligopolistic or even monopolistic markets may raise concerns around the potential for abuses of dominance or tacit collusion.

When it comes to beta diversity, a variety of applications are possible, each of which requiring careful consideration. One clear application of beta diversity on the super-national level is the integration of the EU's Single Market. As discussed above, market integration is an explicit goal of EU competition law, yet fulfilling the goal of market integration does not necessarily mean achieving a beta diversity of 1. There could, for example, be good reasons why different national markets are contested by different assemblages of competitors, such as a result of different consumer tastes, or regulatory barriers. Likewise the presence of different "effective markets" may not indicate less competition *per se*, but rather more potential competition and less actual competition, depending on the barriers to entry in the market in question.

Fully addressing these questions lies beyond the scope of this paper, which aims primarily to introduce these concepts into the competition law discourse rather than to undertake a comprehensive analysis of their implications - an endeavour that would exceed the limitations of a single study. Other applications of beta diversity could be to ascertain how much variation there is in media markets around a country (as discussed in Section 4.4), or assess the degree of similarity (or not) between different digital ecosystems (as discussed in Section 3.2.1).

4.6. Interpreting market churn

When considering how market churn should be interpreted, we must first return to how it is calculated. As per Section 3.2, the beta diversity is equivalent to the gamma diversity (the total number of effective competitors over the whole time span) divided by the alpha diversity (the average number of effective competitors at any given time), and gives the effective number of different market regimes that occurred. As defined in Section 3.2.2, the market churn metric then divides the number of regime changes by the time over which those changes took to occur, to get an average rate of change. Hence, the more that market shares are traded between firms, the more firms enter and exit the market, and the shorter time over which those changes occur, the higher the market churn will be. The market churn metric can therefore be interpreted as a proxy for the degree of observed dynamism in a market.

Although dynamism is a under-theorised concept in competition law,[129] it is nevertheless incredibly important to its enforcement. Indeed, the rhetoric of innovation, underpinned

[129] Wolfgang Kerber, *Towards a Dynamic Concept of Competition That Includes Innovation* (SSRN Scholarly Paper, DAF/COMP/WD(2023)42, OECD 2023).

often by a Schumpeterian understanding of competition, is beginning to take an increasingly central role in the normative underpinnings of competition law,[130] often on the basis that innovation leads to growth.[131] The argument often goes - as was famously voiced in *Trinko* - that undertakings are incentivised to innovate by the promise of the potential for temporary monopoly profits, that is, until other firms replicate or leapfrog their innovations.[132] To those subscribing to this view, monopoly power is justified in markets where rivalry occurs not through static price competition, but rather through dynamic innovations.

A growing body of scholarship repudiates this view. McLean, for instance, points out that there are often significant barriers to entry in markets which undermines the "temporary" nature of monopoly profits derived from innovation, and notes that while the private sector may take innovations to market, the public sector plays "a profound role in catalysing, producing, and disseminating innovation".[133] Drawing from the political economy literature, Rikap emphasises the difference between value creation and value extraction.[134] Her work notes the increasing prevalence of "intellectual monopolies",[135] powerful firms which are able to extend their control of assets beyond their ownership of those assets through a combination of intellectual property law and digital control.[136] In other words, innovations in industries dominated by large and powerful firms may have their value captured by those firms, rather than being shared more equally among society at large.

This contribution does not make a deep theoretical contribution to that debate. It does, however, provide a means to empirically assess whether disruption has actually occurred in markets. If dynamic, innovation-based competition is working as its proponents assume, then one would expect to observe markets cycling through different regimes as rival firms progressively out-innovate each other. If, on the other hand, the fruits of innovation is consistently captured by incumbents, then those same markets may show low levels of dynamism.

This kind of outcome-oriented approach to conceptualising competition has been used by other disciplines, such as political science. There, political democracy was famously defined by Adam Przeworski as "a system in which parties lose elections",[137] characterised by "periodic winners and losers".[138] Notably, the definition goes on to explicitly exclude systems where the same party consistently wins elections.[139] Taking such a view in the context of

[130] McLean (n 91).

[131] In the UK Government's words in its latest strategic steer to its Competition and Markets Authority (CMA), "the CMA should support the positive benefits of innovation, recognising the key role it plays in driving net zero, public sector reform and economic growth." "Strategic Steer to the Competition and Markets Authority 2025" (15 May 2025) ⟨https://www.gov.uk/government/publications/strategic-steer-to-the-competition-and-markets-authority/strategic-steer-to-the-competition-and-markets-authority⟩ accessed 4 July 2025.

[132] "The opportunity to charge monopoly prices—at least for a short period—is what attracts "business acumen" in the first place: it induces risk taking that produces innovation and economic growth." *Verizon Communications, Inc v Law Offices of Curtis V Trinko, LLP* 540 U.S. 398.

[133] McLean (n 91) p. 388, 395; For the role of small firms as sources of capabilities, see also Ketan Ahuja, "Promoting Innovation Ecosystems in Antitrust: A Framework for Antitrust Analysis Applied to Emerging AI Technologies" (27 June 2024) ⟨https://rooseveltinstitute.org/publications/promoting-innovation/⟩ accessed 6 July 2025, p. 10.

[134] Cecilia Rikap and Bengt-Åke Lundvall, "Big Tech, Knowledge Predation and the Implications for Development" (2022) 12(3) Innovation and Development 389, p. 392, 396.

[135] See generally Cecilia Rikap, "From Global Value Chains to Corporate Production and Innovation Systems: Exploring the Rise of Intellectual Monopoly Capitalism" (2022) 7(2) Area Development and Policy 147.

[136] Cecilia Rikap, "A Fit-for-Purpose Platform Research Agenda for a Broken World" (2024) 1 Platforms & Society 29768624241263951.

[137] "Democracy", in Adam Przeworski (ed), *Democracy and the Market: Political and Economic Reforms in Eastern Europe and Latin America* (Studies in Rationality and Social Change, Cambridge University Press 1991) p. 10.

[138] ibid p. 10.

[139] ibid p. 10.

competition law, one could provocatively define dynamic competition as a system in which "undertakings lose market share". Competition authorities may use the churn metric to assess whether a low number of effective competitors may be justified by correspondingly high levels of churn. If not, scrutiny by competition regulators may be warranted in order to assess whether barriers to entry or anti-competitive behaviour is preventing such disruption from occurring, since theory indicates that perhaps it should be.

5. Conclusion

Structural metrics, taking into account only market shares, are inherently limited when it comes to assessing the effective functioning of competition. However, given the relative ease of obtaining market share data, such metrics nevertheless provide a useful "first impression" of market competitiveness and a lower-bound estimate as to how competitive a market may be. Despite this appeal, competition scholars have until very recently been content to rely on structural metrics, particularly the Hirschman-Herfindahl Index (HHI), which has received little theoretical attention for decades. This reliance persists despite notable flaws, including an implicit bias toward large firms, difficulties in interpretation, and atemporality.

This paper recognises that the challenge of assessing market structure is not one limited to competition law and economics, but is rather one faced by several fields. Drawing from the ecology literature, it has proposed several improvements to how competition law should conceptualise and apply structural measures of competition.

First, it argued that competition authorities and scholars should consider the structural intensity of competition not from the perspective of market concentration, but rather its inverse, diversity. It proposed metrics to calculate the 'true diversity' of a market, expressed in the effective number of competitors. This number can be weighted according to a sensitivity parameter q, which allows for explicit adjustments in how firm size influences the results given by the metric.

Second, it has shown how diversity can be measured across distinct markets, as to compute not only the effective number of competitors (alpha diversity), but also the total amount of diversity (gamma diversity) and the effective number of markets (beta diversity). These metrics could be applied to help competition authorities assess market fragmentation, whether across geographic boundaries - such as within the EU's single market - or across product boundaries such as occurs in conglomerate or ecosystem markets. Since these diversity metrics are based off the 'true diversity' described above, they can also be tuned to be variably sensitive to the size of firms.

Third, the paper proposes a "churn" metric to quantify the rate of change to market structure as measured in market regimes per unit time. This metric could serve as the foundation for legal tests of market stability and the integrity of the competitive process, enabling competition authorities to classify markets as stagnant or characterised by disruption. Again, the metric can be tuned to be variably sensitive to firm size, and hence can serve as an indicator as to whether disruption has occurred among smaller or larger market players.

Thus, while structural metrics must always be used in concert with other means of assessing the intensity of market competition, their relative under-theorisation within competition law today leaves vast room for improvement. In that spirit, this paper has shown how by incorporating metrics developed in ecology to address essentially the same questions, competition

law can adopt a more nuanced and robust approach to assessing market structure.

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