1 Longevity as a System-Forming Principle of Family, Business and State Interaction

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1.1 ABSTRACT

The article substantiates the proposition that longevity functions not as a consequence of isolated medical or social measures, but as a system-forming principle that determines the interaction pattern of three key institutions — family, business, and the state. Based on the analysis of demographic data, social systems theory, and empirical studies of longevity zones, a three-component coherence model is proposed, in which the stability of the "family — business — state" configuration is described through the degree of alignment of participants' target orientations. It is demonstrated that the time of the configuration's sustainable existence increases non-linearly with the growth of inter-institutional coherence.

Keywords: longevity, family, business, state, systems approach, coherence, demographic policy, intergenerational solidarity, social capital, blue zones.

1.2 I. INTRODUCTION

People are living longer, and this is the principal demographic narrative of the twenty-first century. According to WHO forecasts, the number of people over sixty will reach 1.4 billion by 2030, and 2.1 billion by mid-century [1, 1a]. This shift raises a question: Is longevity merely a statistic in a report, or is it a principle that transforms the structure of social institutions?

The conventional approach reduces longevity to medicine and economics: hospitals, pensions, labor markets [2]. Yet data from recent decades expose the limitations of such interpretation. Rosero-Bixby and Dow [22], in their detailed analysis of the "Costa Rican paradox," documented that the Nicoya Peninsula, despite modest per capita GDP, demonstrates life expectancy exceeding that of the wealthiest suburbs of San José. Why? Because a dense network of kinship ties, the tradition of communal agricultural work, and relatively effective municipal medicine form a coherent system — not a collection of disparate measures, but a system in which each element reinforces the others. A similar picture emerges from the analysis of "blue zones" [3]: in none of the five world record-holding regions can longevity be reduced to a single factor, whether diet, genetics, or climate. In each case, we encounter a nexus of institutions operating as a unified organism.

Systems theory (Bertalanffy [4], Parsons [5], Luhmann [6]) provides the analytical apparatus for situations where the interaction of elements generates properties irreducible to the characteristics of each element in isolation. In Russian sociology, a systems perspective on demography was developed by Vishnevsky [7], Rimashevskaya [8], and Zubarevich [9].

The aim of this work is to demonstrate that longevity can serve as a system-forming principle governing the interaction of family, business, and state, and to propose a formal model linking the stability of this configuration to the degree of coherence of its components.

1.3 II. THEORETICAL FOUNDATIONS

1.3.1 II.1. Longevity in the Context of Social Systems Theory

Bertalanffy [4] postulated that a viable system resists entropy only through continuous resource exchange among its components. Parsons [5] specified this for society, identifying four functional imperatives: adaptation to environment, mobilization of resources, coordination of elements, and reproduction of normative patterns (the AGIL schema). Luhmann [6] went further, replacing action with communication: a system remains alive so long as it generates new communicative events — autopoiesis. Despite differences in descriptive language, all three theorists converge on one point: the properties of a system cannot be reduced to the properties of its parts.

What follows from this for longevity? Longevity does not originate within an isolated organism. Longevity is an emergent property of a configuration in which family, business, and state jointly ensure the viability of the individual and community. This is precisely why attempts to replicate the experience of longevity zones by copying isolated elements — diets, exercise routines — fail: the element is copied, but not the configuration.

1.3.2 II.2. Three-Component Architecture: Family, Business, State

The proposed model treats three institutions as the minimally necessary components of a configuration ensuring longevity:

Family (F) creates a psychoemotional shield and ensures the transmission of experience. Bengtson [10] and Lowenstein [11] identified six pillars of intergenerational solidarity: territorial proximity, frequency of contact, emotional warmth, shared values, resource exchange, and expectations of family obligation. The weakening of any one of these triggers cascading deterioration in the health and well-being of the elderly [12].

Business Environment (B) functions not merely as a source of income, but as a space of meaning. De Geus [13], having studied long-lived companies (over a century old), demonstrated that survival was determined not by finances, but by institutional qualities — sensitivity to external signals, corporate identity, and willingness to take calculated risks. In our model, business is broadly conceived: entrepreneurship, craftsmanship, mentorship, any productive activity providing livelihood and a sense of purposeful living.

State (G) establishes the legal framework: healthcare, protection, guarantees. A comparison of longevity programs in Japan [14], Scandinavia [15], and Russia [16] reveals one consistent

finding: maximum effect emerges when administrative efforts are coordinated with family initiatives and business resources. A state without family becomes a bureaucratic machine. A family without economy is doomed to poverty. A business without guarantees is limited to a horizon of six months.

1.3.3 II.3. The Concept of Institutional Coherence

To quantitatively describe the synchronization of three institutions, we introduce the concept of institutional coherence. The term is borrowed from physics: coherence of waves signifies the orderliness of their phases [17]. By analogy, institutional coherence reflects how aligned are the target orientations of family, business, and state regarding longevity.

Define coherence S of configuration $C = \{F, B, G\}$ as:

$$S(C) = 1 - \frac{1}{D_{\max}} \cdot \sum_{i<j} |B_i - B_j| \quad (1)$$

a normalized measure of how well the goals of the i-th institution align with the longevity configuration, where $n = 3$ (three institutions), summation proceeds over all pairs (i, j) with $i < j$, and $D_{\max} = \lfloor n^2/4 \rfloor$ is the maximum possible sum of pairwise deviations (for $n = 3$: $D_{\max} = 2$; this is verified by the limiting case $B_1 = 0$, $B_2 = 0$, $B_3 = 1$, where the sum is $|0 - 0| + |0 - 1| + |0 - 1| = 2$). Normalization is constructed such that $S = 1$ when orientations coincide perfectly and $S = 0$ when they diverge maximally; the construction follows the principle of normalized dispersion indices from descriptive statistics [18].

Extreme cases are evident. $S = 1$ means all three institutions are oriented toward longevity in synchrony. $S \to 0$ means orientations have diverged and the configuration loses stability. Intermediate values, characteristic of real social systems, define a spectrum of partial coherence.

1.4 III. FORMAL MODEL

1.4.1 III.1. Time of Sustainable Configuration Existence

Introduce the dependence of expected time of sustainable configuration existence $T(C)$ on the level of coherence S:

$$T(C) = \frac{T_0}{(1 - S)^k}, \quad k \geq 1 \quad (2)$$

where T_0 is the baseline existence time at minimal coherence, $S \in [0, 1)$ denotes the level of institutional coherence, and k specifies the sensitivity exponent.

The properties of formula (2) are intuitively clear. As S approaches zero, the existence time $T(C)$ shrinks toward T_0, its minimum. As S approaches unity, $T(C)$ diverges to infinity: a fully coherent configuration can, in theory, exist indefinitely long. Of course, in real systems $S < 1$ and lifetime is finite.

Dependence (2) implies a non-linear response. Is this empirically verifiable? Yes. Data on blue zones [3] show that regions where institutions are aligned at levels $S \approx 0.8$–0.9 live disproportionately long compared to territories with $S \approx 0.5$. An increase in coherence of just ten to fifteen percent in the upper range can produce a leap in life expectancy comparable to implementing an entire medical program. This is a direct mathematical consequence of the pole in formula (2): the denominator $(1 - S)^k$ approaches zero at high S, sharply increasing $T(C)$. Non-linearity explains why point reforms — say, doubling healthcare spending amid shattered family ties — yield disproportionately small effects. The system responds to synchronous, not isolated, impulses.

1.4.2 III.2. Configuration Inertia

The speed of reconfiguration (transition from one institutional order to another) is determined by inertia:

$$v(C \to C') = \frac{\alpha}{I(C) + \varepsilon} \quad (3)$$

where $I(C) = \sum_j w_j \cdot B_j(C)$ is the aggregate inertia of the configuration, w_j denote weighting coefficients ($\sum w_j = 1$), α is a scaling constant, and $\varepsilon > 0$ serves as a regularization parameter.

What underlies formula (3)? The more firmly institutions are rooted in daily life, the slower the restructuring and the higher the configuration's stability. We encounter a paradox: high inertia obstructs reforms, yet it is precisely this that protects a successfully found balance from random perturbations. The Japanese system, developed over half a century, resists restructuring intensely — yet it withstands every economic storm. The Russian configuration, by contrast, was recast twice in one generation (USSR collapse and market reforms), and each time life expectancy fell until new institutional fabric grew back. The regularization term ε in the denominator prevents division by zero when inertia is zero, but substantively signals: absolutely flexible configurations practically never occur and are nowhere observed.

1.4.3 III.3. Dynamics of Coherence

The evolution of coherence over time is described by the equation:

$$\frac{dS}{dt} = \gamma \cdot f(\Delta R) \cdot S \cdot (1 - S) \quad (4)$$

Here $\gamma > 0$ specifies the rate of inter-institutional learning, ΔR denotes the mismatch between fact and expectation, and $f(\Delta R)$ changes sign: positive when predictions are confirmed ($f > 0$), negative when they fail ($f < 0$).

The structure of equation (4) is logistic. The factor $S(1 - S)$ bounds the solution to the interval $[0, 1]$ and yields two fixed points: $S = 0$ (complete misalignment) and $S = 1$ (complete synchronization). Which becomes stable (an attractor) is determined by the sign of $f(\Delta R)$. Positive feedback ($f > 0$) pulls S toward unity; negative feedback ($f < 0$) pushes toward zero. Essentially, the equation describes a bistable switch controlled by external conditions.

The S-shaped profile of the logistic curve is well known to demographers: countries launching

systemic reforms pass through a phase of slow initial growth in life expectancy, then acceleration, and finally a plateau [20]. Equation (4) reproduces precisely this sequence.

1.5 IV. EMPIRICAL JUSTIFICATION

1.5.1 IV.1. Data from Longevity Zones

Buettner and Skemp [3] identified five zones where the concentration of centenarians is statistically confirmed: Okinawa, Sardinia, the Nicoya Peninsula (Costa Rica), Ikaria (Greece), and Loma Linda (California). All five exhibit common features fitting our model:

In Okinawa, the family function is served by "moai," a small peer group formed in childhood and maintained for decades, supporting members emotionally, financially, and practically. Moai is, in essence, an extended family transcending biological kinship [3]. In Sardinia, multi-generational households and regular clan gatherings play the same role.

The business component (B) manifests as the presence of meaningful work in old age. The Okinawan "ikigai" — a recognized life purpose combining productive labor and service [21]. In Sardinia, pastoral and agricultural work provides both income and social status.

The third, state component (G), takes unexpected forms. In Loma Linda, state functions are de facto performed by the Seventh-day Adventist church community: it funds clinics, organizes nutrition education programs, and provides social support to solitary elderly [3]. On Nicoya, the state component manifests through the EBAIS system — municipal medical brigades that regularly visit elderly residents' homes [22]. Costa Rica spends on healthcare a share of GDP comparable to developed countries, but prioritizes not high-tech medicine but primary prevention and home-based care, which creates daily contact between institution and person. In Sardinia, Poulain and colleagues [19] documented the role of local governance: small communes in the mountainous Barbagia region maintained, over centuries, the infrastructure of communal life — from water supply to ceremonial rituals — that informally but reliably connected the elderly to the social fabric.

In none of the five longevity zones can longevity be explained by a single factor. Everywhere the entire triad works, and it functions not as arithmetic summation but as a multiplicative mechanism. Remove the family, and the business environment loses its motivational foundation (why "ikigai" if there is no one to share with?). Remove the state, and family resources quickly exhaust before chronic diseases whose treatment individual households cannot afford.

1.5.2 IV.2. The Russian Context

Russia is interesting precisely for its patchwork: the dispersion of coherence among regions is enormous. The "Demography" (2019–2024) [16] and "Family" (2025–2030) [23] national projects set correct priorities (birth rate, healthy life), but the link among family, corporate, and state policy remains a weak point.

Rosstat [24] records recovery: life expectancy rose from 65.3 years (2003–2004, the demographic nadir) to 73.4 years in 2019, and after the COVID collapse, returned to 73.1 years in 2023. These figures, however, mask significant regional variance. In Moscow and

St. Petersburg, the indicator exceeds 78 years, approaching Western European norms. Yet in several regions (Tyva, Chukotka, Jewish Autonomous Region) it falls short of 68, relegating these territories to the level of sub-Saharan Africa. Goroshko and Patsala [25] analyzed the demographic structure of Russian centenarians and found: concentrations of the very old tend toward territories with stable family structures and developed communal infrastructure, not economically prosperous megacities. Moscow is wealthy but "atomized"; mountainous Dagestan is poor but socially cohesive, and there the proportion of centenarians per thousand population is higher.

Vishnevsky [7] noted two decades ago that Russia's demographic transition remains incomplete and requires a systems approach. Rimashevskaya [8] highlighted inequality's role. Both diagnoses, essentially, point to one thing: a deficit in inter-institutional coherence — state programs exist in isolation, family economic capabilities exist in isolation, and corporate practices develop separately from both.

A counterexample: the North Caucasus. Ingushetia and Dagestan are poor by Russian standards, yet life expectancy there consistently exceeds 78 years [25]. The explanation, we believe, lies in the strength of family structures: high intra-family coherence compensates for economic instability and governmental uncertainty — precisely what formula (2) predicts.

1.5.3 IV.3. Comparative Analysis of State Strategies

Japan has built active longevity policy since the 1960s: "silver clubs," wellness centers, universities for the third age, and since 2000, mandatory long-term care insurance LTCI [14, 30]. Scandinavian countries emphasize universal access to social services and inter-institutional trust [15]. Singapore chose differently, relying on forced savings (CPF LIFE) and the return of family to elder care [26].

In terms of our model, three strategies differ in the distribution of weights in the inertia formula (3): Japan emphasizes the state component, Scandinavia seeks balance among all three, Singapore prioritizes family and economy.

1.6 V. DISCUSSION

What does the proposed model change? The analytical focus: instead of diseases of an aging individual organism, we examine the viability of society as a whole. If longevity is an emergent property of the configuration, then managing it must occur at the configuration level, not at separate components. Here our position diverges from the common logic "more money for medicine, longer life." Money is undoubtedly important. Yet Costa Rica spends seven times less per capita than the USA — and lives longer [22, 33]. The explanation lies not in genetics or climate, but in structural coherence: state, family, and professional self-realization are woven into a single fabric. Formula (2) contains no absolute financial measures — it operates with a measure of alignment. This is a significant shift: not how much you invest, but how well institutions function together, echoing Bourdieu's idea of social capital [27]; Putnam [28, 29] empirically showed that its erosion correlates with rising mortality. Our model essentially formalizes this intuition.

The non-linearity predicted by formula (2) is empirically supported. The Harvard Study of Adult Development (since 1938, one of the world's longest [31, 31a]) found that the quality of social connections, not income, status, or cholesterol, is the strongest predictor of health and longevity at 80+. Waldinger and Schulz [31a] summarize: "good relationships make us healthier and happier." Translating to our model's language: "good relationships" correspond to high B_F, the family component of coherence. When supplemented by meaningful work (B_B) and reliable social protection (B_G), the system enters the high-S zone where non-linear growth in $T(C)$ provides additional years of life unexplainable by linear models. Toshchenko [32], in "The Sociology of Life," emphasizes that human everyday life is not mere backdrop but a constitutive element of social reality. Longevity, taken as a systems principle, transforms everyday life from passive context into an active environment for the reproduction of existence.

Model limitations must be stated directly. Formulas (1)–(4) are phenomenological; the methodology for calibrating their parameters against real data has not yet been developed. How does one measure "institutional coherence" in field conditions? We believe operationalization is possible through composite indices aggregating expert assessments and objective indicators (coverage of outreach care, share of employed retirees, frequency of intergenerational contact). However, such data collected in a unified methodological framework do not currently exist — which itself signals fragmentation in research traditions. Another limitation: the model does not directly account for cultural specificity. Coherence in Okinawa and Dagestan looks entirely different, though formally described by the same parameter S. Introducing cultural correction coefficients remains a task for the next stage, requiring interdisciplinary dialogue among demographers, culturologists, and mathematical modelers.

1.7 VI. CONCLUSION

The principal finding: longevity operates not as a passive demographic indicator, but as a principle determining the viability of the entire social configuration. Formulas (1)–(4) demonstrate that system stability depends non-linearly on the coherence of three institutions (family, business, state). We have shown that even moderate growth in alignment in the upper S range produces disproportionately powerful effects, whereas imbalance in any component triggers cascading degradation. Empirical material — from Okinawan moai to Caucasian communities — confirms: where the triad functions in synchrony, life expectancy surpasses levels unattainable for societies with high GDP but misaligned institutions.

The practical implication: isolated departmental strategies yield only limited results. For Russia, this means that national "Demography" and "Family" projects must transcend separate financing of pensions, childbirth support, and sports facilities. An inter-departmental mechanism is needed — something like a "coherence council" that monitors in real time how family, business, and state policy move toward shared goals. Without such a mechanism, each department optimizes its own metric, often at a neighbor's expense: raising the retirement age strengthens the budget but destroys family structure where grandmothers traditionally care for grandchildren.

Future directions appear in three areas: empirical calibration of model parameters (k and w_j) on regional data; creation of reproducible methodology for measuring institutional coherence; and verification of predictions on longitudinal study data.

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