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A quadrant-based innovation index (KQM) for diagnosing structural maturity

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Abstract

Purpose – This article introduces a quadrant-based innovation index (KQM) designed to diagnose the structural maturity of national R&D systems. Unlike composite or ranking-based indices, KQM does not produce an aggregated score; instead, it positions systems within a multidimensional analytical space and conceptualises maturity as a structural position emerging from the configuration of core system dimensions. The study demonstrates that KQM enables the identification of structural differences consequential for systems' transformative potential and developmental trajectories, yet invisible in linear evaluation models.

Design/methodology/approach – Building on the Kauzon Quadrant Model, maturity is defined as a structural property arising from the alignment between innovation system capacity and workforce composition. The framework adopts a quadrant-based logic that positions national R&D systems within a two-dimensional space, distinguishing four structural configurations. It is operationalised through four indicators: a synthesised capacity dimension (R&D intensity, innovation performance, and R&D expenditure per researcher) and an analytically independent workforce composition indicator represented by the share of women among researchers.

Findings – The empirical application shows that systems with similar innovation capacity may occupy different structural positions. Differences in alignment between capacity and workforce composition distinguish consolidated, transitional and imbalanced configurations. The workforce parameter exhibits a consistent pattern across configurations, indicating a systematic association with structural maturity that remains undetected in aggregate metrics.

Originality/value – KQM advances innovation system analysis by formalising maturity as a configurational structural position rather than performance intensity. It offers a new analytical instrument for researchers and policymakers engaged in forward-looking innovation governance and technology forecasting.

Keywords Social systems, Public policy, Innovation policy, Composite indicators, Workforce composition, KQM index

Paper type Impact article

1. Introduction: from performance benchmarking to structural maturity in innovation policy

Assessing national research and development (R&D) systems is a central task in innovation policy and technology forecasting. Governments and international organisations rely extensively on quantitative indicators and composite indices to benchmark national performance, compare innovation outcomes, and inform strategic decision-making (OECD, 2015; European Commission, 2023). These instruments typically focus on measurable inputs and outputs of innovation activity, such as R&D expenditure, innovation performance scores, or research intensity.

While such indicators provide valuable descriptive information, their analytical logic remains predominantly performance-oriented and implicitly linear. Innovation system development is often interpreted as a monotonic process in which higher levels of

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expenditure, output, or composite scores signal more advanced system states (Hollanders and Es-Sadki, 2017). This interpretation is increasingly problematic, as innovation systems evolve through structural change, institutional reconfiguration, and non-linear transitions that cannot be inferred from performance intensity alone (Fagerberg *et al*., 2010).

Recent discussions in innovation policy increasingly emphasise structural transformation, directionality, and systemic reconfiguration, calling for analytical approaches that move beyond input–output intensity and capture how different dimensions of innovation systems align and stabilise over time.

As a result, countries with similar innovation scores may face markedly different future trajectories. Systems that appear comparable in terms of aggregate R&D performance may differ substantially in how innovation activities are embedded within labour markets, institutions, and sectoral configurations. These structural differences condition long-term resilience, adaptability, and transition potential, yet remain largely invisible in conventional benchmarking frameworks (Edquist, 2005; Lundvall, 1992). Consequently, innovation policy lacks analytical tools capable of distinguishing structurally mature innovation systems from systems that merely exhibit high performance under potentially unstable configurations.

This article advances the argument that innovation system maturity should be conceptualised as a structural property rather than as a performance outcome. Maturity, in this sense, reflects the degree of alignment and consolidation between key system dimensions, not the aggregate magnitude of innovation activity. Although the notion of maturity appears in innovation systems research, it is rarely operationalised explicitly as a structural condition (Malerba, 2002).

The novelty of this article lies in operationalising innovation system maturity as a configurational property rather than an aggregate performance measure. To address this gap, the article introduces the Kauzon Quadrant Model (KQM), which positions national R&D systems within a two-dimensional analytical space defined by (1) innovation system capacity and (2) workforce composition in research activities.

These dimensions are operationalised using four explicitly defined indicators. Innovation system capacity is represented by a synthesised indicator combining (1) R&D intensity, (2) innovation performance, and (3) R&D expenditure per researcher, following established measurement practices (OECD, 2015; Nardo *et al*., 2005). Workforce composition is captured by a single, analytically independent indicator: (4) the relative share of women among researchers.

Importantly, the share of women among researchers is not interpreted as a normative gender equality measure. The use of this variable should be understood in a pragmatic and empirical sense. The present study does not seek to analyse gender differences or contribute to debates in gender theory. Instead, the indicator is employed because it represents a stable and internationally harmonised statistical measure that captures structural patterns of labour market participation and institutional embedding within national R&D systems. While this proxy is suitable for the baseline specification of the model, alternative markers of workforce differentiation may be explored in future research as data availability and conceptual developments evolve. Within the KQM framework, it functions as a structural indicator of labour market embedding and institutional configuration, reflecting long-term patterns that cannot be inferred from capacity or output indicators alone (Hall and Soskice, 2001).

By jointly analysing these four indicators within a configurational framework, the article demonstrates how maturity can be assessed as a structural condition of national R&D systems. Rather than proposing a new ranking or composite performance index, the contribution shows how a configurational innovation index can complement existing indicators by revealing structural imbalances, transition sensitivities, and latent development potential relevant for innovation policy and technology forecasting.

2. Measuring innovation systems: indicators, structure, and the concept of maturity

2.1 Performance indicators and the limits of linear benchmarking

Empirical analysis of national innovation systems has long relied on quantitative indicators developed within the Frascati tradition and its extensions (OECD, 2015). Indicators such as R&D intensity, innovation performance scores, and R&D expenditure per researcher form the empirical backbone of widely used policy tools, including international benchmarking exercises and composite innovation indices.

These indicators share a common analytical orientation: they measure the scale or intensity of innovation activity. R&D intensity captures relative investment effort, innovation performance reflects outputs and diffusion, and R&D expenditure per researcher proxies the resource environment in which research is conducted. Together, these measures provide important information about innovation system capacity.

However, when interpreted individually or aggregated into composite indices, these indicators implicitly impose a linear model of system development, in which higher values are interpreted as advancement and lower values as deficit (Hollanders and Es-Sadki, 2017). This interpretation treats innovation systems as scalable entities whose development can be represented along a single performance continuum.

From an innovation policy perspective, this approach is limited. It offers little insight into how innovation activity is organised, institutionally embedded, or sustained over time. Systems with similar capacity levels may differ substantially in their internal structure, institutional alignment, and vulnerability to transition pressures (Edquist, 2005; Fagerberg *et al*., 2010). Linear benchmarking obscures these differences by focusing on magnitude rather than configuration.

Recent contributions to innovation studies similarly argue that understanding system dynamics requires attention to structural relations, institutional complementarities, and patterns of alignment rather than to aggregate performance alone (Mazzucato, 2018; Schot and Steinmueller, 2018). This shift in perspective motivates the search for analytical frameworks capable of distinguishing configurational properties of innovation systems.

2.2 Composite indices and the loss of structural information

Composite innovation indices were developed to summarise multiple performance indicators into a single score. While such indices improve communicability and facilitate ranking, they do so at the cost of structural information loss. Aggregation collapses heterogeneous dimensions into scalar values, masking differences in how system components interact and align (Nardo *et al*., 2005).

In practice, composite indices tend to overweight capacity-related indicators while marginalising structural characteristics that do not translate easily into performance scores. As a result, countries with fundamentally different innovation system configurations may appear similar in rankings, despite facing distinct policy challenges and development trajectories.

For technology forecasting and forward-looking innovation policy analysis, this limitation is critical. Composite indices provide limited guidance on whether observed performance levels reflect structurally consolidated systems or transitional configurations vulnerable to future disruption.

2.3 Workforce composition as a structural indicator

Workforce-related indicators occupy an ambiguous position in innovation policy analysis. They are often interpreted normatively, particularly in relation to gender equality objectives, and therefore treated primarily as policy targets. Within the framework developed here, a different analytical interpretation is adopted.

The use of this indicator should be understood in a pragmatic and empirical sense. The present study does not aim to analyse gender differences or to intervene in debates on gender classifications. Instead, the variable is employed because it represents one of the most stable and internationally comparable measures available for observing how research activity is embedded in labour markets and institutional structures.

While this proxy is suitable for the baseline specification of the model, alternative markers of workforce differentiation may be explored in future research as statistical infrastructures and conceptual approaches continue to develop.

The share of women among researchers is used as a structural indicator of workforce composition, analytically independent from performance measures. It captures long-term patterns of labour market participation, sectoral orientation, and institutional openness that shape how research activities are embedded within national innovation systems (Hall and Soskice, 2001; Smith, 2000).

Importantly, this indicator is not aggregated with capacity-related measures. Instead, it constitutes a separate analytical dimension that interacts with innovation system capacity to form distinct configurations. Systems with similar capacity levels may therefore exhibit different maturity profiles depending on how research activities are structurally embedded within labour markets and institutions.

By explicitly separating workforce composition from performance indicators, the framework preserves structural information that is lost in composite indices and enables a configurational interpretation of innovation system maturity.

2.4 Maturity as a configurational property

Taken together, the four indicators employed in this study—three capacity-related measures and one workforce composition measure—do not form a composite index. Instead, they define a configurational observation space within which national R&D systems can be positioned and compared.

Maturity, as conceptualised here, is not a monotonic function of any single indicator. It is a structural property reflecting the degree of consolidation and balance between innovation system capacity and workforce composition. This interpretation allows innovation policy analysis to move beyond performance benchmarking toward a more nuanced diagnosis of system states, transition sensitivities, and long-term development potential.

The following section introduces the Kauzon Quadrant Model as a framework for operationalising this configurational approach and for deriving a maturity-oriented diagnostic indicator grounded in the joint positioning of national R&D systems across these four explicitly defined indicators.

3. Core framework: the Kauzon Quadrant Model (KQM)

3.1 Conceptual rationale of the Kauzon Quadrant Model

The Kauzon Quadrant Model (KQM) is a configurational analytical framework designed to assess national research and development (R&D) systems as structurally differentiated entities rather than as points along a linear performance continuum. The model responds to the limitations of performance-oriented innovation indicators by shifting analytical attention from output intensity to structural alignment within innovation systems.

At its core, the KQM framework rests on the premise that innovation system maturity emerges from the joint configuration of system capacity and workforce structure, not from the scale of innovation activity alone. Systems with similar levels of R&D expenditure or innovation output may therefore differ substantially in consolidation, stability, and long-term development potential (Lundvall, 1992; Edquist, 2005).

Rather than aggregating indicators into a composite score, KQM preserves multidimensional information by positioning national R&D systems within a structured analytical space. This configurational perspective allows maturity to be interpreted as a *structural condition*, reflecting balance or imbalance between key system dimensions, rather than as a scalar performance outcome.

3.2 Analytical dimensions of the KQM framework

The KQM framework is defined by two analytically independent dimensions capturing both the scale of innovation activity and its structural embedding.

The first dimension represents innovation system capacity and is operationalised as a synthesised construct combining three performance-related indicators: (1) R&D intensity, reflecting relative investment effort; (2) innovation performance, capturing outputs and diffusion; and (3) R&D expenditure per researcher, indicating the resource environment of research activities. These indicators are combined intentionally to distinguish overall capacity from structural characteristics, rather than to compare individual performance metrics.

The second dimension represents workforce composition in research activities, operationalised through a single indicator: the relative share of women among researchers. Within the KQM framework, this indicator is not interpreted normatively. Instead, it functions as a structurally sensitive signal capturing long-term patterns of labour market participation, sectoral orientation, and institutional openness that shape how research activities are embedded within national innovation systems.

The analytical separation of capacity and workforce composition is central to the KQM logic. These dimensions are measured independently and interpreted jointly only at the configurational level, ensuring that structural characteristics do not mechanically influence capacity measurement.

3.3 Quadrant structure and configurational interpretation

Combining the two analytical dimensions defines a two-dimensional space partitioned into four quadrants, each representing a distinct configuration of innovation system capacity and workforce composition relative to a common reference benchmark. The quadrants do not represent stages of linear development nor imply normative judgments about system quality. Instead, they function as analytical regimes capturing qualitatively different structural configurations.

The quadrant structure serves three analytical purposes. First, it enables rule-based system classification without ad hoc thresholds or weighting schemes. Second, it supports structural diagnosis by highlighting patterns of alignment or misalignment between capacity and workforce structure that remain invisible in linear benchmarking approaches. Third, it allows directional interpretation, as movement within the KQM space reflects structural change rather than marginal performance variation. Systems located near quadrant boundaries may therefore exhibit heightened sensitivity to relatively small structural shifts relevant for innovation policy and technology forecasting.

While the quadrant logic permits typological interpretation, the purpose of the KQM framework in this article is not to construct a definitive typology of national innovation systems. Rather, the quadrants serve as an analytical device for conceptualising maturity as a configurational outcome.

3.4 Conceptual representation of the Kauzon Quadrant Model

Figure 1 provides a conceptual representation of the Kauzon Quadrant Model (KQM) and illustrates its quadrant-based analytical logic. The figure depicts a two-dimensional analytical space defined by synthesised R&D system capacity on the horizontal axis and workforce composition in research activities on the vertical axis, represented by the relative share of women among researchers.

National R&D systems are positioned relative to a common reference benchmark, which serves as an analytical point of comparison rather than a normative target. The four quadrants represent distinct structural configurations emerging from the joint alignment—or misalignment—between innovation system capacity and workforce composition. They do not correspond to stages along a linear development path nor imply normative judgments about system performance or desirability.

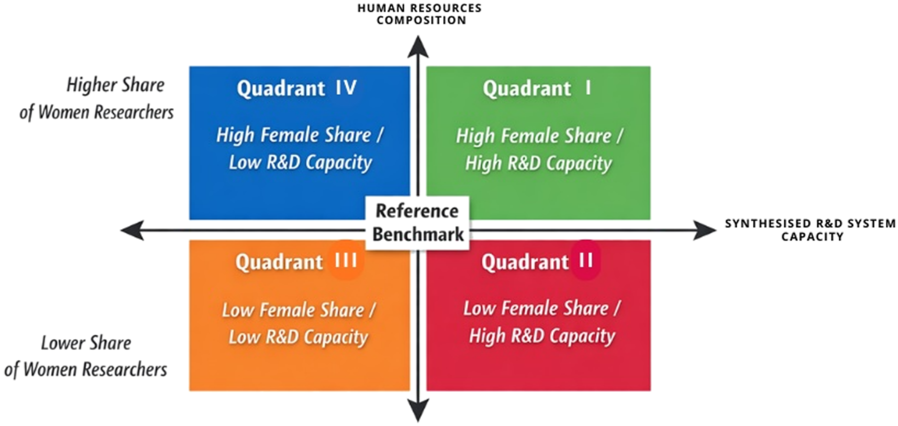

Figure 1. Conceptual structure of the Kauzon Quadrant Model (KQM). Source: Author's own work

The diagram highlights workforce composition as a structurally sensitive indicator that interacts with innovation capacity rather than being absorbed into it. While innovation capacity captures the scale and intensity of R&D activity, workforce composition reflects longer-term patterns of labour market embedding and institutional structure. Their joint representation reveals configurations that remain invisible in performance-oriented benchmarking approaches.

3.5 Positioning maturity within the KQM framework

Within the KQM framework, maturity is not defined as the highest level of innovation capacity nor as a specific quadrant. Instead, it reflects the degree of structural consolidation and alignment between innovation system capacity and workforce composition.

Systems characterised by strong capacity but weak structural embedding may display high performance under potentially unstable conditions, while systems with moderate capacity and balanced structural alignment may exhibit greater resilience and long-term development potential. By preserving configurational information, the KQM framework makes these distinctions explicit and avoids collapsing structural differences into a single performance score.

This interpretation departs fundamentally from conventional composite indices, which rank systems along a single continuum (Nardo *et al.*, 2005). Instead, the KQM framework provides the conceptual foundation for deriving a maturity-oriented diagnostic indicator grounded in configurational positioning rather than performance aggregation. The following section introduces the KQM Index of National R&D System Maturity.

4. The KQM index of structural maturity

4.1 From configurational space to a maturity-oriented index

The Kauzon Quadrant Model (KQM) defines a configurational analytical space in which national R&D systems are positioned according to innovation system capacity and workforce composition. While this spatial representation preserves critical structural information, innovation policy analysis and comparative assessment often require a scalar signal that supports comparison, monitoring over time, and forward-looking interpretation.

The KQM Index of Structural Maturity fulfils this function. Rather than replacing the quadrant framework, it operates as a secondary analytical layer derived from configurational positioning within the KQM space. Its purpose is not to rank systems by performance, but to translate structural alignment into a maturity-oriented diagnostic signal.

The introduction of the index constitutes a key element of theory transfer in this article, demonstrating how a configurational concept of maturity can be operationalised without relying on the aggregation logic characteristic of composite innovation indices (Nardo *et al.*, 2005).

4.2 Analytical logic of the KQM index

The KQM Index is derived from the joint positioning of national R&D systems along the two KQM dimensions, defined by four explicitly specified indicators.

The first dimension — *innovation system capacity* — is a synthesised construct combining three performance-related indicators: (1) R&D intensity, (2) innovation performance, and (3) R&D expenditure per researcher. These indicators are combined intentionally to represent the overall scale and intensity of innovation activity, rather than to compare individual performance metrics.

The second dimension — *workforce composition* — is represented by a single, analytically independent indicator: (4) the relative share of women among researchers. As established earlier, this indicator is not interpreted normatively. Within the KQM Index, it functions as a structural signal reflecting how research activities are embedded within labour markets, institutional arrangements, and sectoral configurations.

The analytical separation of capacity and workforce composition is central to the logic of the KQM Index. Maturity is conceptualised as emerging from their alignment or misalignment, not from their additive magnitude.

4.3 Why the KQM index is not a composite innovation index

At a formal level, the KQM Index yields a scalar value, which may invite comparison with composite innovation indices. However, its analytical logic differs fundamentally in three respects.

First, the index does not aggregate heterogeneous indicators into a single performance score. The three capacity indicators define one analytical dimension, while the workforce composition indicator remains separate and orthogonal.

Second, the index is configuration-sensitive. Systems with similar innovation capacity may receive different maturity signals depending on how capacity aligns with workforce composition, allowing differentiation between structurally consolidated systems and systems characterised by imbalance or transitional tension.

Third, the index is reference-based rather than absolute. All underlying indicators are expressed relative to a common benchmark, ensuring that maturity reflects structural positioning rather than scale effects.

Accordingly, the KQM Index should be interpreted as a diagnostic instrument, not as a ranking device or a substitute for existing innovation indices.

4.4 Interpreting the KQM index as a maturity signal

Within the KQM framework, higher values of the KQM Index correspond to configurations characterised by stronger structural alignment between innovation system capacity and workforce composition. Lower values indicate misalignment, fragmentation, or transitional configurations.

Importantly, higher maturity does not necessarily coincide with higher innovation performance. Systems may exhibit strong capacity indicators while displaying moderate or low maturity due to weak structural embedding, while systems with moderate capacity may achieve higher maturity through balanced configuration.

This interpretation has direct implications for innovation policy and technology forecasting, highlighting conditions under which additional investment may yield diminishing returns, as well as situations where modest structural adjustments may result in disproportionate gains in maturity.

The KQM Index is therefore best understood as a diagnostic signal of structural condition, not as an evaluative score of success or failure.

4.5 Scope and limitations of the KQM index

The KQM Index is designed as a parsimonious and transparent instrument. Its baseline specification is illustrative rather than exhaustive, and alternative functional forms or additional structural indicators may be explored in future research.

Nevertheless, the conceptual contribution of the index does not depend on a specific mathematical formulation. Its novelty lies in demonstrating that innovation system maturity can be operationalised as a configurational property, without collapsing structural dimensions into a composite performance score. The following section provides an illustrative application of the KQM Index to demonstrate how it differentiates structural maturity beyond conventional innovation rankings.

5. Illustrative application: revealing structural maturity beyond performance rankings

The purpose of this section is to provide an illustrative application of the KQM Index of Structural Maturity in order to demonstrate its analytical value. The objective is not statistical validation, but to show how a configurational maturity perspective differentiates national R&D systems beyond what is visible through conventional innovation indicators and composite rankings.

The illustrative application draws on harmonised secondary indicators commonly used in innovation policy analysis. National R&D systems are positioned within the KQM framework relative to a common reference benchmark. This positioning preserves the joint configuration of innovation system capacity—synthesised from three performance-related indicators—and workforce composition, represented by the relative share of women among researchers.

5.1 Differentiating systems with similar innovation performance

A first insight from the illustrative application is that national R&D systems with comparable innovation performance often exhibit markedly different maturity profiles. Systems that appear adjacent in composite innovation rankings may occupy different regions of the KQM space due to differences in workforce composition and structural embedding.

In such cases, similar capacity levels mask divergent structural conditions. Some systems combine strong innovation capacity with relatively balanced workforce structures, resulting in higher maturity signals. Others exhibit comparable capacity but weaker structural alignment, reflected in lower maturity despite similar performance scores. These distinctions cannot be inferred from linear benchmarking alone.

From an innovation policy perspective, this differentiation is critical. It indicates that comparable levels of innovation output may rest on structurally different foundations, with implications for resilience, sustainability, and sensitivity to policy intervention.

5.2 Identifying structural imbalance and transitional configurations

A second insight concerns systems characterised by structural imbalance. The KQM framework reveals configurations in which innovation capacity and workforce composition are misaligned. Such systems may display relatively strong capacity combined with weak structural embedding, or moderate capacity combined with workforce structures indicative of limited institutional consolidation.

These configurations are associated with lower maturity signals, not because of low innovation activity *per se*, but because of weak alignment between system dimensions. Importantly, such systems often appear neither as clear leaders nor as laggards in composite rankings, leaving their structural vulnerability largely unrecognised in conventional assessments.

The illustrative application also highlights systems located near quadrant boundaries. These systems exhibit heightened sensitivity to relatively small changes in either capacity or workforce composition and may represent transitional states in which modest structural adjustments lead to disproportionate changes in maturity.

5.3 Implications for interpreting innovation performance

The illustrative application underscores a key analytical distinction introduced by the KQM Index: high innovation performance does not necessarily imply high structural maturity. Conversely, moderate performance may coexist with relatively strong maturity when system components are well aligned.

This distinction has direct implications for innovation policy interpretation. Policies aimed solely at increasing R&D expenditure or innovation output may yield diminishing returns in structurally misaligned systems. In contrast, targeted measures addressing workforce structure or institutional embedding may enhance maturity without large increases in aggregate investment.

By preserving configurational information, the KQM framework enables a more nuanced reading of innovation indicators. It supports diagnosis of structural conditions underlying observed performance and distinguishes between systems that are structurally consolidated and those relying on potentially unstable configurations.

Overall, the illustrative application demonstrates that the KQM Index adds analytical value by revealing maturity-related differences that remain invisible in performance-oriented innovation rankings. It provides a basis for forward-looking interpretation of national R&D systems grounded in structural alignment rather than output intensity alone.

6. Discussion and implications: maturity-oriented diagnostics for innovation policy and forecasting

The introduction of the KQM framework and the KQM Index of Structural Maturity has important implications for innovation policy analysis and technology forecasting. Most fundamentally, it challenges the assumption that innovation system development can be adequately assessed through performance intensity and output-based benchmarking alone. Instead, it introduces a maturity-oriented diagnostic perspective that foregrounds structural alignment as a key condition shaping long-term system dynamics.

6.1 From performance comparison to structural diagnosis

Conventional innovation indicators and composite indices are well suited for comparative reporting and monitoring aggregate trends, but their performance-oriented logic limits their diagnostic value. They indicate how much innovation activity is taking place, yet provide little insight into how that activity is structurally embedded and sustained.

The KQM framework shifts analytical attention from performance comparison to structural diagnosis. By conceptualising maturity as a configurational property emerging from the alignment between innovation system capacity and workforce composition, it enables analysts to distinguish between structurally consolidated systems and systems relying on potentially unstable configurations. From a policy perspective, this distinction is critical: policies based solely on performance indicators may overlook structural constraints or reinforce imbalances that limit long-term effectiveness.

6.2 Implications for technology forecasting and forward-looking analysis

From a technology forecasting perspective, the KQM Index captures information not available through linear indicators. Forecasting innovation trajectories requires sensitivity to non-linear dynamics, transition thresholds, and regime stability, which performance trends alone cannot reveal.

The KQM framework supports forward-looking analysis by identifying configurations associated with heightened transition sensitivity. Systems near quadrant boundaries may experience disproportionate changes in maturity following relatively small structural shifts, while systems with high capacity but weak alignment may face diminishing returns to additional investment. In this way, the KQM Index complements existing forecasting approaches by providing structural diagnostic insight rather than predictive estimates.

6.3 Workforce composition as an analytical signal, not a policy target

An important implication of the KQM framework concerns the interpretation of workforce composition indicators. In innovation policy discourse, gender-related indicators are often treated normatively, as policy targets or markers of success. Within the KQM framework, the share of women among researchers is interpreted differently: it functions as a *structural indicator* of how research activities are embedded within labour markets, institutions, and sectoral structures.

Differences in workforce composition reflect long-term structural patterns that condition system maturity and adaptability. This interpretation is explicitly analytical rather than normative and highlights information about innovation system structure that cannot be inferred from capacity or output indicators alone. Ignoring this dimension risks misdiagnosing the sources of innovation system strengths and weaknesses.

The current operationalisation therefore prioritises comparability and structural signalling. It should not be read as privileging a particular categorisation, but as a pragmatic choice within the limits of available international statistics.

6.4 Policy relevance without normative prescription

The KQM framework does not prescribe specific policy instruments or define optimal innovation system models. Its contribution lies in providing a diagnostic layer that precedes policy choice. By clarifying the structural nature of maturity and imbalance, it supports more context-sensitive policy deliberation.

This orientation is particularly valuable in heterogeneous policy environments where one-size-fits-all solutions are inappropriate. Rather than ranking systems or promoting convergence toward a single benchmark, the KQM framework highlights structurally specific challenges and potentials. In doing so, it complements existing innovation indicators by adding a maturity-oriented perspective aligned with long-term policy learning and strategic adaptation.

7. Conclusion

This article has introduced a configurational approach to assessing national R&D systems by transferring the concept of structural maturity into innovation policy analysis. Building on the Kauzon Quadrant Model, it conceptualises maturity as a property emerging from the joint alignment of innovation system capacity and workforce composition, rather than as an aggregate performance outcome.

The main conclusions can be summarised as follows.

First, the article demonstrates that innovation system maturity can be operationalised without relying on composite performance indices. By explicitly defining four indicators — three synthesised into an innovation capacity dimension and one representing workforce composition—the framework preserves structural information that is lost in linear benchmarking approaches. The resulting KQM Index functions as a maturity-oriented diagnostic signal derived from configurational positioning rather than additive aggregation.

Second, a key conceptual contribution lies in the use of the share of women among researchers as a structurally sensitive indicator. Analytically independent from performance measures, this indicator is integrated into a configurational framework to capture long-term patterns of labour market embedding and institutional structure. To the best of our knowledge, it has not previously been employed in combination with synthesised innovation capacity measures within a quadrant-based or configurational approach to innovation system analysis.

Third, the illustrative application shows that national R&D systems with similar innovation performance may exhibit markedly different maturity profiles. These differences reflect structural alignment, imbalance, and transition sensitivity that remain invisible in conventional innovation rankings. In particular, variation in workforce composition reveals latent structural conditions that significantly condition system resilience and adaptability.

Finally, the KQM framework does not replace existing innovation indicators, but complements them by adding a structural maturity perspective. Its value lies not in ranking or optimisation, but in enhancing diagnostic understanding of innovation system states and their potential evolution. Future research may extend the framework through longitudinal analysis, alternative structural indicators, or application at regional and sectoral levels, without altering its core configurational logic.

Overall, by shifting the analytical focus from performance benchmarking to structural maturity, this article demonstrates how a configurational innovation index — incorporating workforce composition as a sensitive structural signal rather than a normative target — can enrich innovation policy analysis and support more informed, forward-looking assessment of national R&D systems.

References

Edquist, C. (2005), “Systems of innovation: perspectives and challenges”, in Fagerberg, J., Mowery, D.C. and Nelson, R.R. (Eds), *The Oxford Handbook of Innovation*, Oxford University Press, Oxford, pp. 181-208.

European Commission (2023), *European Innovation Scoreboard 2023*, Publications Office of the European Union, Luxembourg.

Fagerberg, J., Mowery, D.C. and Nelson, R.R. (2010), *The Oxford Handbook of Innovation*, Oxford University Press, Oxford.

Hall, P.A. and Soskice, D. (2001), *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage*, Oxford University Press, Oxford.

Hollanders, H. and Es-Sadki, N. (2017), *European Innovation Scoreboard: Methodology Report*, European Commission, Brussels.

Lundvall, B.-Å. (1992), *National Systems of Innovation: towards a Theory of Innovation and Interactive Learning*, Pinter, London.

Malerba, F. (2002), “Sectoral systems of innovation and production”, *Research Policy*, Vol. 31 No. 2, pp. 247-264, doi: 10.1016/s0048-7333(01)00139-1.

Mazzucato, M. (2018), “Mission-oriented innovation policies: challenges and opportunities”, *Industrial and Corporate Change*, Vol. 27 No. 5, pp. 803-815, doi: 10.1093/icc/dty034.

Nardo, M., Saisana, M., Saltelli, A. and Tarantola, S. (2005), “Tools for composite indicators building”, OECD Statistics Working Papers, OECD Publishing, Paris.

OECD (2015), *Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development*, OECD Publishing, Paris.

Schot, J. and Steinmueller, W.E. (2018), “Three frames for innovation policy: R&D, systems of innovation and transformative change”, *Research Policy*, Vol. 47 No. 9, pp. 1554-1567.

Smith, K. (2000), “Innovation as a systemic phenomenon: rethinking the role of policy”, *Enterprise and Innovation Management Studies*, Vol. 1 No. 1, pp. 73-102, doi: 10.1080/146324400363536.

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