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Digital Transformation, Remote Work and Migration in the European Union: Implications for Sustainable Labour Markets

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Abstract

This study examines the conditional correlates of usual working from home and the net population migration rate across the 27 European Union Member States. Separate balanced panels cover 2014–2025 for working from home (324 observations) and 2015–2024 for migration (270 observations). Country and year fixed-effects models are estimated, with inference compared across White cross-section, country-clustered and Driscoll–Kraay covariance estimators. In the working-from-home model, regular Internet use has a negative coefficient and GDP per capita a positive coefficient; both remain significant under country-clustered inference. Unemployment has a positive baseline coefficient but loses significance under country-clustered inference. In the migration model, R&D expenditure intensity and GDP per capita have positive baseline coefficients, but neither remains significant at the 5% level with country-clustered standard errors. Knowledge-intensive employment is non-significant in both models, and its exclusion leaves the remaining coefficients almost unchanged. Adding unemployment to the migration model removes the baseline significance of R&D intensity. Country and recent-year exclusions preserve positive R&D-intensity and GDP-per-capita coefficients, while significance remains sensitive to inference, conditioning and period coverage. The estimates describe conditional within-country associations without identifying causal mechanisms or a relationship between the two outcomes. Labour-market sustainability provides a conceptual context rather than an empirically evaluated outcome.

Keywords: working from home; net migration; internet use; R&D intensity; panel data; fixed effects; labour-market sustainability; European Union

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1. Introduction

Labour mobility is one of the defining features of contemporary economies, reflecting both the structural transformations of production systems and the technological developments and globalisation processes that have characterised the world economy in recent decades [1]. From a traditional perspective, labour mobility has been analysed mainly in terms of the geographical migration of workers, driven by wage differences, employment opportunities and living conditions across regions or countries. Within this theoretical

framework, mobility is interpreted as an economic adjustment mechanism between labour markets, contributing to the redistribution of labour towards areas where it can be better remunerated and more productively used [2]. However, recent economic and technological transformations have substantially changed both the mechanisms and the motivations underlying labour mobility.

The accelerated digitalisation of the economy and the integration of information technologies into production processes have altered the tasks performed by workers and the organisation of employment [3]. These changes have also enabled some professional activities to be carried out outside the traditional workplace, reducing geographical constraints for certain types of work [4]. Digitalisation therefore affects not only the way work is organised, but also the extent to which access to professional opportunities remains dependent on physical relocation.

Despite the growing spatial flexibility of work, geographical mobility remains an important component of labour-market adjustment. Migration can help economies respond to labour shortages and demographic pressures, while remittances, return movements, skills circulation and migrant integration continue to receive considerable attention in both research and policy debates [5,6]. Labour mobility also contributes to the geographical redistribution of human capital, with implications for productivity, knowledge diffusion and regional development [7]. Thus, the increasing spatial flexibility of work enabled by digital technologies coexists with continued geographical mobility across regions and countries.

These transformations also have implications for the economic and social sustainability of labour markets. More flexible forms of work may widen access to employment and improve the capacity of labour markets to respond to change. Their expansion nevertheless brings concerns related to job conditions, worker protection and unequal opportunities to benefit from new working arrangements [8]. At the same time, persistent migration flows influence the geographical distribution of human capital and the capacity of economies to respond to demographic and labour-market imbalances. From this perspective, the interaction between digital transformation and labour mobility is relevant not only for economic efficiency and competitiveness, but also for the longer-term capacity of labour markets to respond to technological, demographic and structural pressures.

Despite the extensive literature on international migration and the growing body of research on digitalisation and new forms of work, the relationship between these transformations and labour-market sustainability remains insufficiently integrated. Migration studies have traditionally focused on geographical mobility, economic incentives, human-capital flows and the consequences of migration for origin and destination economies [1,5]. Research on technological change has mainly examined automation, employment structures, remote work and changing skill requirements [3,4,9]. These strands of literature provide important but largely separate perspectives. Consequently, less attention has been devoted to examining how the increasing spatial flexibility of work coexists with continued geographical mobility and what this coexistence implies for the adaptive capacity of labour markets.

This gap is particularly relevant in the European Union, where high but uneven levels of digitalisation coexist with substantial differences in economic development, innovation capacity, employment conditions and migration balances. These differences raise a broader sustainability question. The capacity of labour markets to respond to structural change depends not only on technological access, but also on whether technological resources are converted into viable forms of work, whether economic and innovation conditions support the effective use of human capital, and whether adaptation occurs without reinforcing persistent social or territorial imbalances.

These considerations lead to three research questions:

RQ1. *How are digital connectivity, economic development, unemployment and knowledge-intensive employment associated with the prevalence of working from home across EU Member States?*

RQ2. *How are knowledge-intensive employment, R&D expenditure, economic development and poverty and social exclusion associated with net migration across EU Member States?*

RQ3. *How can the findings be situated within the literature on labour-market sustainability, and what additional evidence is needed to assess their sustainability implications?*

This study contributes recent EU-wide evidence on the conditional correlates of two separately observed outcomes: usual working from home and the net migration rate. Its contribution is comparative and descriptive. Both outcomes are examined using country and year fixed-effects models, with GDP per capita and knowledge-intensive employment included in both specifications. The remaining explanatory variables address the specific research question associated with each outcome. The common labour-market sustainability framework provides a basis for discussing the findings alongside one another, but it does not establish an empirical connection between working from home and migration. The study therefore extends existing evidence on these two topics rather than proposing or testing an integrated mechanism linking them.

The empirical analysis estimates two separate panel-data models for the 27 EU Member States. The first examines factors associated with usual working from home during 2014–2025, while the second examines factors associated with the net migration rate during 2015–2024. Neither specification includes the other outcome as an explanatory variable. The models therefore do not test whether working from home substitutes for or complements geographical migration, or whether digitalisation changes the economic correlates of migration. Comparisons are limited to the patterns reported for the two shared regressors and remain qualified by differences in the estimation periods and conditioning sets. Because the analysis uses aggregate observational data, the coefficients represent conditional within-country associations rather than causal effects or evidence about individual workers' and migrants' decisions.

The paper proceeds with the theoretical background and hypothesis development in Section 2. Section 3 presents the data and empirical approach, followed by the results in Section 4. Their implications for labour-market sustainability are discussed in Section 5, while Section 6 concludes the study.

2. Theoretical Background and Literature Review

2.1. Economic and Social Determinants of Labour Mobility

Labour mobility enables workers to respond to uneven economic opportunities across locations. In the neoclassical approach, migration is linked to the economic returns expected from moving rather than to observed wage differences alone. In the Harris–Todaro framework [10], employment prospects at the destination are part of this calculation, meaning that migration may still occur even where unemployment is present if expected opportunities remain comparatively attractive.

Subsequent approaches moved beyond an exclusively individual interpretation of migration. The new economics of labour migration places the decision within the household, where moving can serve as a way of diversifying income sources and managing economic uncertainty [11]. Migration decisions may therefore reflect the constraints and risks faced by the household, alongside the expected gains of the individual migrant.

Network-based explanations add a social dimension to these economic arguments. Massey et al. [12] emphasise that established migrant connections can provide information, employment contacts and practical assistance at the destination. By lowering some of

the uncertainty and costs associated with moving, these networks can facilitate further migration and contribute to the persistence of established migration routes over time.

The international movement of human capital is also an important dimension of contemporary migration. Docquier and Rapoport [5] show that high-skilled migration can generate human-capital losses for origin countries, while also producing potential benefits through remittances, knowledge transfers, networks and incentives for human-capital formation. Migration therefore affects not only the geographical distribution of population, but also the allocation of skills and knowledge between economies.

Mobility is not necessarily permanent. Temporary and return migration represent important forms of international mobility, and the expected duration of migration can influence decisions regarding consumption, savings and human-capital accumulation [13]. These forms of mobility are particularly relevant in integrated economic areas such as the European Union, where the movement of people takes place alongside substantial differences in economic development and labour-market opportunities.

These theories provide a broader explanation of migration than the aggregate specification estimated in this study. Expected-income arguments motivate considering economic and labour-market conditions, but GDP per capita and unemployment do not directly measure individuals' expected earnings or employment prospects. Household risk diversification, migrant networks and decisions about migration duration are not observed. The new economics of labour migration and network theories therefore provide context rather than hypotheses directly tested by the model. The empirical analysis examines selected country-level associations and should not be interpreted as a test of these theories as a whole.

2.2. Digitalisation, Remote Work and the Changing Organisation of Work

Technological change has weakened the link between professional activity and a fixed workplace for a growing range of tasks. Author [3] places this development within the wider transformation of employment, where technology changes both the content of jobs and the skills required from workers.

Whether work can actually be performed remotely depends strongly on what a job involves. Dingel and Neiman [14] identify substantial differences in teleworkability across occupations and industries, reflecting the specific tasks attached to each type of work. Digital access is therefore necessary for many forms of remote work, but it does not make all occupations equally suitable for working from home.

The pandemic brought remote work into much wider use. Barrero et al. [4] show that part of this shift persisted beyond the immediate COVID-19 shock and associate its continuation with technological investment, accumulated experience with remote working and changing attitudes towards these arrangements. The Organisation for Economic Co-operation and Development (OECD) [15] likewise documents the role played by digital technologies in maintaining economic activity when physical mobility was restricted.

Connectivity provides the technical foundation for remote work, but differences in Internet access or use do not fully account for differences in its actual adoption [16]. The OECD [17] points to several complementary conditions, including workers' skills, management practices, digital infrastructure and the organisation of work. This distinction is especially relevant in the EU, where Internet use is already widespread and variations in remote work may increasingly reflect how digital capacity is used within organisations.

The occupational structure of the economy is also relevant. Activities based on information processing and cognitive tasks are generally more compatible with remote work than occupations requiring continuous physical presence. The substantial differences in teleworkability across occupations identified by Dingel and Neiman [14] support the ex-

pectation that economies with a greater presence of knowledge-intensive activities have a higher potential for remote work.

Economic development may further facilitate this process by supporting technological investment and organisational adaptation. At the same time, the pandemic demonstrated that remote work may also become relevant when labour markets face significant disruption. Using evidence from Germany, Alipour et al. [18] find that a greater ability to work from home helped to preserve employment and economic activity during the COVID-19 shock. The relationship between unemployment and the actual prevalence of remote work is nevertheless less straightforward, since remote work may both emerge as part of labour-market adjustment and reduce the employment effects of economic disruption.

Digital technologies also allow some activities to be supplied across locations without requiring the worker to relocate. Baldwin [19] discusses this possibility through the concept of telemigration, referring to the cross-border provision of services enabled by digital technologies. Remote work therefore changes the spatial organisation of employment without becoming equivalent to geographical migration.

These arrangements also bring new employment-related challenges. The International Labour Organization (ILO) [8] draws attention to working-time arrangements, occupational safety, social protection and the increasingly blurred boundary between professional and private life. The expansion of remote work therefore depends not only on what technology makes possible, but also on the conditions under which this form of work is organised.

European empirical studies examine working from home at different levels of aggregation. Jerbashian and Vilalta-Bufí [20] analyse industries in 12 European countries over 2008–2017, combining EU-LFS and EU-KLEMS data. Their difference-in-differences analysis associates falling ICT prices with greater WFH adoption in more ICT-dependent industries. This design examines an industry-level technological channel, using a measure that differs substantially from regular Internet use among individuals.

In a subsequent study covering 28 European countries during 2011–2022, Jerbashian and Vilalta-Bufí [21] document differences across countries, industries and occupations. They also relate increases in WFH to lower employment losses during the pandemic. Together, these studies distinguish technological conditions, employment composition and exceptional-period changes. The present country-level model addresses a narrower question: how changes in usual WFH are associated with selected aggregate indicators after country and year effects are removed. It does not reproduce the industry-level ICT design or directly estimate employment protection during the pandemic.

At the regional level, Ben Yahmed et al. [22] examine local labour-market resilience in Germany during the COVID-19 crisis. Their analysis associates greater digital-capital and WFH potential with lower short-time work, using a difference-in-differences design with continuous treatment. This evidence concerns local employment responses and technological potential, rather than the national association between unemployment and observed WFH prevalence estimated here. It provides context without establishing the mechanism behind the present unemployment coefficient.

The working-from-home specification captures only selected aggregate conditions related to these arguments. INTUSE measures regular Internet use among individuals, while KIA describes employment in knowledge-intensive activities. Neither directly measures workplace technology adoption or the tasks that can be performed remotely. GDP per capita and unemployment provide economic and labour-market context, but do not identify organisational investment or employers' responses to disruption. The hypotheses therefore concern associations between these observed indicators and usual WFH. Occupational, organisational and regulatory explanations remain outside the mechanisms directly examined.

2.3. Innovation, Human Capital and Migration

While digital technologies may reduce the importance of physical proximity for certain professional activities, geographical differences between economies continue to matter for migration. Differences in economic and institutional conditions can shape countries' attractiveness to internationally mobile talent [23].

The mobility of highly skilled workers is particularly relevant for economies in which knowledge and innovation play an important role. Kerr et al. [23] show that international talent flows contribute to the geographical distribution of knowledge and innovative capacity and are also shaped by economic and institutional conditions in destination countries.

Pudryk et al. [24] examine net migration in Bulgaria, Croatia, Lithuania, Latvia, Poland and Romania over 2011–2018. They use fully modified ordinary least squares for homogeneous and heterogeneous panel models, with an innovation index and governance indicators as explanatory variables. Their results associate innovation development and selected governance dimensions with net migration. This provides relevant evidence for examining innovation-related conditions, but differs from the present specification in country coverage, estimator and measurement. A composite innovation index is not equivalent to R&D expenditure intensity, and their inclusion of governance indicators highlights an institutional dimension omitted from the present model.

A more specific strand of research concerns migrant inventors. Caviggioli et al. [25] relate their mobility to the technological specialisation and complexity of destination areas, pointing to a matching process between individual expertise and local technological profiles.

Employment structure may also be relevant. Economies with a larger share of knowledge-intensive activities can offer specialised professional opportunities that are attractive to mobile human capital [23]. However, the relationship between knowledge-intensive employment and aggregate net migration is less direct than in the case of highly skilled migration, since net migration includes individuals with different levels of education, occupations and reasons for moving.

Economic conditions remain relevant to the attractiveness of alternative destinations [26]. Following the logic of Harris and Todaro [10], migration decisions reflect comparisons between the opportunities available across locations. More favourable economic environments may therefore support positive migration balances, whereas social and economic vulnerability can reduce a country's relative attractiveness when alternative destinations offer better prospects.

Economic determinants have also been examined in longitudinal European migration studies. Jennissen [27] analyses Western Europe over 1960–1998 using country-specific time-series regressions and pooled cross-sectional time-series analysis. GDP per capita is positively associated with net migration, while unemployment is negatively associated. His migration rate is derived from demographic change and uses midyear population, whereas the present study uses reported immigration minus emigration relative to population at the beginning of the year.

Franc et al. [28] examine East–West EU migration during 2000–2017 using country-pair and year fixed effects. Their findings identify destination-country GDP per capita and youth unemployment as relevant to emigration rates. Unlike an aggregate national migration balance, their bilateral approach distinguishes origin and destination conditions. It therefore examines migration opportunities and pressures that cannot be represented fully by the national indicators used here.

These studies show why empirical comparisons must distinguish the outcome, unit of observation, period, conditioning set and estimator. National net balances, bilateral flows and particular migrant groups answer different questions. Similarly, innovation expenditure, composite innovation performance and institutional quality capture different

conditions. The present model extends descriptive evidence to the EU-27 over 2015–2024, but does not test the full set of economic, institutional and bilateral mechanisms considered in earlier research.

The literature provides a rationale for examining economic conditions and R&D intensity alongside migration, but the available indicators do not identify the proposed behavioural channels. GERD measures expenditure relative to GDP rather than specialised employment opportunities or innovation outcomes. KIA measures employment structure rather than the skills of migrants, and POVER measures population-level social vulnerability rather than the resources or constraints of prospective migrants. The model consequently examines whether changes in these conditions are associated with changes in the net population migration rate. It does not distinguish attraction from retention, identify household or network mechanisms, or establish the direction of influence between migration and economic conditions.

2.4. Digital Transformation and Sustainable Labour Markets

Digital transformation and labour migration represent distinct but increasingly interconnected dimensions of labour-market change. Digital technologies can reduce the importance of geographical proximity for certain forms of employment, whereas differences in economic development, innovation capacity and employment opportunities continue to influence the geographical distribution of population and human capital. Whether remote work and geographical migration substitute for or complement one another is an empirical question. The present framework considers both topics, while the separate models do not test that relationship.

Labour-market sustainability is used here as a conceptual perspective concerning adaptation to structural change, access to employment, decent working conditions and social and territorial inclusion. These concerns are related to the economic and social dimensions of the United Nations 2030 Agenda, particularly SDGs 8, 9 and 10 [29]. The empirical analysis does not operationalise this perspective as an outcome, index or classification of countries. It therefore cannot determine whether an observed change in working from home or net migration represents an improvement in sustainability. The framework guides the discussion of relevant questions and evidence needs, while the regressions address the narrower associations specified in RQ1 and RQ2.

Employment vulnerability provides an example of a labour-market dimension requiring explicit measurement. Bazillier et al. [30] construct employer-related and job-related vulnerability indices for European countries. These measures concern aspects of employment that are not captured by WFH prevalence or a migration balance. Their approach illustrates why the sustainability discussion in the present study cannot substitute for direct evidence on employment conditions.

Remote work can contribute to labour-market sustainability by increasing organisational flexibility, supporting employment continuity during economic disruptions and expanding access to professional opportunities for workers located outside major employment centres. Previous research indicates that remote-work infrastructure can support recruitment and broaden employment opportunities in peripheral labour markets [31]. Remote work may also reduce some of the geographical constraints traditionally associated with employment and daily commuting [32]. However, these potential benefits are not automatic. Working from home may also generate risks related to working time, work intensity, occupational safety, social protection and unequal access to digitally enabled occupations [8,33]. Sustainable digitalisation therefore requires more than technological connectivity; it also depends on skills, organisational practices, employment quality and the capacity of workers and institutions to adapt.

Migration adds a demographic and territorial dimension to labour-market sustainability. Population mobility can contribute to the adjustment of labour supply, alleviate labour shortages and facilitate the circulation of knowledge and skills. At the same time, persistent differences in countries' capacity to attract and retain population may reinforce the uneven distribution of human capital and economic opportunities. Economies receiving mobile workers may benefit from additional labour and skills, whereas countries experiencing sustained outflows may encounter difficulties in maintaining their human-capital base and responding to demographic pressures [5,23]. Migration can therefore support adjustment at the European level while simultaneously generating sustainability challenges for particular countries or regions.

The empirical indicators represent selected aspects of the broader concepts discussed in this framework. WFH measures usual working from home, without identifying whether the activity is digitally enabled or performed for an employer or client abroad. INTUSE measures regular Internet use among individuals, rather than workplace digitalisation or the quality of professional connectivity. KIA records the employment share in knowledge-intensive activities, rather than the teleworkability of individual occupations. GERD measures R&D expenditure relative to GDP, not innovation outcomes. MIGR records the net population migration balance and does not identify labour migration, migrants' skills or the separate contributions of immigration and emigration. These distinctions limit the mechanisms that the models can examine. The indicators are therefore used to estimate associations between observable country-level measures, while their broader relevance to sustainability is discussed conceptually.

The sustainability perspective provides a conceptual rationale for considering the two outcomes within the same study. The working-from-home model addresses associations involving Internet use, economic development, unemployment and knowledge-intensive employment. The net-migration model addresses associations involving knowledge-intensive employment, R&D expenditure, economic development and poverty and social exclusion. These analyses remain empirically separate. Their placement within a common framework allows the findings to be discussed in relation to the literature on labour-market change, but does not demonstrate interaction, substitution or complementarity between working from home and migration. Such relationships would require a research design that examines them directly.

Evaluating sustainability would require explicit criteria and outcomes beyond those included here. For working from home, relevant evidence would include employment quality, working-time conditions and access across worker groups. For migration, it would include labour-market integration, the characteristics of immigration and emigration, and consequences for origin and destination communities. These outcomes could reveal benefits, costs or trade-offs that aggregate WFH prevalence and net migration balances cannot establish. The sustainability implications discussed in this paper should therefore be understood as literature-informed considerations and directions for further investigation.

2.5. Hypothesis Development

The hypotheses translate RQ1 and RQ2 into expected directions of association between the observed indicators. The theoretical arguments motivate these expectations, but the indicators only partially represent the broader concepts discussed above. Each hypothesis is therefore evaluated as a conditional within-country association after accounting for the other regressors and country and year effects. Support for an expected sign does not validate the underlying theory or identify its mechanism, while a non-significant coefficient does not refute that theory.

The first group of hypotheses addresses RQ1 and concerns the factors associated with working from home. Internet use provides the technological foundation required for performing professional activities outside the traditional workplace, although its relationship with actual working-from-home practices depends on complementary organisational and occupational conditions [15–17]. Economic development may support the technological investment, organisational capacity and occupational structure required for flexible work arrangements. In addition, the occupational evidence provided by Dingel and Neiman [14] indicates that knowledge-intensive activities are generally more compatible with working from home. Labour-market pressures may also be associated with the prevalence of working from home, particularly during periods of economic disruption [18]. In addition, because WFH is measured as a share of employed persons, employment losses concentrated in activities that cannot be performed remotely may increase the proportion of remaining workers who work from home. On this basis, a positive association with unemployment is expected. Based on these arguments, the following hypotheses are formulated:

H1. *Higher regular Internet use is expected to be positively associated with the share of employed persons usually working from home.*

H2. *A higher GDP-per-capita PPS index is expected to be positively associated with the share of employed persons usually working from home.*

H3. *A higher share of employment in knowledge-intensive activities is expected to be positively associated with the share of employed persons usually working from home.*

H4. *Higher unemployment is expected to be positively associated with the share of employed persons usually working from home.*

The second group of hypotheses addresses RQ2 and concerns the factors associated with net migration. The expected-income approach identifies economic opportunities as an important motivation for migration [10], while research on international talent flows emphasises the attractiveness of knowledge-oriented and innovation-intensive economic environments [23]. Evidence from European countries also indicates that innovation development is associated with migration outcomes [24]. At the same time, social vulnerability may reduce a country's relative attractiveness and may affect its capacity to retain population. These arguments provide the basis for the following hypotheses:

H5. *A higher share of employment in knowledge-intensive activities is expected to be positively associated with the net population migration rate.*

H6. *Higher R&D expenditure as a percentage of GDP is expected to be positively associated with the net population migration rate.*

H7. *A higher GDP-per-capita PPS index is expected to be positively associated with the net population migration rate.*

H8. *A higher population share at risk of poverty or social exclusion is expected to be negatively associated with the net population migration rate.*

The hypotheses corresponding to RQ1 and RQ2 are evaluated through the two panel-data models. RQ3 is addressed through a literature-informed discussion of the findings and their limitations. No statistical hypothesis is formulated for RQ3 because the study does not observe an outcome or apply an empirical criterion that distinguishes more sustainable from

less sustainable labour-market change. The sustainability discussion therefore identifies relevant questions and evidence gaps rather than evaluating sustainability performance.

3. Materials and Methods

3.1. Research Design, Data and Variables

The empirical analysis examines usual working from home and the net population migration rate in two separate country-level panels. A panel-data approach allows repeated observations for each EU Member State to be analysed over time [34,35]. The final specifications include country and year fixed effects, so the slope coefficients are estimated from variation remaining after persistent country differences and common annual shifts are removed.

The analysis covers the 27 Member States of the European Union and relies on harmonised data retrieved from Eurostat. Two balanced panels are constructed according to the availability of the indicators included in each model. The first covers the period 2014–2025 and contains 324 country-year observations (27 countries × 12 years). It is used to analyse remote work. The second covers the period 2015–2024 and contains 270 observations (27 countries × 10 years) and is used to examine net migration. The 2025 annual EU-LFS results were officially released by Eurostat on 17 April 2026 and were available for all EU Member States at the time of data extraction (20 June 2026).

The periods analysed include important changes in European labour markets, particularly the rapid expansion of remote work during the COVID-19 pandemic and its continuation in subsequent years. They also cover a period characterised by substantial economic and migration-related developments across EU Member States.

Two dependent variables are considered. Work from home (WFH) measures the percentage of employed persons aged 15–64 who usually work from home. It excludes the separate category of persons who sometimes work from home and does not distinguish particular hybrid arrangements. It also does not identify the use of digital technologies, the location of the employer or client, or the cross-border provision of services. The outcome therefore concerns usual working from home, rather than remote work in all its forms or telemigration. Net migration (MIGR) measures the difference between immigration and emigration for the total population, expressed per 1000 residents at the beginning of the year. Absolute values were retrieved from Eurostat's "Net migration by age and sex" dataset (migr_netmigr), using the total population and both sexes. This is a population migration balance, rather than a measure of labour migration or the total volume of mobility. Large immigration and emigration flows can offset each other, and an increase in MIGR can result from higher immigration, lower emigration or both. The indicator does not distinguish migrants by employment status, education, skills or reason for moving. Unlike net migration plus statistical adjustment, the measure used here is based on the reported difference between immigration and emigration and excludes residual demographic adjustments.

$$MIGR_{it} = \frac{NM_{it}}{POP_{it}} * 1000$$

where NM_{it} represents net migration, calculated as the difference between immigration and emigration in country i during year t, while POP_{it} represents the resident population at the beginning of year t. The indicator therefore expresses the net migration balance per 1000 inhabitants.

The explanatory variables were selected based on the theoretical arguments developed in Section 2 and the availability of comparable data for all EU Member States. The remote-work model includes indicators of digital connectivity, economic development, labour-market conditions and occupational structure. The net-migration model considers

employment structure, research and innovation effort, economic development and social vulnerability. The variables, their measurement and the corresponding Eurostat datasets are presented in Table 1.

Table 1. Variable definitions and data sources.

Variable	Abbreviation	Definition	Data Source
Work from home	WFH	Share of employed persons aged 15–64 usually working from home (%)	Eurostat [36], lfsa_ehomp
Internet use	INTUSE	Share of individuals aged 16–74 using the internet at least once a week, %	Eurostat [37], isoc_ci_ifp_fu
GDP per capita	GDPCAP	GDP per capita in purchasing power standards, PPS volume index (EU-27 = 100)	Eurostat [38], tec00114
Unemployment	UNEMP	Unemployment rate for persons aged 15–74, %	Eurostat [39], une_rt_a
Knowledge-intensive employment	KIA	Share of employment in knowledge-intensive activities among persons aged 15–64, %	Eurostat [40], htec_kia_emp2
Net migration	MIGR	Difference between immigration and emigration for the total population, both sexes, relative to the resident population at the beginning of the year, expressed per 1000 inhabitants.	Eurostat [41], migr_netmigr
R&D expenditure	GERD	Gross domestic expenditure on research and development, % of GDP	Eurostat [42], rd_e_gerdtot
Poverty and social exclusion	POVER	Population at risk of poverty or social exclusion, total population, both sexes, %	Eurostat [43], ilc_peps01n

The two models cover slightly different periods because the complete set of indicators required for each specification is not available over an identical longer time window. To preserve the maximum balanced sample available for each model, the baseline estimations therefore use 2014–2025 for working from home and 2015–2024 for net migration. As a robustness check, the working-from-home model was also re-estimated over the common 2015–2024 period used in the net-migration specification.

The population denominator for MIGR was obtained from Eurostat's "Population on 1 January by age and sex" dataset (demo_pjan). For each country and year, absolute net migration was divided by the resident population at the beginning of that year and multiplied by 1000. The population groups and measurement units used for the remaining indicators are specified in Table 1. The explanatory variables are interpreted according to their operational definitions. INTUSE records the percentage of individuals aged 16–74 who use the Internet at least weekly; it does not measure technology adoption by firms, workers' digital skills or connectivity quality. GDPCAP is a GDP-per-capita PPS volume index relative to the EU average, while UNEMP measures the unemployment rate. KIA records the share of employment in knowledge-intensive activities and does not directly identify the tasks that can be performed from home. GERD records gross domestic expenditure on R&D as a percentage of GDP and should be distinguished from innovation outputs or effectiveness. POVER records the percentage of the population at risk of poverty or social exclusion. The "usually working from home" category is retained because the analysis concerns that specific working arrangement. Including persons who sometimes work from

home would broaden the outcome, but would still not identify all hybrid arrangements or digitally enabled cross-border work. Likewise, the migration model concerns the aggregate net population balance and cannot test whether economic or R&D conditions are associated specifically with skilled-worker attraction or retention. The hypotheses are evaluated at the level of these observed indicators; the broader mechanisms discussed in the literature are not directly tested.

The baseline specifications contain selected aggregate correlates rather than a comprehensive set of determinants. KIA provides a broad measure of employment structure, but does not replace detailed industry shares or occupational teleworkability. Digital skills, firm size, workplace technology adoption and telework regulation are not included. The migration specification also omits wage differentials, demographic structure, diaspora networks and institutional quality. Adding unemployment provides one further labour-market control, but does not address these other omissions. Country effects absorb persistent differences, and year effects absorb common annual shifts; neither removes all time-varying omitted influences.

3.2. Econometric Specification, Model Selection and Diagnostic Tests

The empirical strategy is based on two panel specifications that exploit variation across EU Member States and over time. The general model is written as follows:

$$Y_{it} = \alpha + X\prime_{it}\beta + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

In Equation (1), Y_{it} denotes the outcome for country i in year t, X_{it} is the vector of explanatory variables, and β is the corresponding coefficient vector. The intercept is denoted by α, μ_i represents country fixed effects, λ_t represents year fixed effects, and ε_{it} is the error term.

Based on this framework, two specifications are estimated. The first examines the factors associated with remote work:

$$WFH_{it} = \alpha + \beta_1 IntUse_{it} + \beta_2 GDPcap_{it} + \beta_3 Unemp_{it} + \beta_4 KIA_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

The second specification examines the factors associated with the net migration rate:

$$Migr_{it} = \alpha + \beta_1 KIA_{it} + \beta_2 GERD_{it} + \beta_3 GDPcap_{it} + \beta_4 Pover_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

Both equations include country and year fixed effects. Country effects absorb persistent differences in outcome levels between Member States, while year effects absorb common annual shifts. The specifications nevertheless impose common slope coefficients across countries and years. They therefore do not estimate whether the associations differ between country groups or periods. Fixed effects should not be interpreted as accounting for all forms of heterogeneity, particularly differences in slopes or time-varying country-specific influences.

RQ3 does not correspond to an additional econometric equation. The models estimate associations with usual working from home and the net migration rate, without measuring whether changes in either outcome improve employment quality, social inclusion or territorial balance. The discussion addresses RQ3 by relating the subject matter to the sustainability literature and identifying the additional information required for an empirical assessment. It does not derive a sustainability effect from the combined coefficients of the two models.

For each model, pooled ordinary least squares (OLS), fixed-effects and random-effects specifications were initially estimated. The redundant fixed effects test was performed to

assess the relevance of country and year effects. The conventional Hausman test was initially used to compare fixed- and random-effects specifications [44]. Given the evidence of serial correlation, this comparison was supplemented with a Mundlak auxiliary regression, in which the country means of the time-varying explanatory variables were added to the model and tested jointly using country-clustered standard errors. The fixed-effects specification is retained because the analysis focuses on within-country changes over time and does not require the country-specific effects to be uncorrelated with the explanatory variables.

Residual cross-sectional dependence was examined using the Breusch–Pagan LM, Pesaran scaled LM, bias-corrected scaled LM and Pesaran CD tests [45]. Non-rejection by the CD test is not interpreted as evidence that residual dependence is absent, particularly when the LM-type tests reject independence. Serial correlation was assessed using the Wooldridge test [35]. The diagnostic results are used to identify limitations of the inference procedures rather than to claim that a single covariance estimator adequately addresses all forms of dependence.

The baseline tables report EViews White cross-section standard errors with degrees-of-freedom correction. The covariance calculations build on heteroskedasticity-consistent estimation [46], with the dependence assumptions determined by the chosen clustering structure. This estimator clusters observations by year, allowing heteroskedasticity and dependence across countries within the same year, but does not accommodate arbitrary serial correlation within countries across years. It also relies on only 12 annual clusters in the working-from-home panel and 10 in the migration panel, which limits the reliability of cluster-based inference. Country-clustered estimates are therefore reported separately in Table A4. They allow heteroskedasticity and serial correlation within countries, but do not accommodate arbitrary dependence between countries. Neither estimator is treated as sufficient on its own to resolve the full residual-dependence problem.

Driscoll–Kraay standard errors are also reported as a sensitivity check, using a Bartlett kernel with two lags (Table A3) [47]. This covariance estimator accommodates cross-sectional and temporal dependence under its asymptotic assumptions. However, its justification relies on a sufficiently long time dimension, whereas the present panels contain only 12 and 10 annual observations per country. The Driscoll–Kraay results therefore cannot be treated as definitive confirmation of statistical significance. Inference is assessed across the reported covariance estimators, and conclusions are qualified where significance changes.

As a timing sensitivity check, the net-migration model was re-estimated using one-year-lagged values of all explanatory variables (Table A5). This specification relates the migration balance in year t to the observed conditions in year $t - 1$. It does not constitute an identification strategy for addressing simultaneity: previous migration may already have affected those conditions, and lagged regressors may remain correlated with persistent omitted factors. In addition, introducing the lags reduces the estimation sample from 270 to 243 observations. Differences from the baseline may therefore reflect both the timing of the regressors and the shorter sample.

The working-from-home model was also re-estimated after excluding 2020 and 2021 (Table A6). This check assesses whether the reported associations persist when observations from the two main pandemic years are removed. It does not estimate separate pre-pandemic and post-pandemic slopes or account directly for differences in national restrictions, employment-support policies or pandemic exposure. The retained observations may also reflect lasting pandemic-related changes. Year fixed effects absorb common annual shifts, but do not fully account for shocks whose effects differ across countries.

For the net-migration model, two additional sensitivity checks were conducted to assess the influence of exceptional migration patterns and population size. The specification was re-estimated after excluding 2022 and, separately, after excluding Malta, Luxembourg,

Cyprus and Ireland, the countries highlighted as potentially influential because of comparatively small populations and volatile migration rates.

Two further specification checks were conducted. First, each model was re-estimated without KIA while retaining its baseline sample, to assess whether the other coefficients depend on including this regressor (Table A9). Second, the net-migration model was estimated repeatedly after excluding each country in turn (Table A10). Collinearity was also assessed using VIF values calculated after removing country and year effects, alongside the pooled diagnostics (Table A2). These checks address selected aspects of specification and sample sensitivity; they do not establish robustness to all alternative control sets or resolve omitted-variable bias.

The migration model was further extended to include unemployment, a labour-market condition examined in previous European migration studies [27,28]. This specification retains the baseline sample and permits comparison under White cross-section and country-clustered inference (Table A11). Two additional period restrictions exclude 2023–2024 and, separately, 2022–2024 (Table A12). These checks distinguish removing observations after 2022 from removing the entire period beginning in 2022. They assess sensitivity to conditioning and sample coverage, without identifying the causes of any differences.

The sensitivity analyses address four dimensions. Alternative covariance estimators assess changes in statistical inference (Tables A3 and A4). Period restrictions assess the common estimation window, pandemic-year exclusions and recent migration years (Tables A1, A6, A7 and A12). Specifications excluding KIA or adding unemployment assess selected changes in the conditioning set (Tables A9 and A11), while lagged regressors assess a different temporal specification (Table A5). Country exclusions assess sensitivity to sample composition (Tables A7 and A10). These checks are interpreted separately because stability in one dimension does not establish stability in the others.

The estimated coefficients are interpreted as conditional associations between the explanatory variables and the two outcomes considered. The empirical design is not intended to establish causal relationships. The specification tests and the final estimates are reported in Section 4.

The econometric estimations were performed using EViews 11.

4. Results

4.1. Descriptive Statistics and Correlation Analysis

The descriptive statistics reported in Table 2 show substantial variation across EU Member States over the periods analysed. In the remote-work panel, the share of employed persons usually working from home averages 7.76%, ranging from 0.20% to 32.20%. Internet use is considerably higher, with an average of 86.04% and values between 54.08% and 99.78%. GDP per capita in PPS ranges from 48 to 280, while knowledge-intensive employment varies between 19.50% and 61.60%. The unemployment rate averages 7.30%, with a maximum of 26.60%.

The net-migration panel also displays substantial variation across EU Member States. The average net migration rate is 5.42 per 1000 inhabitants, with values ranging from −8.60 to 43.06. The maximum value is recorded for Malta in 2019 and reflects the country's high net migration balance relative to its comparatively small resident population. R&D expenditure averages 1.68% of GDP, while the share of the population at risk of poverty or social exclusion averages 21.53%. Differences in GDP per capita and knowledge-intensive employment remain substantial in this panel as well.

Table 2. Descriptive statistics.

Variable	Mean	Median	Minimum	Maximum	Std. Dev.	Two-Way Within SD	Observations
Panel (**A**) Remote-work model, 2014–2025							
WFH	7.759	6.450	0.200	32.200	5.759	2.498	324
INTUSE	86.040	88.290	54.080	99.780	9.685	3.205	324
GDPCAP	102.142	91.000	48.000	280.000	43.097	6.770	324
UNEMP	7.297	6.400	2.000	26.600	3.884	1.518	324
KIA	36.964	36.350	19.500	61.600	6.592	1.106	324
Panel (**B**) Net-migration model, 2015–2024							
MIGR	5.418	3.775	−8.601	43.056	7.585	4.214	270
KIA	36.885	36.050	20.900	61.600	6.495	1.031	270
GERD	1.678	1.400	0.450	3.640	0.890	0.114	270
GDPCAP	102.233	91.000	49.000	279.000	43.100	5.319	270
POVER	21.526	20.050	10.700	46.000	6.113	1.655	270

Note: Within standard deviations are calculated after removing country and year effects and therefore reflect the variation used for identification in the two-way fixed-effects models. Source: Authors' calculations based on Eurostat data.

The correlation matrices in Table 3 show several differences between the two panels. Remote work is positively correlated with Internet use (0.633), knowledge-intensive employment (0.615) and GDP per capita (0.584), while the correlation with unemployment is negative and lower in magnitude (−0.220). The highest correlation between explanatory variables is observed between GDP per capita and knowledge-intensive employment (0.790).

Table 3. Pearson correlation matrices.

	WFH	INTUSE	GDPCAP	UNEMP	KIA
Panel (**A**) Remote-work model, 2014–2025					
WFH	1.000	0.633	0.584	−0.220	0.615
INTUSE	0.633	1.000	0.526	−0.429	0.622
GDPCAP	0.584	0.526	1.000	−0.215	0.790
UNEMP	−0.220	−0.429	−0.215	1.000	−0.134
KIA	0.615	0.622	0.790	−0.134	1.000
Panel (**B**) Net-migration model, 2015–2024					
	MIGR	**KIA**	**GERD**	**GDPCAP**	**POVER**
MIGR	1.000	0.477	0.002	0.429	−0.261
KIA	0.477	1.000	0.396	0.784	−0.479
GERD	0.002	0.396	1.000	0.244	−0.514
GDPCAP	0.429	0.784	0.244	1.000	−0.336
POVER	−0.261	−0.479	−0.514	−0.336	1.000

Source: Authors' calculations based on Eurostat data.

For net migration, positive correlations are observed with knowledge-intensive employment (0.477) and GDP per capita (0.429), while poverty and social exclusion is negatively correlated with MIGR (−0.261). The correlation between R&D expenditure and

net migration is close to zero (0.002). As in the first panel, the highest correlation between explanatory variables is found between GDP per capita and knowledge-intensive employment (0.784).

The within-country correlation patterns differ markedly from the pooled correlations once country and year effects are removed (Table A8). In the working-from-home panel, the correlation between WFH and Internet use becomes negative, while the correlation with unemployment becomes positive. The correlation between WFH and knowledge-intensive employment falls substantially. Similar differences are observed in the net-migration panel. These patterns confirm that the fixed-effects estimates rely on a different source of variation from the pooled correlations reported in Table 3.

The collinearity diagnostics distinguish the original variables from the variation used in the fixed-effects models (Table A2). Pooled VIF values range from 1.304 to 3.361 for working from home and from 1.427 to 3.136 for net migration. After removing country and year effects, the corresponding ranges are 1.026–1.464 and 1.007–1.309. These transformed-regressor diagnostics do not indicate substantial linear collinearity within either specification. In particular, the relatively high pooled correlations between GDP per capita and KIA do not carry over to the two-way within variation. This does not eliminate concerns about limited within variation or omitted variables, but it provides no indication that severe collinearity among the included transformed regressors explains the near-zero KIA coefficients.

4.2. Model Selection and Diagnostic Evidence

The specification tests support the inclusion of country and year effects in both models (Table 4). For remote work, the Redundant Fixed Effects F-statistics are 17.689 for cross-section effects, 27.824 for period effects and 18.920 for their joint inclusion, with *p*-values below 0.001. For net migration, the corresponding statistics are 9.530, 8.437 and 9.686, respectively, also with *p*-values below 0.001. The null hypothesis that the fixed effects are redundant is therefore rejected for both specifications.

Table 4. Model-selection and diagnostic tests.

Test	Remote Work	Net Migration
Redundant FE—Cross-section F	17.689 ($p < 0.001$)	9.530 ($p < 0.001$)
Redundant FE—Period F	27.824 ($p < 0.001$)	8.437 ($p < 0.001$)
Redundant FE—Cross-section/Period F	18.920 ($p < 0.001$)	9.686 ($p < 0.001$)
Hausman χ^2	32.756 ($p < 0.001$)	20.625 ($p = 0.0004$)
Mundlak auxiliary test F	6.227 ($p = 0.001$)	1.801 ($p = 0.1589$)
Breusch–Pagan LM	1436.491 ($p < 0.001$)	791.234 ($p < 0.001$)
Pesaran scaled LM	40.969 ($p < 0.001$)	16.616 ($p < 0.001$)
Bias-corrected scaled LM	39.742 ($p < 0.001$)	15.116 ($p < 0.001$)
Pesaran CD	−0.882 ($p = 0.378$)	0.950 ($p = 0.342$)
Country fixed effects	Yes	Yes
Year fixed effects	Yes	Yes

Note: The null hypothesis of the cross-sectional dependence tests is the absence of cross-sectional dependence in the residuals. FE denotes fixed effects. The Mundlak auxiliary test evaluates the joint significance of the country means of the time-varying regressors. The auxiliary regressions include year effects and use country-clustered standard errors. Source: Authors' calculations based on Eurostat data.

The conventional Hausman test rejects the random-effects specification in both models, with $\chi^2 = 32.756$ ($p < 0.001$) for the remote-work model and $\chi^2 = 20.625$ ($p = 0.0004$) for the net-migration model. Because this test is sensitive to assumptions concerning the error structure, the comparison was supplemented with the Mundlak auxiliary test. The country means of the explanatory variables are jointly significant in the working-from-home model ($F(4,26) = 6.227$; $p = 0.0012$), but not in the net-migration model ($F(4,26) = 1.801$; $p = 0.1589$). The evidence is therefore not uniform across the two specifications. Fixed effects are nevertheless retained in both models because the empirical analysis is concerned with within-country changes and does not rely on the random-effects orthogonality assumption.

All three LM-type tests reject residual cross-sectional independence in both models (Table 4), whereas the Pesaran CD test does not reject it: $p = 0.378$ for working from home and $p = 0.342$ for net migration. These outcomes do not establish that dependence is absent. Because the CD statistic aggregates signed pairwise correlations, positive and negative correlations may offset one another, although this possibility is not demonstrated by the reported tests alone. The short time dimension also warrants caution about finite-sample performance. Residual cross-sectional dependence therefore remains a concern, and statistical inference is assessed using the alternative covariance estimators rather than relying on CD non-rejection.

The Wooldridge test rejects the null hypothesis of no first-order serial correlation in both specifications: $F(1,26) = 101.476$ for working from home and $F(1,26) = 85.420$ for net migration, with p-values below 0.001. This evidence is consequential because the baseline White cross-section covariance estimator does not allow arbitrary within-country serial dependence. The country-clustered estimates in Table A4 address that dimension of dependence, although their validity also requires assumptions about independence between countries. Given the cross-sectional-dependence diagnostics, no single reported covariance estimator is regarded as resolving all inferential concerns.

4.3. Fixed-Effects Estimation Results

According to Table 5, the working-from-home model records an R^2 of 0.857 and an adjusted R^2 of 0.836, while the corresponding values for the net-migration model are 0.714 and 0.665. These statistics refer to the complete specifications, including country and year fixed effects. The within R^2 values are 0.238 for working from home and 0.072 for net migration, indicating that the observed regressors account for a larger share of the variation remaining after country and year effects are removed in the working-from-home model than in the net-migration model. The distinction is important because the overall R^2 should not be interpreted as the explanatory contribution of the observed regressors alone.

Regarding RQ1, Internet use, GDP per capita and unemployment are statistically significantly associated with working from home, whereas knowledge-intensive employment is not significant. Internet use has a negative coefficient ($\beta = -0.266$; $p < 0.001$). Thus, H1, which expected a positive association, is not supported. A one-percentage-point increase in Internet use is linked with a 0.266-percentage-point decrease in the share of employed persons usually working from home, holding the other variables and the country and year effects constant. This estimate should not be described as evidence that greater Internet use causes a reduction in working from home.

GDP per capita has a positive baseline coefficient of 0.179 ($p < 0.001$). A one-point increase in the PPS volume index is associated with an estimated 0.179-percentage-point increase in usual working from home, conditional on the other regressors and fixed effects. H2 is supported under both baseline and country-clustered inference. The unemployment coefficient is positive and significant in the baseline model, consistent with H4, but is not significant at the 5% level under country-clustered inference. Support for H4 is therefore

sensitive to the covariance estimator. KIA has a near-zero and non-significant coefficient ($p = 0.968$), providing no support for H3 in this specification without establishing the absence of a relationship more generally.

Table 5. Two-way fixed-effects estimates.

Variable	Remote Work	Net Migration
Constant	10.525 ** (5.147)	−11.830 (10.499)
Internet use	−0.266 *** (0.039)	–
GDP per capita	0.179 *** (0.030)	0.156 *** (0.053)
Unemployment	0.281 *** (0.057)	–
Knowledge-intensive employment	−0.005 (0.136)	0.001 (0.160)
R&D expenditure	–	3.313 ** (1.382)
Poverty and social exclusion	–	−0.201 (0.178)
Country fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	324	270
R^2	0.857	0.714
Adjusted R^2	0.836	0.665
Within R^2	0.238	0.072
F-statistic	41.054 ***	14.688 ***

Note: White cross-section robust standard errors with degrees-of-freedom correction are presented in parentheses. The dependent variable is expressed in percentage points in the working-from-home model and as net migrants per 1000 inhabitants in the net-migration model. Within R^2 is calculated after removing country and year effects and reflects the variation explained by the observed regressors within the two-way fixed-effects framework. *** $p < 0.01$; ** $p < 0.05$. Source: Authors' calculations.

The signs obtained for Internet use and unemployment differ from their pairwise correlations with WFH. Internet use is positively correlated with working from home in the pooled data, whereas its coefficient is negative in the two-way fixed-effects model. Conversely, unemployment has a negative pairwise correlation with WFH but a positive coefficient in the final specification. The fixed-effects estimates rely on within-country changes over time after accounting for common year effects and the other explanatory variables. They therefore address a different relationship from unconditional correlations and should be interpreted accordingly.

Regarding RQ2, GERD has a positive baseline coefficient of 3.313 ($p = 0.0173$). A one-percentage-point increase in R&D expenditure relative to GDP is associated with an estimated increase of 3.313 net migrants per 1000 inhabitants, conditional on the other regressors and fixed effects. This is a substantial change in R&D intensity relative to its observed within-country variation. The coefficient supports the direction proposed in H6 under baseline inference, but is not significant at the 5% level with country-clustered standard errors. Evidence for H6 is therefore sensitive to the covariance estimator.

GDP per capita has a positive baseline coefficient of 0.156 ($p = 0.0032$). A one-point increase in the PPS volume index is associated with an estimated increase of 0.156 net migrants per 1000 inhabitants; a ten-point increase corresponds to approximately 1.56. This supports H7 under baseline inference, but the coefficient is not significant at the 5% level under country-clustered inference. H7 therefore receives covariance-sensitive support rather than consistent support across the reported inference procedures.

Knowledge-intensive employment has a coefficient close to zero and is not statistically significant ($\beta = 0.001$; $p = 0.9969$), providing no support for H5. Poverty and social exclusion have a negative but statistically insignificant coefficient ($\beta = -0.201$; $p = 0.2610$), and H8 is therefore not supported. The absence of statistical significance does not demonstrate that employment structure or social vulnerability is irrelevant to migration. It indicates that the models do not identify independent within-country associations for these variables during the period analysed after accounting for the other regressors and the country and year effects.

A similar distinction applies to knowledge-intensive employment in both models. Although KIA is positively correlated with WFH and MIGR in the pooled data, its coefficient is not statistically significant in either of the full fixed-effects specifications.

The GERD result differs from its pairwise correlation with net migration. Although the correlation between R&D expenditure and MIGR is close to zero, its coefficient becomes positive and statistically significant in the two-way fixed-effects specification. This indicates that the conditional within-country relationship, after controlling for economic development, employment structure, social vulnerability and common year effects, differs from the association observed in the pooled data.

As an additional robustness check, the working-from-home specification was re-estimated over the common 2015–2024 period used in the net-migration model. The results remain substantively unchanged (Table A1). Internet use remains negatively and statistically significantly associated with working from home, while GDP per capita and unemployment retain positive and statistically significant coefficients. Knowledge-intensive employment remains statistically non-significant.

Using Driscoll–Kraay standard errors preserves the baseline signs and the significance pattern at the 5% level (Table A3). However, this agreement is qualified by the short time dimension on which the estimator is applied. It also does not remove the sensitivity evident under country-clustered inference: unemployment in the working-from-home model, and GERD and GDP per capita in the migration model, are not significant at the 5% level with country-clustered standard errors (Table A4). These differences concern statistical precision rather than changes in the estimated coefficients. The migration findings in particular should therefore be presented as positive point estimates with covariance-sensitive significance.

Excluding 2020 and 2021 preserves the signs and baseline significance pattern of the working-from-home coefficients under White cross-section inference (Table A6). Internet use remains negatively associated with WFH, GDP per capita and unemployment remain positively associated, and KIA remains non-significant. The unemployment coefficient changes from 0.281 to 0.230. These results show that the associations are also present in the pooled sample of retained years. They do not establish that the slopes are stable across the pre-pandemic and subsequent periods, or that pandemic-related changes have no influence on the estimates.

The country-clustered estimates provide a further check on the sensitivity of inference to within-country dependence (Table A4). The coefficients are unchanged, but the associated standard errors are generally larger. In the working-from-home model, the coefficients on Internet use and GDP per capita remain statistically significant, whereas the unemployment coefficient is no longer significant at the 5% level. In the net-migration model, the positive coefficients on R&D expenditure and GDP per capita are no longer statistically significant at the 5% level. These differences indicate that inference for some coefficients, particularly in the net-migration specification, is sensitive to the covariance estimator.

The within-country variation in R&D expenditure is substantially smaller than a full percentage point. After removing country and year effects, the within standard deviation of

GERD is approximately 0.114 percentage points. A one-within-standard-deviation increase therefore corresponds to an estimated change of approximately 0.38 net migrants per 1000 inhabitants in the baseline specification.

The net-migration model was additionally estimated after excluding 2022 and, separately, after excluding Malta, Luxembourg, Cyprus and Ireland (Table A7). The GERD and GDP-per-capita coefficients remain positive in both restricted samples. Excluding the four countries produces coefficients of 3.033 for GERD and 0.413 for GDP per capita, compared with baseline estimates of 3.313 and 0.156. The increase in the GDP coefficient shows that its magnitude is sensitive to country coverage, even though its sign is unchanged. These group exclusions provide sample-sensitivity evidence, but do not identify the influence of any individual country or observation. The POVER coefficient also changes across the restricted samples, indicating further specification sensitivity.

In the net-migration specification with one-year-lagged regressors, GERD and GDP per capita retain positive and statistically significant coefficients under White cross-section inference, while KIA remains non-significant (Table A5). POVER becomes negative and statistically significant. This provides evidence on sensitivity to a different temporal specification, but does not establish delayed causal effects or resolve simultaneity. Because the lagged model also uses a shorter sample, the differences cannot be attributed exclusively to the timing of the explanatory variables.

Excluding KIA leaves the remaining coefficients almost unchanged in both models (Table A9). The signs and significance patterns under White cross-section inference are preserved, and the two-way within R^2 changes negligibly. Under country-clustered inference, the reduced models likewise retain the baseline pattern: Internet use and GDP per capita remain significant in the WFH equation, while unemployment does not; GERD and GDP per capita remain non-significant at the 5% level in the migration equation. The principal estimates therefore do not depend materially on the inclusion of KIA, although this check does not assess omitted controls.

The leave-one-country-out migration estimates preserve positive GERD and GDP-per-capita coefficients in all 27 restricted samples (Table A10). Their magnitudes nevertheless vary: GERD ranges from 2.442 to 4.670, and GDP per capita from 0.134 to 0.322. Under White cross-section inference, GERD is significant in 24 samples and GDP per capita in all 27. Under country-clustered inference, each is significant in only one restricted sample. The checks therefore support the stability of the positive signs across country exclusions, but not general stability of statistical significance. POVER remains negative in every restricted sample and is generally non-significant.

Adding unemployment changes the migration results more than removing KIA (Table A11). The GERD coefficient decreases from 3.313 to 2.438 and is no longer significant at the 5% level under White cross-section inference ($p = 0.129$). GDP per capita remains positive and significant under that convention, but not under country-clustered inference. Unemployment has a negative coefficient and is not significant at the 5% level under either procedure. Because the estimation sample is unchanged, this comparison demonstrates sensitivity to the conditioning set. It does not establish that unemployment explains the baseline GERD association.

Excluding 2023–2024 preserves positive GERD and GDP-per-capita coefficients, but neither remains significant at the 5% level under White cross-section inference (Table A12). Their p-values are 0.086 and 0.060, respectively. Excluding 2022–2024 likewise preserves their positive signs without significance at the 5% level, while POVER becomes negative and significant under White cross-section inference. None of the coefficients in the restricted samples is significant at the 5% level under country-clustered inference. These results

indicate sensitivity to period coverage and reduced statistical precision; they do not identify a structural break or a specific migration shock.

The reported checks provide different levels of support across outcomes. In the WFH model, the negative Internet-use and positive GDP-per-capita coefficients retain their signs and significance in the reported covariance, period and KIA-exclusion checks. The unemployment association is less secure because it is not significant at the 5% level under country-clustered inference. These results establish stability across the checks conducted, rather than across all plausible specifications.

The migration results are more sensitive. Positive GERD and GDP-per-capita coefficients persist across the reported country and period restrictions, but their significance does not persist uniformly. Adding unemployment removes GERD's significance under White cross-section inference, and excluding recent years removes significance for both coefficients at the 5% level. Country-clustered inference also generally yields non-significant estimates. The migration findings should therefore be presented as positive point estimates with specification-sensitive statistical support. Further controls and longer panels would be required to assess whether these patterns persist beyond the specifications examined here.

The results address RQ1 and RQ2 separately. GDP per capita and knowledge-intensive employment are the only explanatory variables included in both equations. GDP per capita has a positive and statistically significant coefficient in both baseline specifications, although its significance in the net-migration model is sensitive to the covariance estimator. Knowledge-intensive employment is not statistically significant in either model. These results provide a limited comparison of conditional associations, rather than a formal test of coefficient differences across outcomes. Internet use and unemployment are included only in the working-from-home model, while R&D expenditure and poverty and social exclusion are included only in the net-migration model. Their results cannot therefore establish that these associations are specific to one outcome. The different baseline periods further qualify the comparison, although the working-from-home estimates remain similar over the common 2015–2024 window. The following discussion considers each set of findings separately before addressing their conceptual relevance to RQ3.

Table 6 distinguishes baseline support from sensitivity across the additional checks. H1 is not supported because the estimated association is negative rather than positive. H2 receives support across the reported WFH specifications, while H3 and H5 remain unsupported. H4 receives baseline support that does not persist under country-clustered inference. For migration, the positive baseline coefficients support H6 and H7 under White cross-section inference, but this evidence is qualified by the alternative estimators and specifications. H8 is not supported in the baseline model, although selected alternatives produce a significant negative coefficient. These differences are reported as sensitivity of the evidence rather than uniform confirmation or rejection.

Table 6. Summary of hypothesis assessment.

Hypothesis	Expected Association	Baseline Result	Assessment Across Reported Checks
H1: Internet use → WFH	Positive	Negative and significant	Not supported. The negative coefficient also remains significant under country-clustered inference.
H2: GDP per capita → WFH	Positive	Positive and significant	Supported in the baseline model and the reported WFH checks, including country-clustered inference.

Table 6. *Cont.*

Hypothesis	Expected Association	Baseline Result	Assessment Across Reported Checks
H3: KIA → WFH	Positive	Non-significant	Not supported in the reported specifications.
H4: Unemployment → WFH	Positive	Positive and significant	Supported under baseline inference, but not at the 5% level under country-clustered inference.
H5: KIA → net migration	Positive	Non-significant	Not supported in the reported specifications.
H6: GERD → net migration	Positive	Positive and significant	Baseline support is sensitive to inference, controls and sample coverage. Significance is lost with country-clustered errors, added unemployment and recent-year exclusions.
H7: GDP per capita → net migration	Positive	Positive and significant	Baseline support is sensitive to inference and period coverage. Significance is lost with country-clustered errors and recent-year exclusions.
H8: POVER → net migration	Negative	Negative but non-significant	Not supported in the baseline model. Negative significance appears in selected alternative specifications under White cross-section inference.

Note: Baseline results refer to Table 5 and use White cross-section inference. Assessment is based on the expected direction and statistical significance at the 5% level. Additional checks are reported in Tables A1–A12. Support concerns conditional associations in the estimated specifications, not causal effects or validation of the underlying theoretical mechanisms. A non-significant coefficient does not establish the absence of an association.

5. Discussion

The two models provide separate evidence on usual working from home and the net migration rate across EU Member States. The empirical comparison is restricted to GDP per capita and knowledge-intensive employment, the two regressors included in both specifications. Their baseline significance patterns are similar: GDP per capita has a positive and statistically significant coefficient, while knowledge-intensive employment is not significant. This similarity does not establish a common mechanism, just as the results for variables included in only one equation do not demonstrate outcome-specific mechanisms. Differences in the conditioning sets and estimation periods also limit direct comparison. The discussion therefore examines the findings for each outcome on their own terms and uses the sustainability framework to place them in context, without treating the two regressions as evidence of a relationship between working from home and migration.

5.1. Digital Connectivity, Economic Conditions and Working from Home

Internet use has a negative conditional association with usual working from home in the two-way fixed-effects model. The coefficient of −0.266 indicates that, within a country, a one-percentage-point increase in regular Internet use is associated with a 0.266-percentage-point decrease in usual working from home, conditional on the other regressors and country and year effects. This differs from the positive pooled correlation of 0.633. The two estimates describe different relationships: the pooled correlation combines variation between countries and over time without adjustment, whereas the regression coefficient

uses variation remaining after the fixed effects and other regressors are accounted for. This distinction explains why the signs need not agree, but does not identify the reason for the negative conditional coefficient.

The model does not establish why this inverse association occurs. High Internet-use levels may motivate investigating saturation or nonlinearity, but saturation alone does not explain a negative coefficient, and the specification does not test either possibility. Occupational tasks, digital skills and organisational practices are relevant to working from home in the literature [14,17], but their role in generating the present coefficient remains untested. The finding should therefore be reported as an inverse conditional association in this specification, rather than as evidence that connectivity is insufficient, that Internet use discourages working from home, or that particular organisational capabilities explain the result.

The negative INTUSE coefficient differs in direction from the technological association reported by Jerbashian and Vilalta-Bufí [20], who link falling ICT prices to greater WFH adoption in ICT-dependent industries. This is not a direct contradiction: their explanatory variable concerns ICT prices and industry exposure, while INTUSE measures individuals' regular Internet use. The periods, aggregation and estimation designs also differ. The present result therefore does not overturn their evidence or explain its own negative sign.

The positive unemployment coefficient likewise cannot be read as confirming the employment-protection relationship discussed by Jerbashian and Vilalta-Bufí [21]. Their analysis relates WFH changes to employment losses during the pandemic, whereas the present model relates the unemployment rate to the share of people usually working from home over a longer period. These are different empirical relationships, and the present coefficient is not significant at the 5% level under country-clustered inference.

The positive GDP-per-capita coefficient indicates that increases in a country's PPS volume index relative to the EU average are associated with increases in its usual-working-from-home share, conditional on the other regressors and country and year effects. A one-point increase in the index corresponds to an estimated increase of 0.179 percentage points in WFH. This is a within-country association and does not estimate whether persistently more developed countries have higher WFH prevalence. Nor does it identify technological investment, service-sector composition or organisational resources as the mechanism underlying the coefficient, since these factors are not measured directly in the specification.

Knowledge-intensive employment has a near-zero and statistically non-significant coefficient in the working-from-home model. Its positive pooled correlation with WFH does not contradict this result, because the regression changes both the source of variation and the conditioning set. The difference cannot be attributed specifically to persistent between-country differences. It may also involve adjustment for the other regressors, the relatively limited variation in KIA remaining after country and year effects are removed, or other specification features. Table 2 reports a two-way within standard deviation of 1.106 percentage points for KIA, while Table A8 reports a transformed correlation with WFH of 0.055. These statistics describe the available variation but do not identify the reason for the non-significant coefficient. The result provides no support for H3 in this specification; it does not establish that employment in knowledge-intensive activities is unrelated to working from home more generally.

The common slope coefficients may conceal differences in associations across countries, occupations and periods. The European evidence discussed above documents substantial variation in WFH across industries and occupations [20,21], whereas the present model uses national aggregates. The same change in regular Internet use or knowledge-intensive employment need not have the same association with WFH in countries with different

employment structures. This possibility is not tested by the pooled slope specification. Excluding pandemic years assesses sample sensitivity, but does not determine whether pre-pandemic and subsequent slopes differ. The results should therefore be interpreted as common conditional associations rather than relationships demonstrated for every Member State.

The positive unemployment coefficient does not identify increased adoption of working from home or an adaptive response by continuing workers. WFH is measured as a share of employment, so its value can rise when employment falls more sharply among people who do not work from home, even if the number of people usually working from home does not increase. The model cannot distinguish this compositional change from changes in individual working arrangements. Country-specific pandemic exposure, restrictions and employment-support measures may also have affected unemployment and WFH together. Country and year fixed effects do not fully absorb such time-varying, country-specific influences.

Previous studies document the role of working from home in maintaining employment during the pandemic [18] and its persistence after the initial shock [4,21]. These findings provide context, but do not establish the mechanism behind the unemployment coefficient in this study. Its positive sign persists when 2020–2021 are excluded, although that check combines the retained pre-pandemic and subsequent years rather than estimating their associations separately. Moreover, the baseline coefficient is not significant at the 5% level under country-clustered inference. The result should therefore be treated as a conditional association whose interpretation and statistical precision remain uncertain.

The model does not test whether technological access is a necessary condition for labour-market adaptability or whether working from home improves sustainability. These are broader questions that require additional measures and a different empirical design. The literature nevertheless provides reasons to examine working conditions alongside the prevalence of home-based work. The ILO [8], for example, discusses risks involving working time, occupational safety, isolation and social protection. These considerations provide context for interpreting WFH, but they are not mechanisms or consequences identified by the present regression.

5.2. Innovation, Economic Development and Net Migration

The baseline results for RQ2 show positive conditional associations of the GDP-per-capita PPS index and R&D expenditure intensity with the net migration rate. These coefficients concern changes within countries after accounting for the remaining regressors and country and year effects. The GDP association is compatible with the emphasis on economic opportunities in migration theory [10], but the aggregate outcome does not reveal the motivations or employment characteristics of those moving. Nor does it show whether the association reflects increased immigration, reduced emigration or both. The results therefore concern the population migration balance and cannot be interpreted specifically as evidence of labour-migrant attraction or human-capital retention.

The positive baseline GDP-per-capita coefficient is directionally consistent with Jennissen's [27] findings for net migration in Western Europe. Franc et al. [28] also identify destination GDP per capita as relevant to bilateral East–West EU migration. Neither comparison establishes replication: the studies differ in periods, outcomes, country coverage and controls. In addition, the present GDP coefficient loses significance under country-clustered inference, which qualifies the strength of the evidence.

The positive GERD estimate can also be considered alongside Pudryk et al. [24], who report an association between innovation development and net migration in six EU countries. Their composite innovation measure, governance controls and FMOLS approach

differ from the present R&D-intensity specification. Our result is therefore related evidence rather than confirmation of the same mechanism. Its covariance-sensitive significance and the omission of governance indicators further limit comparability. The current model cannot determine whether including those institutional conditions would alter the GERD estimate.

In the baseline specification, R&D expenditure is also positively and significantly associated with net migration. This relationship becomes visible in the fixed-effects specification despite the nearly zero pairwise correlation between GERD and MIGR. The difference indicates that the conditional within-country relationship, after accounting for economic development, employment structure, social vulnerability and common year effects, differs from the unconditional relationship observed in the pooled data. The positive GERD coefficient should therefore be interpreted as conditional co-variation between changes in innovation effort and changes in the net migration balance. It does not establish that higher R&D expenditure attracts migrants or reduces emigration. Innovation effort may move together with broader economic and institutional conditions that are also related to migration outcomes.

The positive GERD coefficient also appears in the specification using one-year-lagged explanatory variables. This shows that the association is not confined to a contemporaneous specification, but does not demonstrate that R&D intensity precedes migration in a causal sense. Earlier migration may have influenced R&D expenditure and GDP, while persistent economic or institutional changes may affect both variables. The lagged result therefore complements the descriptive evidence without resolving the direction of the relationship.

Previous research links innovation-related conditions to migration outcomes [24,26], while studies of international talent flows and migrant inventors discuss possible contributions of migration to knowledge diffusion and innovation [23,25,48]. These studies provide context for the GERD association, but the present indicators cannot identify those mechanisms. GERD measures R&D spending intensity rather than research capacity, innovation outputs or the availability of specialised jobs, and MIGR does not identify highly skilled migrants. In addition, R&D intensity can rise because expenditure increases, GDP falls, or both. The positive coefficient therefore describes conditional co-variation between R&D expenditure relative to GDP and the net population migration rate. It does not establish attraction of specialised workers, retention of human capital or the direction of the relationship.

The GERD association is sensitive to both inference and specification. Its positive baseline coefficient is not significant at the 5% level with country-clustered standard errors, and adding unemployment reduces its magnitude and removes significance under White cross-section inference as well. Removing the most recent years also leaves positive but non-significant GERD estimates. GDP per capita retains a positive coefficient across these checks, although its significance is sensitive to the covariance estimator and estimation period. The results therefore provide descriptive evidence of positive conditional co-variation, with limited support for stable statistical significance. They should not be presented as established determinants of migration.

The model does not identify a statistically significant conditional association between changes in knowledge-intensive employment and changes in the net migration rate. The positive pooled correlation of 0.477 and the near-zero fixed-effects coefficient cannot, by themselves, establish that the pooled relationship mainly reflects persistent cross-country differences. Removing country and year effects and conditioning on the other regressors are separate adjustments whose contributions are not isolated by this comparison. KIA also has relatively limited two-way within variation, with a standard deviation of 1.031 percentage points, and its transformed correlation with MIGR is −0.032 (Tables 2 and A8). The broad migration outcome and the activity-based employment indicator may further limit the

correspondence between the measures and the proposed mechanism. These possibilities remain explanations to investigate rather than findings established by the model. H5 is not supported in this specification, but the result does not rule out associations involving particular migrant groups or employment categories.

Poverty and social exclusion also have no statistically significant independent association with net migration in the final specification. This result does not imply that social vulnerability is unimportant to migration decisions or labour-market sustainability. It indicates only that the model does not identify a systematic within-country relationship during the period analysed after the other variables and fixed effects are considered. Poverty and social exclusion may influence immigration and emigration through different mechanisms that are obscured when both flows are combined into a single net indicator.

The negative and statistically significant POVER coefficient in the lagged specification contrasts with its non-significant baseline estimate. This indicates sensitivity to the temporal specification and estimation sample. It does not, by itself, establish that poverty and social exclusion affect migration with a one-year delay. Distinguishing a timing relationship from sample differences and persistent omitted influences would require additional analysis.

The sensitivity checks provide additional evidence that this relationship depends on the treatment of particular periods: POVER becomes negative and statistically significant when 2022 is excluded, while it remains non-significant when the countries highlighted as potentially influential because of their population size are removed (Table A7). Together with the lagged specification, this suggests that the POVER result is less stable than the baseline estimate alone would imply.

Migration-related heterogeneity is also obscured by the aggregate outcome and common slopes. Economic conditions may be associated differently with immigration, emigration and return migration, and these associations may vary across migrant groups and countries. A net balance combines these processes, including movements for employment, education, family and other reasons. The country-exclusion checks show how the estimated common coefficients change with sample coverage; they do not estimate country-specific responses or identify which migration categories generate the associations. Similarly, the recent-year exclusions do not establish a distinct post-2022 mechanism. Disaggregated flows and explicitly specified interactions would be needed to investigate these differences.

A more positive net migration balance is not, by itself, evidence of stronger labour-market performance or more sustainable development. Its interpretation depends on the underlying immigration and emigration flows, the characteristics of those moving and their circumstances before and after migration. The present model does not measure changes in labour supply attributable to migration, migrant integration, employment quality or the allocation of skills. Its findings are limited to associations with the aggregate population migration balance. Assessing the broader consequences discussed in the literature would require separate flow measures and information on migrants' employment, education and skills.

5.3. Implications for Sustainable Labour Markets and the SDGs

This section addresses RQ3 by placing the findings within the literature on labour-market sustainability and the Sustainable Development Goals. The study does not assess sustainability performance or progress towards the SDGs. In particular, neither a higher WFH share nor a more positive migration balance is assigned a favourable sustainability interpretation. Assessing such changes would require evidence on working conditions, access to employment, migrant integration and distributional consequences, none of which is directly evaluated by the two regressions.

SDG 8 concerns productive employment and decent work [29], providing a relevant context for research on working arrangements. The literature discusses both the opportunities and the risks associated with working from home, including employment continuity, working time and worker protection [8,18]. The present WFH indicator records prevalence rather than these consequences. An increase in its value could accompany improved flexibility, deteriorating working conditions or a change in the composition of employment. The estimated associations therefore do not establish a contribution to decent work. Assessing that contribution would require measures of employment quality and workers' experiences alongside WFH prevalence.

SDG 9 provides a conceptual context for discussing infrastructure, technological capacity and innovation [29]. The empirical results concern narrower measures: regular Internet use among individuals and R&D expenditure relative to GDP. Within the estimated specifications, Internet use has a negative conditional association with usual working from home, while R&D intensity has a positive conditional association with the net migration rate. Neither coefficient measures progress towards SDG 9 or identifies the organisational and technological mechanisms behind the association. Moreover, the statistical significance of the migration coefficient is sensitive to the covariance estimator. The connection to SDG 9 therefore rests on the subject matter and literature, rather than on an empirical assessment of infrastructure quality or innovation performance.

SDG 10 offers a conceptual perspective on inequalities within and between countries [29]. Previous research discusses the potential for remote work to broaden employment opportunities beyond major economic centres [31,32]. The present analysis does not measure regional access to employment, territorial inequality or geographical concentration. Its fixed-effects coefficients also do not estimate whether persistently richer or more R&D-intensive countries record higher migration balances. They concern conditional changes within countries after common year effects are removed. Consequently, the results cannot establish whether working from home reduces territorial disparities or whether migration reinforces them. These questions require regional information and evidence on the composition and direction of migration flows.

The conceptual discussion focuses on economic and social dimensions of sustainability, but the regressions do not directly evaluate sustainability outcomes in either dimension. Environmental consequences are also outside the empirical scope. Changes in commuting, household and workplace energy use, residential location and the environmental footprint of digital infrastructure are not measured. The study therefore cannot determine the environmental implications of changes in WFH or migration, or assess trade-offs between environmental, economic and social outcomes.

The common framework brings together two sets of findings that can inform discussion of the economic and social dimensions of labour-market change. The working-from-home estimates concern variation in a particular working arrangement, while the migration estimates concern variation in the population migration balance. The analysis does not establish whether either process changes the other or whether digitalisation strengthens or weakens geographical mobility. Their relevance to SDGs 8, 9 and 10 rests on the conceptual arguments and literature discussed above, rather than on an estimated relationship between the two outcomes. Direct evidence on that relationship remains a question for future research.

5.4. Policy Considerations and Evidence Needs

The policy considerations below draw on the literature and the conceptual framework, rather than on estimated effects of policy interventions. The regressions do not test digital-skills programmes, management practices, worker protection, research incentives or

migrant-integration policies. They therefore cannot determine which interventions would improve the observed outcomes or make labour markets more sustainable.

For working from home, the literature supports examining occupational eligibility, organisational practices and working conditions alongside digital access [8,14,17]. These subjects remain relevant to policy discussion, but the negative INTUSE coefficient does not demonstrate that deficiencies in skills or management explain the observed association. Nor does it identify an effective remedy. Policy evaluation would require direct measures of these conditions and evidence on the consequences of specific interventions.

For migration, the positive GERD point estimate does not establish that increasing R&D spending would attract skilled workers or retain human capital. Its statistical significance is also sensitive to the covariance estimator. The literature on talent flows and migration-related knowledge exchange provides a rationale for investigating links between research environments and human-capital mobility [5,23,25], but assessing policy options requires information on migrants' characteristics, the direction of flows and the opportunities available before and after migration.

The measurement limitations suggest a practical research and monitoring agenda. WFH prevalence could be examined alongside working hours, employment security, earnings and access across occupational groups. Net migration could be accompanied by separate immigration and emigration measures, disaggregated by employment status, education and reason for moving. Regional indicators would be needed to assess territorial consequences. Such information would allow sustainability questions to be evaluated directly, rather than inferred from changes in aggregate prevalence or population balances.

6. Conclusions

This study examined the conditional correlates of usual working from home and the net population migration rate across EU Member States. Two separate country and year fixed-effects models were estimated for 2014–2025 and 2015–2024, respectively. The analyses provide evidence on within-country associations for each outcome, while the common conceptual framework places their subject matter within the literature on labour-market sustainability. The study does not estimate a relationship between working from home and migration.

Regarding RQ1, the baseline model identifies a negative conditional association between regular Internet use and usual working from home, and positive associations for the GDP-per-capita PPS index and unemployment. These coefficients concern changes within countries after accounting for the other regressors and country and year effects. The Internet-use result does not identify the reason for the inverse association and should not be reduced to a claim that connectivity alone is insufficient. The GDP coefficient does not estimate persistent differences between richer and poorer countries or identify an organisational mechanism. Knowledge-intensive employment is not statistically significant, but the contrast with its positive pooled correlation does not isolate why the association disappears after adjustment. Internet use and GDP per capita remain significant under country-clustered inference, whereas unemployment does not remain significant at the 5% level.

For the working-from-home hypotheses, H1 is not supported because the Internet-use coefficient has the opposite sign to that expected. H2 is supported across the reported checks, and H3 is not supported. H4 is supported in the baseline model, but its statistical significance does not persist under country-clustered inference. The evidence for unemployment should therefore be described as qualified support.

Regarding RQ2, GERD and GDP per capita have positive and statistically significant baseline coefficients, supporting H6 and H7 under White cross-section inference. This support is qualified by additional checks. Neither coefficient remains significant at the 5% level under country-clustered inference; GERD also loses significance when unemployment is included, and both lose significance when the most recent years are excluded. Their positive signs persist, but statistical significance is not stable across inference procedures, conditioning sets and period coverage. H5 and H8 are not supported in the baseline model. POVER becomes significant in selected alternative specifications under White cross-section inference, indicating sensitivity rather than consistent support. The models do not identify causal effects or distinguish changes in immigration from changes in emigration.

Regarding RQ3, the study identifies the limits of interpreting WFH prevalence and net migration through a sustainability framework. Neither outcome establishes whether labour-market change improves working conditions, inclusion or territorial balance. The findings can be situated within the literature on sustainable labour markets, but an empirical assessment requires additional outcomes and explicit evaluation criteria. Sustainability therefore remains a conceptual context for this study, rather than a result demonstrated by the regressions.

The links to SDGs 8, 9 and 10 concern the topics discussed: working arrangements and decent work, research and technological capacity, and social and territorial inequalities. They do not constitute estimates of progress towards those goals. Likewise, the policy considerations draw on existing literature and identify evidence needs; the models do not establish the effectiveness of interventions involving digital skills, worker protection, innovation support or human-capital retention.

The study's empirical contribution consists of two separate EU-wide analyses using a common fixed-effects approach. Among the shared regressors, GDP per capita has a positive coefficient in both baseline models, although inference for net migration is sensitive to the covariance estimator, while knowledge-intensive employment is not statistically significant in either specification. These findings extend the evidence on the conditional correlates of usual working from home and net migration. They do not establish whether working from home affects migration, whether the two outcomes substitute for or complement one another, or whether digitalisation changes the economic conditions associated with migration. The value of considering the analyses together lies in their common conceptual context and the questions they raise for subsequent research.

Several limitations must be considered. First, the study is conducted at the country level and cannot capture regional or within-country inequalities. Second, the two models cover different periods because of data availability: 2014–2025 for working from home and 2015–2024 for net migration. Third, WFH measures the share of employed persons who usually work from home and does not capture occasional or all forms of remote and hybrid work. This definition was retained because the analysis focuses on regular working-from-home arrangements. Future research could examine the sensitivity of the results to broader measures that also include occasional working from home. Fourth, net migration represents the balance between immigration and emigration for the total population, rather than the total volume of population mobility. It does not distinguish migration by motivation, employment status, education, age or skill level. It should therefore not be interpreted as a direct measure of labour migration or human-capital mobility.

The construction of the net migration rate introduces an additional measurement consideration because the resident population at the beginning of the year is used as the denominator rather than the average annual population. Moreover, the study does not estimate a direct relationship between working from home and migration and does not construct a composite measure of labour-market sustainability. Sustainability is used as

the conceptual framework through which the two sets of findings are interpreted. The relatively short time dimension of the panels also limits the implementation and statistical power of additional diagnostics concerning temporal dependence. Although country and year fixed effects and robust standard errors are employed, possible omitted variables, reverse causality and other forms of endogeneity cannot be excluded.

The working-from-home model imposes common slope coefficients across the pre-pandemic, pandemic and subsequent periods. Year effects account for common annual shifts, but do not fully capture differences in national pandemic exposure, restrictions or employment-support policies. Excluding 2020–2021 provides a useful sensitivity check, although it neither tests equality of slopes across periods nor removes lasting pandemic effects. Changes in the composition of employment may also alter the WFH share without changes in individual working arrangements. In addition, the EU-LFS methodological transition in 2021 may introduce country-specific discontinuities. Removing the transition year does not necessarily remove differences in measurement between earlier and later observations.

The migration model likewise cannot resolve feedback between migration, economic conditions and R&D expenditure. Using lagged regressors changes temporal ordering but does not eliminate possible endogeneity and also reduces the estimation sample. GERD is a ratio to GDP, so changes may arise from its numerator, denominator or both. These limitations prevent the coefficients from identifying particular behavioural or adjustment mechanisms, even where their signs persist across the reported checks.

Residual dependence and the small number of countries and years limit statistical inference. Excluding KIA leaves the remaining coefficients almost unchanged, whereas adding unemployment changes the magnitude and significance of GERD. Country exclusions preserve the positive GERD and GDP-per-capita signs, but significance varies across covariance estimators and period restrictions. Transformed-regressor VIF values do not indicate substantial collinearity among the included variables. Nevertheless, detailed sectoral, occupational, demographic and institutional controls remain absent, and the reported checks do not eliminate omitted-variable bias.

Future research could incorporate direct measures of digital skills, occupational teleworkability, firm-level technology adoption, hybrid working arrangements and employment quality. Separate immigration and emigration measures could be disaggregated by age, education, employment status, occupation and reason for moving. Regional data could help assess whether working from home is associated with a wider geographical distribution of employment opportunities, and whether research environments are associated with skilled-worker attraction or retention. A research design examining working from home and migration jointly would be needed to test substitution, complementarity or other relationships between them.

Further econometric research could examine slope heterogeneity using theoretically motivated interactions with country characteristics and period indicators. Such analyses would require sufficient variation and sample size, particularly when comparing pre-pandemic and subsequent periods. Separate immigration and emigration models could assess whether economic and institutional conditions relate differently to the two flows. Longer panels, dynamic specifications and credible identification strategies could also help investigate persistence and feedback. Country-specific or group-specific associations, however, should be estimated and tested directly rather than inferred from fixed effects or sample exclusions.

The findings should therefore be read as evidence on the conditional correlates of usual working from home and net migration, while keeping the limitations of each specification explicit. Their broader relevance to sustainable labour markets follows from the conceptual framework and existing literature. Establishing how these outcomes are connected, and whether their interaction improves employment quality, social inclusion or territorial balance, requires direct measures of those outcomes and a research design that tests the proposed relationships.

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Data Availability Statement: The data analysed in this study are publicly available from Eurostat. Absolute net migration values were retrieved from the dataset "Net migration by age and sex" (migr_netmigr), while the resident population at the beginning of each year was obtained from "Population on 1 January by age and sex" (demo_pjan). The remaining datasets are listed in Table 1. The net migration rate was calculated by the authors by relating absolute net migration to the resident population at the beginning of the year and multiplying the resulting ratio by 1000. The assembled country-year panels used in the empirical analysis are openly available in Zenodo at https://doi.org/10.5281/zenodo.22665522.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

CD	Cross-Section Dependence
EU	European Union
FE	Fixed Effects
GDP	Gross Domestic Product
GDPCAP	GDP per Capita
GERD	Gross Domestic Expenditure on Research and Development
ILO	International Labour Organization
INTUSE	Internet Use
KIA	Knowledge-Intensive Activities
MIGR	Net Migration Rate
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
POVER	Poverty and Social Exclusion
PPS	Purchasing Power Standards
R&D	Research and Development
RQ	Research Question
SDG	Sustainable Development Goal
UNEMP	Unemployment Rate
WFH	Work from Home

Appendix A. Robustness Checks and Additional Diagnostics

Table A1. Robustness check for the working-from-home model using the common 2015–2024 estimation window.

Variable	Baseline WFH Model 2014–2025	Common-Window WFH Model 2015–2024
Internet use	−0.266 *** (0.039)	−0.327 *** (0.028)
GDP per capita	0.179 *** (0.030)	0.222 *** (0.039)
Unemployment	0.281 *** (0.057)	0.325 *** (0.081)
Knowledge-intensive employment	−0.005 (0.136)	0.114 (0.183)
Country fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	324	270
R^2	0.857	0.863
Adjusted R^2	0.836	0.840
F-statistic	41.054 ***	37.185 ***

Note: White cross-section robust standard errors with degrees-of-freedom correction are reported in parentheses. The dependent variable is the share of employed persons usually working from home. *** $p < 0.01$. The baseline specification corresponds to the remote-work model reported in Table 5 of the manuscript.

Table A2. Variance inflation factors before and after removing country and year effects.

Variable	WFH: Pooled VIF	WFH: Two-Way Within VIF	Net Migration: Pooled VIF	Net Migration: Two-Way Within VIF
Internet use	2.033	1.464	-	-
GDP per capita	2.753	1.272	2.636	1.309
Unemployment	1.304	1.231	-	-
Knowledge-intensive employment	3.361	1.026	3.136	1.019
R&D expenditure	-	-	1.427	1.007
Poverty and social exclusion	-	-	1.550	1.308

Note: Pooled VIF values are calculated from the original explanatory variables. Two-way within VIF values are calculated after residualising each explanatory variable with respect to country and year effects. Each transformed regressor is regressed on the remaining transformed regressors, and VIF is calculated as $1/(1 - R^2)$. The within diagnostics correspond to the variation used to estimate the slope coefficients in the two-way fixed-effects models.

Table A3. Robustness of the two-way fixed-effects estimates using Driscoll–Kraay standard errors.

Variable	Working from Home	Net-Migration
Internet use	−0.266 *** (0.037)	-
GDP per capita	0.179 *** (0.029)	0.156 ** (0.054)
Unemployment	0.281 *** (0.056)	-
Knowledge-intensive employment	−0.005 (0.156)	0.001 (0.138)
R&D expenditure	-	3.313 *** (0.894)
Poverty and social exclusion	-	−0.201 (0.112)
Country fixed effects	Yes	Yes

Table A3. *Cont.*

Variable	Working from Home	Net-Migration
Year fixed effects	Yes	Yes
Observations	324	270

Note: Driscoll–Kraay standard errors are reported in parentheses. A Bartlett kernel with two lags is used. Both specifications include country and year fixed effects. *** $p < 0.01$; ** $p < 0.05$.

Table A4. Robustness check using country-clustered standard errors.

	Baseline	Country-Clustered
Panel (**A**) Working from home		
INTUSE	−0.266 *** (0.039)	−0.266 *** (0.092)
GDPCAP	0.179 *** (0.030)	0.179 *** (0.052)
UNEMP	0.281 *** (0.057)	0.281 (0.152)
KIA	−0.005 (0.136)	−0.005 (0.258)
Panel (**B**) Net migration		
KIA	0.001 (0.160)	0.001 (0.307)
GERD	3.313 ** (1.382)	3.313 (2.048)
GDPCAP	0.156 *** (0.053)	0.156 (0.094)
POVER	−0.201 (0.178)	−0.201 (0.238)

Note: Baseline estimates use White cross-section robust standard errors with degrees-of-freedom correction. Country-clustered standard errors use a finite-sample correction for 27 clusters, with inference based on 26 cluster degrees of freedom. Both specifications include country and year fixed effects. *** $p < 0.01$; ** $p < 0.05$.

Table A5. Robustness check using one-year-lagged explanatory variables in the net-migration model.

Variable	Baseline Model	Lagged Model
Knowledge-intensive employment	0.001 (0.160)	0.102 (0.230)
R&D expenditure	3.313 ** (1.382)	3.181 ** (1.549)
GDP per capita	0.156 *** (0.053)	0.128 ** (0.063)
Poverty and social exclusion	−0.201 (0.178)	−0.392 ** (0.178)
Country fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	270	243
R^2	0.714	0.719
Adjusted R^2	0.665	0.667

Note: White cross-section robust standard errors with degrees-of-freedom correction are reported in parentheses. In the lagged specification, all explanatory variables enter with a one-year lag. *** $p < 0.01$; ** $p < 0.05$.

Table A6. Robustness check for the working-from-home model excluding 2020–2021.

Variable	Baseline Model	Excl. 2020–2021
INTUSE	−0.266 *** (0.039)	−0.253 *** (0.053)
GDPCAP	0.179 *** (0.030)	0.165 *** (0.024)
UNEMP	0.281 *** (0.057)	0.230 *** (0.027)
KIA	−0.005 (0.136)	−0.140 (0.107)
Country fixed effects	Yes	Yes

Table A6. *Cont.*

Variable	Baseline Model	Excl. 2020–2021
Year fixed effects	Yes	Yes
Observations	324	270
R^2	0.857	0.868
Adjusted R^2	0.836	0.846

Note: White cross-section robust standard errors with degrees-of-freedom correction are reported in parentheses. The robustness specification excludes observations from 2020 and 2021. Both specifications include country and year fixed effects. The dependent variable is the share of employed persons usually working from home. *** $p < 0.01$.

Table A7. Sensitivity of the net-migration model to 2022 and selected countries.

Variable	Baseline Model	Excl. 2022	Excl. Malta, Luxembourg, Cyprus, Ireland
Knowledge-intensive employment	0.001 (0.160)	−0.057 (0.168)	−0.008 (0.239)
R&D expenditure	3.313 ** (1.382)	3.539 ** (1.438)	3.033 ** (1.192)
GDP per capita	0.156 *** (0.053)	0.153 *** (0.053)	0.413 *** (0.102)
Poverty and social exclusion	−0.201 (0.178)	−0.346 ** (0.137)	0.143 (0.224)
Observations	270	243	230
R^2	0.714	0.736	0.599
Adjusted R^2	0.665	0.687	0.527

Note: White cross-section standard errors with degrees-of-freedom correction are reported in parentheses. All specifications include country and year fixed effects. The first restricted specification excludes 2022, while the second excludes Malta, Luxembourg, Cyprus and Ireland. Significance markers follow the baseline convention, using Student's t distribution with residual degrees of freedom. *** $p < 0.01$; ** $p < 0.05$.

Table A8. Within-country correlation matrices after removing country and year effects.

Variable	WFH	INTUSE	GDPCAP	UNEMP	KIA
Panel (**A**) Remote-work model, 2014–2025					
WFH	1.000	−0.193	0.287	0.192	0.055
INTUSE	−0.193	1.000	0.455	−0.423	−0.137
GDPCAP	0.287	0.455	1.000	−0.253	−0.018
UNEMP	0.192	−0.423	−0.253	1.000	0.116
KIA	0.055	−0.137	−0.018	0.116	1.000
Panel (**B**) Net-migration model, 2015–2024					
	MIGR	**KIA**	**GERD**	**GDPCAP**	**POVER**
MIGR	1.000	−0.032	0.109	0.243	−0.177
KIA	−0.032	1.000	−0.004	−0.108	0.127
GERD	0.109	−0.004	1.000	0.082	−0.038
GDPCAP	0.243	−0.108	0.082	1.000	−0.479
POVER	−0.177	0.127	−0.038	−0.479	1.000

Note: Correlations are calculated using the variation remaining after removing country and year effects from each variable.

Table A9. Sensitivity to excluding knowledge-intensive employment.

Variable	WFH: Baseline	WFH: Without KIA	Net Migration: Baseline	Net Migration: Without KIA
Internet use	−0.266 *** (0.039)	−0.266 *** (0.043)	-	-
GDP per capita	0.179 *** (0.030)	0.179 *** (0.030)	0.156 *** (0.053)	0.156 *** (0.052)
Unemployment	0.281 *** (0.057)	0.281 *** (0.063)	-	-
Knowledge-intensive employment	−0.005 (0.136)	-	0.001 (0.160)	-
R&D expenditure	-	-	3.313 ** (1.382)	3.313 ** (1.379)
Poverty and social exclusion	-	-	−0.201 (0.178)	−0.201 (0.180)
Country fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	324	324	270	270
Two-way within R^2	0.238	0.238	0.072	0.072

Note: White cross-section standard errors with degrees-of-freedom correction are reported in parentheses. Each restricted model excludes KIA while retaining the baseline estimation sample and country and year fixed effects. Significance markers use the same convention as the baseline estimates. *** $p < 0.01$; ** $p < 0.05$. The unchanged rounded within R^2 values reflect negligible differences in explanatory power.

Table A10. Leave-one-country-out sensitivity of the net-migration model.

Variable	Baseline Coefficient	Minimum Coefficient	Maximum Coefficient	Significant at 5%: White Cross-Section	Significant at 5%: Country-Clustered
R&D expenditure	3.313	2.442	4.670	24/27	1/27
GDP per capita	0.156	0.134	0.322	27/27	1/27
Poverty and social exclusion	−0.201	−0.329	−0.006	1/27	0/27

Note: The baseline net-migration specification is re-estimated 27 times, excluding one country at a time. Each estimation contains 260 observations and retains country and year fixed effects. Minimum and maximum coefficients refer to these restricted samples. White cross-section inference follows the baseline degrees-of-freedom convention. Country-clustered inference uses the finite-sample correction $G/(G-1) \times (N-1)/(N-K)$, where G is the number of country clusters, N is the number of observations, and K is the rank of the full design matrix, including the intercept, regressors and fixed-effect indicators. Here, G = 26, and inference uses Student's t distribution with 25 degrees of freedom. GERD is not significant under White cross-section inference when Denmark, Estonia or Portugal is excluded. Under country-clustered inference, GERD is significant only when Belgium is excluded, while GDP per capita is significant only when Ireland is excluded. These checks assess sensitivity to country coverage rather than the influence of individual observations. Counts of significant estimates summarise sensitivity across overlapping samples; they are not independent replications or a formal probability that an association is robust.

Table A11. Net-migration estimates with unemployment as an additional control.

Variable	Baseline: White Cross-Section	With Unemployment: White Cross-Section	With Unemployment: Country-Clustered
Knowledge-intensive employment	0.001 (0.160)	0.064 (0.169)	0.064 (0.281)
R&D expenditure	3.313 ** (1.382)	2.438 (1.600)	2.438 (1.913)
GDP per capita	0.156 *** (0.053)	0.149 *** (0.048)	0.149 (0.092)
Poverty and social exclusion	−0.201 (0.178)	−0.129 (0.179)	−0.129 (0.247)

Table A11. *Cont.*

Variable	Baseline: White Cross-Section	With Unemployment: White Cross-Section	With Unemployment: Country-Clustered
Unemployment	-	−0.442 (0.252)	−0.442 (0.361)
Country fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	270	270	270
R^2	0.714	0.718	0.718
Adjusted R^2	0.665	0.669	0.669
Two-way within R^2	0.072	0.087	0.087

Note: Standard errors are reported in parentheses. The extended specification adds the unemployment rate for persons aged 15–74, using the same country-year observations as the baseline model. White cross-section inference follows the baseline correction and uses residual degrees of freedom. Country-clustered inference uses the correction $G/(G-1) \times (N-1)/(N-K)$, with 27 clusters and 26 degrees of freedom. *** $p < 0.01$; ** $p < 0.05$. Coefficients without significance markers are not significant at the 5% level.

Table A12. Sensitivity of net-migration estimates to excluding recent years.

Variable	Baseline: 2015–2024	Excluding 2023–2024: 2015–2022	Excluding 2022–2024: 2015–2021
Knowledge-intensive employment	0.001 (0.160)	0.140 (0.240)	0.100 (0.348)
R&D expenditure	3.313 ** (1.382)	3.251 (1.885)	3.069 (1.885)
GDP per capita	0.156 *** (0.053)	0.114 (0.060)	0.098 (0.071)
Poverty and social exclusion	−0.201 (0.178)	−0.203 (0.290)	−0.482 ** (0.219)
Country fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	270	216	189
R^2	0.714	0.711	0.737
Adjusted R^2	0.665	0.651	0.675
Two-way within R^2	0.072	0.040	0.079

Note: White cross-section standard errors with degrees-of-freedom correction are reported in parentheses. All specifications retain the baseline regressors and country and year fixed effects. The restricted panels contain eight and seven annual observations per country, respectively. Significance markers use residual degrees of freedom, following the baseline convention. *** $p < 0.01$; ** $p < 0.05$. None of the coefficients in either restricted sample is significant at the 5% level under country-clustered inference.

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