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Social Transformations and Labor Market Dynamics in Bulgaria: Historical Mechanisms and a Structural–Dynamic Model

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Abstract
The transformation of Bulgarian society after 1989 cannot be reduced to a change of political institutions or ownership arrangements. It disrupted established production relations, altered demand for labour and placed social groups in unequal positions in relation to employment. Building on an earlier historical study of the Bulgarian labour market, this article develops a structural–dynamic model of employment, unemployment and inactivity, structural mismatch, social vulnerability and institutional response. The mathematical specification is the authors' proposed framework, informed by the methodological discussion of Vitanov and Vitanov, rather than a model borrowed from that review. An empirical illustration uses the ten annual employment-rate observations for Bulgaria in 2014–2023 reproduced in the foundational manuscript. The employment rate increased from 64.4% to 76.2%; a linear time-trend regression gives an estimated rise of 1.284 percentage points per year (95% confidence interval 0.955–1.613). The fall in 2020 and the subsequent recovery demonstrate why linear extrapolation alone cannot explain the mechanisms of social adjustment. Historical interpretation and observed descriptive associations are distinguished from causal claims. The available aggregate series cannot identify the proposed transition probabilities or establish the causal effect of labour-market programmes. The contribution is a historically grounded, explicitly testable model accompanied by a limited and reproducible quantitative examination.

Keywords: Social transformations, Bulgarian Transition, Labour Market, Unemployment, Structural Mismatch, Social Policy, Mathematical Social Dynamics

1. Introduction

A political transformation may be formally completed within a relatively short historical period. The consequences for economic activity and the social position of individuals, however, are not exhausted by the adoption of new institutions. In Bulgaria, the change that began in 1989 was accompanied by the dissolution of established economic links, the restructuring or closure of enterprises and the emergence of unemployment on a scale unfamiliar to the preceding system. The resulting difficulties were not experienced simultaneously or with equal intensity by different groups of the population [1].

The central problem of the present study is the duration and unevenness of adjustment. The loss of an enterprise is not simply the disappearance of a number of jobs. It also means the devaluation of acquired professional skills, the interruption of household income, the weakening of local demand and the need for institutions to respond to a problem for which their existing instruments may be inadequate. A temporary employment programme can reduce the immediately visible number of unemployed persons, yet the restoration of sustainable employment requires changes in the structure of production and in the correspondence between available skills and labour demand [2].

The purpose of this article is to develop the authors' historical and socio-economic reasoning into a formal framework that can be examined empirically. Mathematical representation is not used here as a substitute for historical explanation. It is employed to identify the assumptions that connect political change, economic disruption, labour-market flows and the response of public institutions. The survey of mathematical social dynamics by Vitanov and Vitanov [3] provides a methodological point of departure, without implying that the specific model proposed below is taken from that publication.

2. The Character of Social Transformations in Bulgaria

The Bulgarian transition combined several processes that did not advance at the same pace. Political pluralism and new constitutional arrangements were established while enterprises continued to operate within inherited production structures and under rapidly changing market conditions. The disappearance of traditional external markets, the difficulties of financing and the reorientation of economic relations placed considerable pressure on industrial employment. A change in ownership did not automatically create new demand for labour, just as the removal of administrative allocation mechanisms did not immediately create a functioning system of professional mobility [1, 4].

This distinction between institutional change and economic adjustment is essential. When the structure of production changes abruptly, the number of people seeking work may increase before the economy creates occupations corresponding to their qualifications. The effect is particularly serious in settlements whose employment has been concentrated in one or a few enterprises. The closure of a large employer alters not only the labour market but also the social environment of the locality. The loss of wages affects families, consumption, municipal revenues and the opportunities available to younger generations. These are connected consequences, not separate episodes of the transition.

The original analysis distinguishes the early crisis of the 1990s [4], the subsequent restructuring of the economy and the later problems of adapting labour-market policy to changing demand. It also draws attention to the difference between the formal regulation of the primary labour market and the public measures used to compensate for its inability to absorb available labour [1]. This distinction is preserved in the present model. The creation of subsidised temporary employment is not equated with the creation of a lasting position in an economically viable enterprise.

3. The Labour Market as a Sensitive Social Subsystem

The labour market responds to disturbances through several channels at once. Enterprises reduce employment; workers search for alternative occupations; some persons cease to participate in the labour force; others move to different regions or leave the country. The unemployment rate provides important but incomplete information. Its decline may result from hiring, but also from demographic contraction, emigration or withdrawal from economic activity. Employment, unemployment and inactivity must be examined jointly if the direction of social change is to be understood.

The groups identified in the earlier study, young persons without professional experience, older workers, people with limited qualifications, persons with disabilities and the long-term unemployed, face different barriers to employment [1]. A uniform policy instrument cannot be expected to produce identical results for all of them. Retraining may be effective when new occupations are available, but considerably less so where regional demand remains weak. Financial support can preserve minimum household consumption without changing the probability of finding suitable work. The effects of each instrument depend on the environment in which it is applied.

The regional dimension is equally important. National indicators combine territories with different industrial structures, demographic profiles and opportunities for mobility. The national model proposed below should, where the data permit, be supplemented by regional and group-specific estimates. Otherwise the apparent stability of the aggregate series may conceal persistent local exclusion.

4. From Historical Interpretation to Mathematical Social Dynamics

Mathematical models are useful only when their variables correspond to identifiable social processes. The approaches discussed by Vitanov and Vitanov [3] and Yonkova [5] show that social systems may be studied through dynamic equations, stochastic variation, and interaction structures. In the present case, the starting point is not the diffusion of an opinion or the imitation of individual behaviour. It is the movement of persons between observable labour-market states under the influence of economic restructuring and public intervention.

A distinction must be made between accounting identities and behavioural assumptions. The number of persons employed, unemployed and inactive must be consistent with the population to which the measures refer. By contrast, the proposition that an economic shock increases the probability of job loss, or that a training programme improves the probability of employment, is a hypothesis. It requires estimation and may be contradicted by the evidence. Treating the two types of statement as interchangeable would give the mathematical model an appearance of certainty that the available information cannot support.

5. A Structural–dynamic Model of Labour-Market Adjustment

Let E_t denote employed persons, U_t unemployed persons and N_t economically inactive persons of working age at the end of period t. Their sum $W_t = E_t + U_t + N_t$ represents the relevant working-age population. Let s_t be the probability that an employed person enters unemployment, d_t the probability of movement from employment to inactivity, f_t the probability that an unemployed person finds employment, b_t the probability of leaving unemployment for inactivity, a_t the probability of entering unemployment from inactivity, and c_t the probability of moving directly from inactivity into employment. Let g^E_t, g^U_t and g^N_t represent net demographic and migration changes assigned to each state.

$$E_{t+1} = (1 - s_t - d_t)E_t + f_tU_t + c_tN_t + g^E_t$$

$$U_{t+1} = s_tE_t + (1 - f_t - b_t)U_t + a_tN_t + g^U_t$$

$$N_{t+1} = d_tE_t + b_tU_t + (1 - a_t - c_t)N_t + g^N_t$$

For every period, the probabilities must be non-negative and satisfy $s_t + d_t \le 1$, $f_t + b_t \le 1$ and $a_t + c_t \le 1$. Summing the three equations gives $W_{t+1} = W_t + g^E_t + g^U_t + g^N_t$. The unemployment rate is $u_t = U_t/(E_t + U_t)$, while the employment

rate is $e_t = E_t/W_t$. These are different indicators, and their movements need not coincide.

The first substantive mechanism concerns structural mismatch. Let M_t denote a non-negative index reflecting the divergence between available professional qualifications, regional location and the composition of labour demand. Let X_t represent the severity of adverse economic disturbances; A_t the intensity of active labour-market measures; Q_t the quality or effective targeting of these measures; and G_t a measure of labour-demand growth. One possible specification is:

$$logit(s_t) = \alpha_0 + \alpha_1 X_t + \alpha_2 M_t + \alpha_3 Z_t$$

$$logit(f_t) = \beta_0 - \beta_1 M_t + \beta_2 A_t Q_t + \beta_3 G_t$$

Here Z_t denotes institutional conditions affecting separations, and $\text{logit}(p) = \ln[p/(1-p)]$. The signs $\alpha_1 \geq 0$, $\alpha_2 \geq 0$, $\beta_1 \geq 0$ and $\beta_2 \geq 0$ are theoretical expectations, not estimated results. The product A_tQ_t is introduced deliberately: expenditure or programme participation alone does not establish policy effectiveness. Measures may be extensive in scale but weak in their correspondence to actual vacancies or to the qualifications of the participants.

Structural mismatch is itself persistent. Closure of enterprises, changes in production technology and the disappearance of occupations may create an imbalance that cannot be corrected within one reporting period. A provisional dynamic representation is:

$$M_{t+1} = \rho M_t + \kappa R_t - \lambda T_t + E_t$$

R_t measures the intensity of sectoral reallocation, and T_t measures effective retraining and mobility. The parameter ρ expresses persistence, while ε_t covers disturbances not included in the observed indicators. This linear specification is local and must not be extrapolated where it predicts a negative mismatch index; a bounded or transformed equation should be used when necessary. Its significance is analytical: even after the initial economic shock weakens, mismatch may continue to depress hiring.

6. Social Vulnerability and the Limits of Compensatory Measures

The social consequences of unemployment cannot be measured by the unemployment rate alone. The duration of exclusion, the purchasing power of households, the adequacy of benefits and the territorial concentration of hardship all influence the extent of social vulnerability. In the early stages of the Bulgarian transition, measures designed to contain immediate tension had to operate in an environment of severe economic contraction. Their social purpose was substantial, but the existence of such measures did not mean that the underlying problem of labour demand had been resolved [1].

Let V_t be a composite indicator of social vulnerability, L_t the exposure to long-term unemployment, D_t a measure of distributional pressure, and B_t the effective coverage of social protection. A testable reduced-form relation is:

$$V_{t+1} = \varphi V_t + \theta_1 L_t + \theta_2 D_t - \theta_3 B_t + \eta_t$$

This equation requires a clearly documented method of constructing V_t. It should not be interpreted as showing that all forms of public assistance necessarily reduce vulnerability by the same amount. Benefits may protect immediate consumption while doing little to alter employment opportunities. Conversely, an effective programme of qualification and placement may influence vulnerability indirectly by changing the future employment prospects of its participants.

Public policy also responds to social conditions. Let A_t denote active-policy intensity. The descriptive feedback equation $A_{t+1} = \psi A_t + \omega V_t + \nu_t$ expresses the possibility that worsening social conditions lead to an expansion of measures. This creates an important difficulty for evaluation: a positive correlation between programme spending and unemployment may reflect the fact that governments intervene when unemployment is already rising. It cannot by itself be interpreted as evidence that the programmes caused unemployment.

7. Historical Periods and the Problem of Comparable Data

For the purposes of empirical work, the period 1989–2025 can be divided into four analytically distinct stages. The years 1989–1997 cover the initial institutional transformation and the severe economic and financial disturbances. The period 1998–2006 concerns stabilisation and the continuing adjustment of production and employment. The years 2007–2019 include European Union membership, new opportunities for labour mobility and the effects of international economic cycles. The years 2020–2025 involve the pandemic shock and subsequent adjustments. These boundaries are interpretative and should not be treated as statistically established structural breaks without formal tests.

The original article presents employment rates for persons aged 20–64 across European countries for 2014–2023 and a separate series of monthly unemployment observations for late 2023 and 2024 [1]. These tables are useful for describing later labour-market conditions, but they do not directly measure the first decade of the transition. The two tables concern different indicators and time frequencies. They should not be joined into a single time series. The original employment table itself identifies breaks and differences in statistical definitions that must be preserved.

A historical database should draw on the National Statistical Institute, Eurostat and the Employment Agency, with explicit documentation of the population covered, survey definitions, revisions and missing years [6]. Series on enterprise restructuring, industrial employment, educational attainment, migration, programme participation, benefit receipt and regional employment should be added only where their coverage is sufficiently consistent. In cases where harmonisation is impossible, the analysis should be limited to separately comparable subperiods rather than creating artificial continuity.

8. Research Hypotheses and Estimation

The model gives rise to six propositions. H1: adverse economic disturbances are followed by an increase in the probability of employment-to-unemployment transitions. H2: structural mismatch reduces the probability of re-employment even after aggregate economic conditions improve. H3: the effect of active labour-market programmes depends on their targeting and correspondence to demand, not only on their scale. H4: long-term unemployment and uneven regional exposure contribute to the persistence of social vulnerability. H5: public intervention responds to

worsening social conditions, making policy intensity endogenous. H6: changes in participation and migration can improve the measured unemployment rate without a comparable expansion of sustainable employment.

The empirical strategy must begin with descriptive reconstruction, not immediate estimation of a large system. Annual employment, unemployment and inactivity stocks should first be assembled for each consistent statistical period. Break tests and plots of the principal indicators can then identify candidate episodes of discontinuity. If individual or aggregate gross-flow observations are available, transition probabilities may be estimated directly. If only annual stocks are available, the six transition probabilities cannot generally be recovered uniquely from the three stock equations; additional data, long-term series descriptions [6], or identifying restrictions are indispensable.

A parsimonious specification should be preferred to a model containing more parameters than the available observations can support. For unemployment and employment rates, an initial benchmark may be an autoregressive model with a small number of economic and demographic covariates. The structural–dynamic model should then be compared against that benchmark using out-of-sample prediction, residual diagnostics and sensitivity to alternative definitions of mismatch and policy intensity. Confidence intervals and parameter uncertainty must be reported. No numerical parameter values are claimed in the present article.

Evaluating policy effectiveness requires particular care. Programmes may select participants according to age, education, duration of unemployment or region; such selection can bias simple comparisons. Where the rules of implementation allow it, regional differences, eligibility thresholds or staggered introduction may support a stronger design. Otherwise, the results should be described as associations rather than causal effects. These restrictions are part of the scientific interpretation, not a weakness to be concealed.

9. Policy Scenarios and Their Interpretation

After the model has been estimated, three types of policy response can be compared. The first is a greater emphasis on retraining, professional mobility and matching between qualifications and vacancies. In the equations, this may reduce mismatch and increase the probability of movement from unemployment into employment. The second is the expansion of temporary publicly supported employment. Such measures may rapidly improve recorded employment and household income but do not necessarily alter future private demand for labour. The third combines training and placement with measures directed at regional economic development, seeking to influence both the supply of skills and the availability of suitable positions.

A scenario is meaningful only when its assumptions are explicit. The number of participants, cost, duration of assistance, displacement of unsubsidised employment and the persistence of outcomes after programme completion should all be considered. Without calibrated parameters, the scenarios remain analytically described possibilities, not numerical forecasts. The historical experience discussed in the original article suggests why this distinction matters: an intervention may be socially necessary in the short term and still insufficient as a long-term mechanism of structural adjustment [1-2].

10. Discussion

The proposed model gives a more precise meaning to the assertion that the labour market is especially sensitive to social transformations. Its sensitivity is expressed not merely in the level of unemployment but in the simultaneous changes in job loss, hiring, inactivity and migration. A period of institutional change can generate a disturbance; structural mismatch can preserve its effects; and policy measures can modify the path of adjustment without necessarily reversing the original restructuring. In this interpretation, the labour market is both an indicator of transformation and a mechanism through which its social consequences are transmitted.

The mathematical representation also introduces necessary limits into the argument. Not every deterioration in employment is caused by the political transition, and not every improvement is evidence that the transition has been completed. International cycles, technological changes, demographic decline and labour mobility must be considered alongside domestic institutional processes. The interpretation of historical experience becomes stronger, rather than weaker, when these alternative influences are made explicit.

Another limitation concerns the scale of observation. National averages may conceal the fate of regions in which production was concentrated in a narrow group of industries. Similarly, a programme that produces a modest aggregate effect may have a significant social value for a particular group. The extension of the model to regional and demographic subpopulations is therefore a logical next step, provided the available observations allow stable estimation.

11. Empirical Examination of Employment Dynamics, 2014–2023

The historical argument requires a distinction between the first decades of transition and the recent statistical observations actually available in the source study. Table 1 of the foundational manuscript reports the employment rate for persons aged 20–64 in Bulgaria for 2014–2023 [1]. The ten values are reproduced below without interpolation. The 2022 observation is marked by Eurostat as a break in the series; this qualification limits direct comparison across the entire interval.

Table 1: Employment rate in Bulgaria, ages 20–64, annual observations (%)

2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
64.4	66.5	67.0	70.6	71.7	74.3	72.7	73.2	75.9	76.2

Source: Source: Eurostat, as cited in Terziev, Georgiev, and Simeonov, 2025 [1].

A descriptive ordinary least-squares benchmark estimates the relationship $e_t = a + bt + \varepsilon_t$, where e_t is the employment rate in percentage points and $t = 0$ for 2014. With the ten observations, the fitted equation is $\hat{e}_t = 65.071 + 1.284t$. The estimated annual slope is 1.284 percentage points (standard error 0.143; conventional two-sided 95% interval 0.955–1.613), with $R^2 = 0.910$ and an in-sample root-mean-square residual of 1.159 percentage points. These conventional inferential statistics assume the standard linear-regression error conditions; ten temporally ordered observations, a flagged statistical break, and likely serial dependence make the confidence interval illustrative rather than definitive.

The rate increased by 11.8 percentage points between 2014 and 2023. Its annual change was not uniform: it fell by 1.6

percentage points from 2019 to 2020 and rose by 3.0 percentage points between 2021 and 2022, although the latter comparison crosses a documented series break. The arithmetic supports the narrower conclusion that employment improved substantially over the observed decade while remaining sensitive to disturbances. It does not establish that any particular government programme caused the increase, nor that the structural consequences of the 1990s had disappeared.

11.1. Numerical Checks and Identification Limits

As a sensitivity check, removing the flagged 2022 observation and fitting the same time trend to the remaining nine calendar-year observations changes the estimated slope only modestly. This check is descriptive: the break may also affect comparability between 2023 and earlier years. A stronger test requires the original Eurostat metadata and consistently defined historical series.

Excluding 2022, the estimated slope is 1.275 percentage points per year (n = 9), compared with 1.284 in the complete series. This result describes sensitivity to one observation; it is not a correction for the definitional break.

The three-state model has six unknown transition probabilities per period, whereas stock totals alone provide at most two independent transition restrictions after the population identity is imposed. Even a long series of employment and unemployment rates cannot uniquely identify all six flows without supplementary gross-flow data, identifying restrictions or microdata. It would be incorrect to report calibrated values for separation, hiring or inactivity transitions from Table 1. Similarly, the model's mismatch, vulnerability and institutional-response terms cannot be estimated without independent measures. This is a substantive finding about the limits of available evidence, not a reason to replace missing observations with assumed coefficients.

11.2. Illustrative Policy Mechanism, Not a Forecast

Consider the unemployment stock equation while holding employment and inactivity inflows fixed for one period. An increase Δf in the probability that an unemployed person finds work changes the next-period unemployment stock by $\Delta U_{t+1} = -U_t \Delta f$, other flows unchanged. If, purely for illustration, the unemployed stock were 100,000 and the transition probability increased by 0.01, the mechanical one-period difference would be 1,000 fewer unemployed persons. These are hypothetical inputs, not Bulgarian observations or an estimated programme effect. The same policy may also alter participation, migration, displacement and subsequent separation, so this one-period identity cannot be treated as a cost–benefit estimate.

12. Conclusions

The social and economic transformations in Bulgaria were not a sequence of isolated political decisions and market adjustments. They altered the relations between production, employment, professional qualification and social security. The labour market registered these changes rapidly, while their consequences for particular groups and local communities could remain visible for considerably longer. The earlier historical analysis identified the central problem: emergency measures may moderate the consequences of a crisis without resolving the structural conditions that generated it [1].

The present article develops this proposition into a structural–dynamic research framework. The separation of employment, unemployment and inactivity, the explicit treatment of structural mismatch and the inclusion of social vulnerability and institutional feedback make it possible to formulate hypotheses that can be confronted with evidence. The mathematical apparatus is subordinate to the socio-economic explanation; its purpose is to make the assumptions visible and to establish what must be measured before a conclusion can be defended.

The principal task remaining is empirical calibration with comparable historical series. Until this has been completed, the model should be regarded as a theoretically specified instrument for investigation, not as proof of the magnitude or causal direction of particular effects. Its value lies in opening a more rigorous examination of the duration of social transformations, the unequal distribution of their consequences, and the conditions under which public policy can contribute to lasting employment.

13. Declaration on the Use of Artificial Intelligence Tools

During the preparation of this study, artificial intelligence (AI)-based tools were used solely for technical support related to the visualization, graphic design, editing, and structuring of selected figures, tables, and other visual elements presented in the manuscript.

All scientific ideas, concepts, methodological approaches, analyses, interpretations, discussions, conclusions, and recommendations were developed, critically evaluated, verified, and approved by the authors. The authors assume full responsibility for the content, accuracy, and scientific integrity of the publication.

Artificial intelligence tools were not used to generate scientific results, conduct data analysis or interpretation, formulate scientific conclusions, or create original scholarly contributions. Their use was strictly limited to technical and editorial assistance during the preparation of the manuscript.

14. Data and Reproducibility

The calculations use exactly the following values, in year order 2014–2023: 64.4, 66.5, 67.0, 70.6, 71.7, 74.3, 72.7, 73.2, 75.9, 76.2. They can be reproduced with ordinary least squares using an intercept and calendar-year index. The original source flags 2022 as a break. The complete historical database for 1989–2025, labour-market transition microdata, and causal policy-evaluation dataset are not available in the supplied materials. This article reports a limited empirical illustration, not a calibrated or causally validated full structural model.

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