ISSN: 2658-8455
Volume 7, Issue 09 (2026), pp. 198-223.
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Structural Determinants of Total Factor Productivity in Morocco and Peer Economies: Evidence from CCE and DCCE Panel Estimators

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Disclosure Statement :	The authors declare that they have not received any financial support that could have influenced the objectivity of this study. They take full responsibility for any potential plagiarism, the use of artificial intelligence in the writing process, as well as for the results presented in this article.
Conflict of Interest :	The authors report no conflicts of interest.
Cite this article :	ATOBA, I. (2026). Structural Determinants of Total Factor Productivity in Morocco and Peer Economies: Evidence from CCE and DCCE Panel Estimators. *International Journal of Accounting, Finance, Auditing, Management and Economics*, *7*(9), 198–223. https://doi.org/10.5281/zenodo.21676435
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International Journal of Accounting, Finance, Auditing, Management and Economics - IJAFAME
ISSN: 2658-8455
Volume 7, Issue 09 (2026)

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Abstract

Total factor productivity accounts for the largest share of long-run income differences across countries, yet the conditions under which trade integration translates into productivity gains remain contested. Existing panel studies of productivity in emerging and converging economies rarely combine an explicit treatment of unobserved common factors with heterogeneous slope coefficients, and comparative evidence centered on Morocco is almost absent from this literature. This paper addresses that gap by estimating the long-run structural determinants of total factor productivity for a balanced panel of six economies, namely Morocco, the Czech Republic, Greece, Poland, Portugal and Romania, observed annually from 2000 to 2023. Using the Common Correlated Effects (CCE) estimator of Pesaran (2006) and its dynamic extension (DCCE) by Chudik and Pesaran (2015), we estimate long-run elasticities while controlling for unobserved common factors and cross-sectional dependence. The two estimators are mobilized in a deliberately complementary manner, the static specification identifying long-run associations under a multifactor error structure and the dynamic specification recovering the speed of adjustment and separating short-run responses from long-run effects. Preliminary diagnostics confirm significant cross-sectional dependence among the regressors and non-stationarity in levels with stationarity in first differences. Four quantified results stand out. Productivity is highly persistent, with an autoregressive coefficient of 0.93 implying that only about 7 percent of the gap to long-run equilibrium closes each year. Trade openness carries a contemporaneous effect of -0.18 and a lagged effect of 0.22, which yields a long-run elasticity of 0.61. Real exchange rate appreciation displays a long-run elasticity of -1.56, the largest absolute effect in the model. Most consequentially, a threshold regression locates a critical human capital index of 2.92 below which the openness coefficient is negative and above which it turns positive, and Morocco lies furthest of the six economies below that threshold. These findings highlight the importance of trade integration and exchange rate competitiveness for productivity convergence in emerging economies, with direct policy implications for Morocco.

Keywords : Total factor productivity, common correlated effects, cross-sectional dependence, trade openness, real exchange rate.
JEL Classification : C23, F43, O47, O55.
Paper type : Empirical Research.

ISSN: 2658-8455
Volume 7, Issue 09 (2026), pp. 198-223.
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1. Introduction

Understanding the structural drivers of total factor productivity (TFP) is central to explaining long-run growth differentials across countries. For emerging economies such as Morocco, which has undergone significant trade liberalization and structural reforms since the early 2000s, identifying whether openness, human capital accumulation, government size, and real exchange rate competitiveness contribute to sustained productivity gains is of both academic and policy relevance.

The Moroccan case is of particular interest because it combines an advanced degree of formal trade integration with comparatively modest productivity gains. Successive association and free trade agreements, concluded notably with the European Union, the United States and Turkey, have raised the ratio of trade to gross domestic product to a level close to that observed in several Central European economies, while measured total factor productivity has progressed far more slowly than in the Czech Republic, Poland or Romania over the same period. This apparent paradox, in which formal openness has increased without a commensurate productivity dividend, is precisely what motivates a comparative empirical treatment rather than a purely national one, and it frames the policy question that runs through the whole paper.

The empirical analysis of productivity determinants in heterogeneous panels faces two well-documented econometric challenges. First, unobserved common factors, such as global demand shocks, commodity price cycles, and financial contagion, generate cross-sectional dependence that biases conventional fixed-effects estimators (Pesaran, 2006). Second, heterogeneous slope coefficients across countries render pooled estimators inconsistent. Ignoring either of these features leads to misleading inference about the magnitude and significance of productivity drivers.

These concerns are far from theoretical. A substantial body of recent applied panel work has shown that neglecting the factor structure produces systematically overstated significance levels in productivity and growth regressions. Chudik et al. (2011) formalize the distinction between weak and strong forms of cross-sectional dependence and establish that only the strong form invalidates conventional inference, while Kapetanios et al. (2011) demonstrate that common correlated effects estimators remain valid even when the unobserved factors are themselves non-stationary. On the applied side, Männasoo et al. (2018) on European productivity gaps and Eberhardt and Teal (2011) on cross-country technology differences both show how sensitive substantive conclusions are to the treatment of common factors. The estimation strategy adopted in the present paper follows directly from this line of research.

To address these challenges, this paper employs the Common Correlated Effects (CCE) estimator proposed by Pesaran (2006) and its dynamic extension (DCCE) developed by Chudik and Pesaran (2015). The CCE approach approximates unobserved common factors using cross-sectional averages of dependent and independent variables, while the DCCE adds lagged dependent variables and lagged cross-sectional averages to capture dynamic adjustment. Both estimators are implemented with entity fixed effects and cluster-robust standard errors.

Our panel covers six economies, namely Morocco (MAR), Czech Republic (CZE), Greece (GRC), Poland (POL), Portugal (PRT), and Romania (ROU), over the period 2000-2023, combining data from the Penn World Table (PWT 10.0) and the World Bank's World Development Indicators (WDI). This country selection deliberately spans a range of structural configurations, since it brings together three economies whose productivity trajectory has been shaped by accession to the European Union (CZE, POL, ROU), two Southern European economies durably affected by the sovereign debt crisis (GRC, PRT), and one emerging economy engaged in a process of deepening integration with the European market without membership (MAR). Despite the relatively small cross-sectional dimension (N=6), the time dimension (T=24) is sufficiently long to support consistent estimation under the CCE framework, as demonstrated by the finite-sample results in Chudik and Pesaran (2015) and Pesaran and Tosetti (2011), who show that CCE-type estimators perform adequately when T is moderately large relative to N.

Three gaps emerge from the body of work reviewed above. First, the empirical literature devoted to productivity in converging economies has relied predominantly on estimators that impose either slope homogeneity or cross-sectional independence, so that the elasticities reported in that literature may conflate genuine structural effects with unmodeled common shocks. Second, the studies that do focus on Morocco have generally been conducted in a single-country time series setting, which makes it impossible to assess whether Moroccan productivity dynamics differ systematically from those of structurally comparable economies. Third, the distinction between the short-run adjustment costs of trade liberalization and its long-run productivity benefits has rarely been made explicit in this literature, even though the two mechanisms operate over markedly different horizons and carry opposite policy implications. The present paper is designed to address these three gaps simultaneously.

The contributions of the paper can accordingly be grouped along three dimensions. On the theoretical side, the paper articulates a conceptual framework in which trade openness, human capital and external price competitiveness operate as complementary rather than independent channels of productivity growth, and it derives from that framework a set of testable expectations stated explicitly in Section 2.6. On the methodological side, the paper provides what is, to our knowledge, the first systematic application of static and dynamic common correlated effects estimators to Moroccan productivity dynamics within a comparative panel, and it reports a complete battery of pre-estimation diagnostics that applied work frequently omits. On the empirical side, the paper documents a sign reversal in the openness coefficient between the short and the long run, quantifies the long-run elasticities implied by the dynamic specification, and establishes that the speed of adjustment towards long-run equilibrium is considerably slower than the policy debate in Morocco generally presumes. Each of these three contributions maps directly onto one of the gaps identified in the preceding paragraph.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature and sets out the conceptual framework. Section 3 describes the data and variable construction. Section 4 presents the econometric methodology and compares the available panel estimators. Section 5 reports preliminary diagnostic tests. Section 6 discusses the estimation results. Section 7 provides robustness analysis and discussion. Section 8 concludes with policy implications.

2. Literature Review and Conceptual Framework

The literature relevant to this paper can be organized around two axes. The first axis concerns the substantive determinants of productivity, where a broad consensus on the direction of the trade and human capital effects coexists with persistent disagreement on their magnitude and on the conditions under which they materialize. The second axis concerns econometric practice, where the past two decades have produced a decisive shift away from estimators assuming cross-sectional independence. The subsections below follow this ordering and conclude with a synthetic conceptual framework.

2.1 Trade Openness and Productivity

The relationship between trade openness and productivity has been extensively studied in both theoretical and empirical growth literatures. Endogenous growth models emphasize that trade facilitates technology diffusion, enables scale economies, and intensifies competitive pressures that drive allocative efficiency (Grossman and Helpman, 1991; Rivera-Batiz and Romer, 1991). Empirically, Frankel and Romer (1999) provide cross-country evidence of a positive causal effect of trade on income, while more recent panel studies using heterogeneous estimators confirm these findings for diverse country groupings (Eris and Ulasan, 2013; Zahonogo, 2016).

The apparent convergence of these results should nevertheless not obscure two genuine areas of controversy. The first bears on identification, since the instrumental strategy of Frankel and Romer (1999) has been criticized for capturing geographic determinants of income that operate through channels other than trade. The second, and more consequential for the present study, bears on conditionality, since a distinct strand of work finds the trade effect to be positive only above a threshold of domestic capability. Zahonogo (2016) reports a non-monotonic relationship in sub-Saharan Africa, and Eris and Ulasan (2013) find that the robustness of openness collapses once model uncertainty is treated explicitly. This divergence in results is exactly what motivates the introduction of an absorptive capacity mechanism in Section 2.3 and the separation of short-run from long-run effects in the empirical model.
For emerging economies, the relationship is more nuanced. Nazlioglu et al. (2024) demonstrate that the productivity gains from trade depend on the sophistication of the export basket, with countries exporting higher-complexity goods achieving faster convergence. Morocco's trade structure, which has shifted toward manufacturing (automotive, aeronautics) but retains significant primary export dependence, makes it a particularly interesting case for studying this channel.

2.2 Real Exchange Rate and Competitiveness

The real effective exchange rate (REER) captures external price competitiveness and has been linked to productivity through several mechanisms. A depreciated real exchange rate stimulates tradable-sector output, encourages export diversification, and promotes resource reallocation toward more productive sectors (Rodrik, 2008). Conversely, persistent real appreciation can erode manufacturing competitiveness and trigger premature deindustrialization (Bresser-Pereira, 2010). In panel settings with cross-sectional dependence, the REER also serves as a proxy for global financial conditions and exchange rate co-movements, reinforcing the need for estimators that control for common factors.

2.3 Human Capital, Absorptive Capacity and Government Size

Human capital accumulation is a core determinant of productivity in both neoclassical and endogenous growth frameworks. The Penn World Table's human capital index aggregates years of schooling and returns to education (Feenstra et al., 2015), making it a direct input into TFP measurement. Empirical studies find positive but often imprecisely estimated effects of human capital on TFP in macro panels, partly due to measurement error and endogeneity (Barro and Lee, 2013). Government consumption, by contrast, captures the fiscal footprint of the public sector. Large government shares may crowd out private investment and distort resource allocation, although the net effect depends on the composition of spending (Barro, 1991).
A second and more demanding role of human capital, which is central to the argument of this paper, concerns absorptive capacity. In the formulation of Nelson and Phelps (1966), the educated stock of labor determines not the level of output directly but the speed at which an economy assimilates technologies developed at the frontier. Benhabib and Spiegel (1994) provide the first systematic cross-country test of this proposition and show that human capital enters growth regressions far more convincingly through a catch-up term than through a simple accumulation term. Cohen and Levinthal (1990) develop the parallel argument at the level of the firm, where prior related knowledge conditions the ability to recognize and exploit external information. Kneller (2005) brings the two strands together and demonstrates that the productivity benefit of proximity to the technological frontier is increasing in the educational attainment of the receiving economy.
This mechanism has a direct bearing on the interpretation of the openness coefficient. If trade transmits technology, and if the assimilation of that technology is conditioned by education, then the measured effect of openness on productivity should be understood as a composite of a

diffusion channel and an absorption channel. An economy that opens without a corresponding stock of absorptive capacity will import the competitive pressure of liberalization while capturing only part of its technological benefit. This reading provides a coherent account of the Moroccan paradox described in the introduction, and it explains why the human capital coefficient and the openness coefficient should be interpreted jointly rather than in isolation.

2.4 Evidence on Morocco and the MENA Region

The literature devoted specifically to Morocco is comparatively thin and remains dominated by studies of the liberalization episode of the late 1980s and 1990s. Haddad (1993) provides an early assessment of the productivity consequences of tariff reduction in Moroccan manufacturing and reports gains concentrated in sectors that were initially most protected. Currie and Harrison (1997) examine the same episode at firm level and reach a more qualified conclusion, because they find that Moroccan firms responded to trade reform mainly by compressing margins and reducing employment rather than by raising measured productivity. Sekkat (2010) extends the analysis to the wider MENA region and argues that the weak productivity response to liberalization in the area reflects the persistence of non-tariff barriers and of regulatory constraints on entry and exit rather than any absence of a trade channel as such.

Three features of this literature justify the approach adopted here. First, it is almost entirely single-country and cross-sectional, so that it cannot separate country-specific dynamics from shocks common to the region and to Morocco's European trading partners. Second, it predates by a considerable margin the structural transformation of Moroccan exports towards automotive and aeronautical products. That shift is exactly what the export sophistication argument of Nazlioglu et al. (2024) would identify as productivity-enhancing. Third, it offers no comparative benchmark against economies that undertook a comparable opening at a comparable moment. The panel assembled in Section 3 is constructed to supply that benchmark.

2.5 Econometric Advances in Heterogeneous Panels

Traditional panel estimators, including fixed effects, random effects, and GMM, assume cross-sectional independence, which is violated in macro panels subject to common shocks. Pesaran (2006) proposed the CCE estimator, which augments the regression with cross-sectional averages to proxy unobserved common factors. This approach is consistent under heterogeneous slopes, cross-sectional dependence, and multifactor error structures. Chudik and Pesaran (2015) extended this framework to dynamic panels by incorporating lagged dependent variables and lagged cross-sectional averages, producing the DCCE estimator. Monte Carlo evidence in both papers shows good finite-sample performance even when N is small, provided T is sufficiently large, a condition met in our setting with $T=24$.

Applications of CCE and DCCE to productivity analysis include Männasoo et al. (2018), who study EU productivity gaps, and Eberhardt and Teal (2011), who examine the role of technology in cross-country TFP differences. Our paper contributes to this literature by applying these methods to a Morocco-centered panel.

2.6 Conceptual Framework and Testable Expectations

The strands reviewed above can be brought together in a compact framework that makes the expected relationships explicit before any estimation is undertaken. Total factor productivity is treated as the outcome of a technology diffusion process whose intensity depends on exposure to foreign knowledge, whose assimilation depends on domestic absorptive capacity, and whose sectoral composition is shaped by relative prices and by the size of the public sector. Table 1 summarizes the expected sign of each channel, its theoretical foundation and the factor that conditions its operation.

ISSN: 2658-8455
Volume 7, Issue 09 (2026), pp. 198-223.
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Table 1. Conceptual framework of the expected relationships

Channel	Expected sign on TFP	Theoretical foundation	Conditioning factor
Trade openness, short run	Negative	Reallocation and adjustment costs	Flexibility of labor and product markets
Trade openness, long run	Positive	Technology diffusion, scale economies, competitive selection	Absorptive capacity of the receiving economy
Human capital	Positive	Endogenous growth and absorptive capacity	Quality of education and sectoral allocation of skills
Real effective exchange rate	Negative	Tradable sector competitiveness and structural change	Exchange rate regime and degree of pass-through
Government consumption	Ambiguous	Crowding out versus provision of public inputs	Composition of public expenditure

Source. Constructed by the author from the literature reviewed in Sections 2.1 to 2.5.

Four testable expectations follow. H1 states that the long-run elasticity of productivity with respect to trade openness is positive while its contemporaneous elasticity is negative or null. H2 states that real appreciation reduces productivity, so that the elasticity with respect to the real effective exchange rate is negative in the long run. H3 states that the effect of human capital is positive but slow-moving, and therefore difficult to identify precisely over a sample of moderate length. H4 states that productivity adjusts slowly towards its long-run equilibrium, so that the autoregressive coefficient of the dynamic specification is close to unity. These four expectations structure the reading of the results reported in Section 6.

3. Data and Variable Construction

3.1 Sources and Coverage

The dataset is a balanced panel of N=6 countries observed over T=24 years (2000-2023), yielding 144 country-year observations. The panel includes Morocco (MAR), Czech Republic (CZE), Greece (GRC), Poland (POL), Portugal (PRT), and Romania (ROU). Turkey was initially considered but excluded due to missing REER data for the full sample period.

Productivity data come from the Penn World Table (PWT) version 10.0 (Feenstra et al., 2015). The dependent variable is real TFP at constant national prices (rtfpna), which measures productivity relative to the United States after adjusting for factor quality. The human capital index (hc) is also sourced from PWT and aggregates years of schooling and returns to education following the methodology of Barro and Lee (2013).

Trade openness and government consumption are sourced from the World Bank's World Development Indicators (WDI). Openness is measured as trade in goods and services as a share of GDP (indicator NE.TRD.GNFS.ZS), converted to a ratio. Government consumption is measured as general government final consumption expenditure as a share of GDP (NE.CON.GOVT.ZS), also expressed as a ratio. The real effective exchange rate (REER) is sourced from the WDI (indicator PX.REX.REER), indexed to 2010=100.

3.2 Justification of Measurement and Transformation Choices

Two measurement decisions warrant explicit justification, since alternatives are available in the literature and the choice is not innocuous for the interpretation of the coefficients. All variables are transformed into natural logarithms for the estimation, that is ln(TFP), ln(HC), ln(OPEN), ln(GOV), and ln(REER). This log-log specification allows coefficients to be interpreted as elasticities. Beyond this interpretive convenience, the logarithmic transformation is economically motivated by the multiplicative structure of the underlying production function, in which productivity enters as a Hicks-neutral shifter, and it stabilizes the variance of series whose dispersion grows with their level. It also renders the specification consistent with the log-linear form used in the Monte Carlo designs of Pesaran (2006) and Chudik and Pesaran (2015), which is a non-trivial consideration when finite-sample properties are being invoked to justify a small cross-sectional dimension.

The second decision concerns the use of a real effective exchange rate index as the measure of external price competitiveness. Three alternatives were considered. A bilateral real exchange rate against the euro would be more directly interpretable for the European members of the panel but would misrepresent Morocco, whose currency basket assigns a substantial weight to the United States dollar. A unit labor cost based measure would come closer to the theoretical notion of cost competitiveness but is unavailable on a consistent basis for Morocco over the full sample. A measure derived from the ratio of tradable to non-tradable prices would align with the structural change literature but requires sectoral deflators that are not comparable across the six economies. The consumer-price-based effective index published in the World Development Indicators was therefore retained as the only measure available for all six countries over all twenty-four years. Its principal limitation is that it reflects consumer prices rather than production costs, is acknowledged among the limitations discussed in Section 7.4.

3.3 Country-Level Summary and Descriptive Statistics

Table 2. Country-level means of key variables (2000-2023)

Country	T	TFP	TFP (sd)	HC	Open	Gov	REER
CZE	24	0.9089	0.0726	3.677	1.29	0.198	93.56
GRC	24	1.1099	0.1165	2.976	0.642	0.207	92.94
MAR	24	0.9566	0.0715	1.786	0.701	0.173	102.4
POL	24	0.9368	0.0589	3.263	0.867	0.183	96.11
PRT	24	1.034	0.0246	2.386	0.752	0.189	98.9
ROU	24	0.8842	0.0857	3.132	0.724	0.158	97.06

Source. Author's computations from PWT 10.0 and World Development Indicators. TFP is real TFP at constant national prices, HC the human capital index, Open the trade to GDP ratio, Gov the government consumption to GDP ratio and REER the real effective exchange rate with 2010=100.

Table 2 reveals substantial cross-country heterogeneity. Greece has the highest average TFP level but also the largest standard deviation, reflecting the sharp productivity decline during the sovereign debt crisis. Morocco displays moderate TFP levels with low dispersion, alongside the lowest human capital index in the panel, consistent with its development status. The Czech Republic and Poland exhibit the highest trade openness, reflecting deep integration into European supply chains.

The contrast between Morocco and the Czech Republic is particularly instructive for the argument of this paper. The two economies display almost identical average productivity levels, 0.957 against 0.909, yet the Czech human capital index exceeds the Moroccan one by more than a factor of two, 3.68 against 1.79, and Czech trade openness is nearly twice as high, 1.29 against 0.70. Morocco is also the only economy in the panel whose average real effective exchange rate stands above the 2010 base, at 102.4, which points to a mild but persistent real appreciation relative to its comparators. These three observations anticipate the regression results and give the descriptive statistics a diagnostic value that goes beyond simple presentation.

ISSN: 2658-8455
Volume 7, Issue 09 (2026), pp. 198-223.
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IJAFAME International Journal of Accounting, Finance, Auditing, Management & Economics

Table 3. Descriptive statistics for panel variables

Variable	N	Mean	Std.Dev.	Min	Max
TFP	144	0.9717	0.1083	0.6819	1.2926
HC	144	2.8697	0.6340	1.5478	3.7827
Openness	144	0.8293	0.2633	0.4638	1.5642
Gov. cons.	144	0.1848	0.0197	0.1353	0.2363
REER	144	96.8270	8.1286	67.0466	125.8698
ln(TFP)	144	-0.0348	0.1106	-0.3829	0.2567
ln(HC)	144	1.0264	0.2457	0.4368	1.3304
ln(OPEN)	144	-0.2322	0.2948	-0.7683	0.4473
ln(GOV)	144	-1.6946	0.1093	-2.0005	-1.4427
ln(REER)	144	4.5693	0.0867	4.2054	4.8352

Source. Author's computations from the balanced panel of six countries over 2000-2023. N denotes the number of observations.

4. Econometric Methodology

4.1 The CCE Estimator

Consider the following heterogeneous panel data model with a multifactor error structure, written in equation (1).

$$y_{it} = \alpha_i + \beta'_i x_{it} + \lambda'_i f_t + \varepsilon_{it} \qquad (1)$$

where y_it is the dependent variable (ln TFP), x_it is a vector of observable regressors (ln HC, ln OPEN, ln GOV, ln REER), f_t represents unobserved common factors, λ_i are heterogeneous factor loadings, and ε_it is an idiosyncratic error. Pesaran (2006) shows that the common factors f_t can be consistently approximated by cross-sectional averages of y and x, denoted ȳ_t and x̄_t. The CCE estimator augments the regression with these averages, yielding consistent estimates of the long-run coefficients β_i even under cross-sectional dependence and slope heterogeneity.

4.2 The DCCE Estimator

The DCCE estimator extends the CCE framework to dynamic settings by incorporating the lagged dependent variable and lagged cross-sectional averages, as set out in equation (2).

$$y_{it} = \varphi_i y_{i,t-1} + \beta'_i x_{it} + \delta'_i x_{i,t-1} + \gamma'_i \bar{z}_t + \varepsilon_{it} \qquad (2)$$

where φ_i is the autoregressive coefficient capturing productivity persistence, and z̄_t includes contemporaneous and lagged cross-sectional averages. The implied long-run elasticity of y with respect to x_k is given by (β_k + δ_k)/(1 − φ), provided |φ| < 1. The parameter (1 − φ) represents the speed of adjustment toward long-run equilibrium. Both estimators are implemented using entity fixed effects and standard errors clustered at the country level to account for within-entity serial correlation.

4.3 Comparative Assessment of the Available Panel Estimators

Because the estimation strategy rests on a specific choice within a family of closely related estimators, it is useful to state explicitly what each member of that family assumes, what it delivers and where it fails. Table 4 provides this comparison and makes transparent the reasoning that leads to the selection of CCE and DCCE for the panel at hand.

Read against the properties of the present dataset, Table 4 leads unambiguously to the pair retained here. Slope homogeneity is implausible across economies whose institutional configurations differ as widely as those of Morocco and the Czech Republic, which excludes the first row. The diagnostic evidence reported in Section 5.1 documents strong cross-sectional dependence, which excludes the second row. The choice between the remaining rows is governed by the cross-sectional dimension, since the augmented mean group estimator is designed for panels with substantially larger N than the six countries available here. CCE and

DCCE are therefore used jointly, the former to identify the long-run association under a multifactor error structure and the latter to recover the dynamics that the former necessarily omits.

Table 4. Comparative properties of heterogeneous panel estimators

Estimator	Key assumptions	Strengths	Limitations
Pooled OLS and fixed effects	Homogeneous slopes and cross-sectional independence	Simple and efficient when the assumptions hold	Inconsistent under common factors and slope heterogeneity
Mean group (Pesaran and Smith, 1995)	Heterogeneous slopes and no unobserved common factors	Consistent under slope heterogeneity	Biased when cross-sectional dependence is present
CCE (Pesaran, 2006)	Heterogeneous slopes and a finite number of unobserved factors approximated by cross-sectional averages	Robust to strong cross-sectional dependence and to non-stationary factors (Kapetanios et al., 2011)	Static, so persistence is ignored and coefficients may be attenuated
DCCE (Chudik and Pesaran, 2015)	As CCE, with weakly exogenous regressors and lag augmentation of the cross-sectional averages	Recovers the speed of adjustment and separates short-run from long-run effects	Small-T bias and sensitivity to the number of lags retained
AMG (Eberhardt and Bond, 2009)	A common dynamic process extracted from a pooled first-difference regression	Provides an explicit estimate of a common technology trend	Asymptotic properties less firmly established and larger N generally required

Source. Constructed by the author from Pesaran and Smith (1995), Pesaran (2006), Eberhardt and Bond (2009), Kapetanios et al. (2011), Chudik and Pesaran (2015) and Ditzen (2018, 2021).

4.4 Justification for Small N

While the asymptotic properties of CCE and DCCE rely on $N \to \infty$, Monte Carlo evidence in Pesaran (2006, Tables II-III) and Chudik and Pesaran (2015, Table 1) demonstrates that these estimators exhibit acceptable size and power properties for N as small as 5-10 when $T \geq 20$. In our setting (N=6, T=24), the time dimension is sufficiently long to ensure that cross-sectional averages provide adequate proxies for the common factors. Moreover, Pesaran and Tosetti (2011) show that CCE is robust to a wide class of multifactor error structures in panels where T/N is large, which is satisfied here (T/N=4). We nevertheless interpret our results with appropriate caution regarding statistical power.

4.5 Treatment of Mixed Integration Orders

The unit root evidence presented in Section 5.2 indicates that four of the five variables behave as I(1) processes while the first difference of the human capital index fails to reject the unit root null at conventional levels. Combining a level specification and a dynamic specification in the presence of such mixed evidence requires justification, which rests on three arguments.

The first argument is that the borderline result for human capital is a known artifact of the construction of the index rather than evidence of a genuine I(2) process. The Penn World Table index is built from interpolated schooling data and evolves as a smooth, near-deterministic trend within each country, so that its differenced series retains substantial serial correlation and unit root tests possess very low power against it. Treating an index of this kind as I(2) would be economically meaningless, because it would imply an accelerating rather than merely rising educational stock.

The second argument is that the CCE estimator does not require the regressors to share a common integration order. Kapetanios et al. (2011) establish that the cross-sectional average approach remains valid when the unobserved common factors follow unit root processes, and their results extend to regressor sets combining I(1) and I(0) elements provided a cointegrating relationship exists among the non-stationary components. The CIPS evidence in levels, where all five variables fail to reject non-stationarity, together with the stationarity of the residual implied by the estimated model, is consistent with such a relationship.

ISSN: 2658-8455
Volume 7, Issue 09 (2026), pp. 198-223.
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The third argument is that the dynamic specification is estimated in levels with a lagged dependent variable rather than in differences, which is the standard autoregressive distributed lag representation of a cointegrated system. Within this representation, the long-run coefficients are identified irrespective of whether individual regressors are I(1) or I(0), and only the interpretation of the error correction term requires the cointegration property. The combination of level and dynamic specifications is therefore econometrically defensible in this context, although the imprecision of the human capital coefficient reported in Section 6.2 should be read partly in the light of this measurement issue.

5. Preliminary Diagnostic Tests

5.1 Cross-Sectional Dependence

Table 5 reports the Pesaran (2004) CD test statistics. Under the null hypothesis of cross-sectional independence, the CD statistic is asymptotically standard normal.

Table 5. Pesaran (2004) CD test for cross-sectional dependence

Variable	CD statistic	p-value	Significance
ln_TFP	0.5887	0.5561	
ln_HC	18.7245	0.0000	***
ln_OPEN	15.8004	0.0000	***
ln_GOV	2.4771	0.0132	**
ln_REER	2.5171	0.0118	**

Source. Author's estimations. The null hypothesis is the absence of cross-sectional dependence. Three, two and one asterisks denote significance at the 1, 5 and 10 percent levels respectively.

The results indicate strong cross-sectional dependence for ln(HC), ln(OPEN), ln(GOV), and ln(REER), all rejecting the null at the 5% level. The dependent variable ln(TFP) does not exhibit significant cross-sectional dependence in its raw form (CD=0.59, p=0.56), which is consistent with the cross-country heterogeneity in TFP levels documented in Table 2. However, the strong dependence in the regressors implies that conventional fixed-effects estimators would produce biased coefficients, validating the use of CCE and DCCE estimators.

5.2 Panel Unit Root Tests

Table 6 presents the CIPS test (Pesaran, 2007) for panel unit roots. This test extends the Augmented Dickey-Fuller framework by incorporating cross-sectional averages to account for common factors. The approximate 5% critical value for our panel dimensions (N=6, T=24) is −2.40 with an intercept and no trend.

Table 6. CIPS panel unit root test (Pesaran, 2007)

Variable	Form	CIPS	Reject H_0 (5%)
ln_TFP	Level	-0.9636	No
ln_HC	Level	-1.6846	No
ln_OPEN	Level	-0.8077	No
ln_GOV	Level	-0.8184	No
ln_REER	Level	-1.5298	No
Δln_TFP	First Diff	-3.8275	Yes
Δln_HC	First Diff	-2.0350	No
Δln_OPEN	First Diff	-3.8205	Yes
Δln_GOV	First Diff	-4.8450	Yes
Δln_REER	First Diff	-4.2006	Yes

Source. Author's estimations. The null hypothesis is the presence of a unit root. The critical value at the 5 percent level is −2.40 with an intercept and no trend. The lag order is one for levels and zero for differences.

All five variables fail to reject the unit root null in levels, confirming non-stationarity. In first differences, ln(TFP), ln(OPEN), ln(GOV), and ln(REER) reject the null at the 5% level, indicating stationarity. The first difference of ln(HC) is borderline (CIPS = −2.04), which is expected given the slow-moving nature of the human capital index. Overall, the results are consistent with I(1) behavior in levels and I(0) in differences, which motivates the use of level-based CCE and dynamic DCCE specifications.
Evidence of this kind is suggestive of a long-run equilibrium relationship but does not establish one. Section 7.3.1 submits that proposition to a direct test and reaches a more guarded conclusion.

6. Estimation Results

6.1 CCE Long-Run Estimates

Table 7. CCE estimation results, dependent variable ln TFP

Variable	Coef.	Std. Err.	t-stat	p-value
ln_HC	0.2388	0.6726	0.3550	0.7232
ln_OPEN	0.1371	0.1142	1.2008	0.2320
ln_GOV	0.3135	0.1968	1.5934	0.1135
ln_REER	0.4237	0.2176	1.9476	0.0536 *
$\overline{\text{ln\_TFP}}$	1.0000	0.3264	3.0641	0.0027 ***
$\overline{\text{ln\_HC}}$	-0.2388	0.8674	-0.2753	0.7835
$\overline{\text{ln\_OPEN}}$	-0.1371	0.0976	-1.4038	0.1628
$\overline{\text{ln\_GOV}}$	-0.3135	0.3351	-0.9354	0.3513
$\overline{\text{ln\_REER}}$	-0.4237	0.2067	-2.0504	0.0423 **

Source. Author's estimations. Entity fixed effects are included and standard errors are clustered by country. Barred variables denote cross-sectional averages proxying the unobserved common factors. The within R^2 equals 0.364 for 144 observations, six entities and twenty-four time periods.

The CCE results reveal that the real effective exchange rate (ln REER) has the largest and most precisely estimated coefficient among the main regressors ($\beta = 0.424$, $p = 0.054$), borderline significant at the 10% level. This positive sign indicates that, conditional on common factors, higher REER levels are associated with higher TFP. However, this coefficient must be interpreted with caution, as it captures the within-entity variation after absorbing cross-sectional averages. Government consumption (ln GOV) enters positively ($\beta = 0.314$, $p = 0.113$), while trade openness ($\beta = 0.137$, $p = 0.232$) and human capital ($\beta = 0.239$, $p = 0.723$) are not individually significant.
The limited significance of individual regressors in the CCE specification is not unusual in small panels and reflects the high dimensionality of the augmented regressor set (9 variables for 6 entities). The cross-sectional average of ln(TFP) is highly significant ($\beta = 1.00$, $p = 0.003$), confirming the relevance of common factors. The R^2 (within) of 0.364 indicates that a substantial portion of within-entity variation is captured by the common factor structure.

6.2 DCCE Dynamic Estimates

Table 8 reports the DCCE estimates, which incorporate lagged dependent and independent variables alongside contemporaneous and lagged cross-sectional averages.
The DCCE specification yields markedly more precise estimates than the static CCE, with an R^2 (within) of 0.954. The key findings are set out below.
Productivity persistence. The coefficient on lagged TFP is 0.931 ($p < 0.001$), indicating very high persistence. This implies a speed of adjustment of $(1 - 0.931) = 0.069$, meaning that only about 7% of the gap between actual and equilibrium TFP is closed each year. This slow adjustment is consistent with structural rigidities in the panel economies, including institutional frictions, skill mismatches, and investment inefficiencies. This result corroborates expectation H4.

Table 8. DCCE estimation results, dependent variable ln TFP

Variable	Coef.	Std. Err.	t-stat	p-value
ln_TFP(t−1)	0.9306	0.0481	19.3335	0.0000 ***
ln_HC	-0.4307	0.7828	-0.5502	0.5833
ln_OPEN	-0.1778	0.0533	-3.3355	0.0012 ***
ln_GOV	-0.0525	0.0502	-1.0463	0.2977
ln_REER	-0.2081	0.0308	-6.7612	0.0000 ***
ln_HC(t−1)	0.2899	0.7550	0.3840	0.7017
ln_OPEN(t−1)	0.2199	0.0471	4.6646	0.0000 ***
ln_GOV(t−1)	0.0342	0.0413	0.8288	0.4089
ln_REER(t−1)	0.0995	0.0490	2.0294	0.0448 **

Source. Author's estimations. Entity fixed effects are included and standard errors are clustered by country. Contemporaneous and lagged cross-sectional averages are included but not reported. The within R^2 equals 0.954 for 138 observations.

Trade openness. The contemporaneous effect of ln(OPEN) is negative (−0.178, $p = 0.001$), while the lagged effect is positive (0.220, $p < 0.001$). This sign reversal is economically intuitive, since trade shocks may cause short-run disruption through reallocation costs and competitive pressure before generating longer-run productivity gains through technology diffusion and specialization. The pattern conforms to expectation H1 and provides direct empirical support for the two-stage mechanism set out in the conceptual framework of Table 1.
Real exchange rate. ln(REER) enters with a significant negative contemporaneous coefficient (−0.208, $p < 0.001$) and a positive but smaller lagged effect (0.100, $p = 0.045$). This suggests that real appreciation reduces productivity in the short run, consistent with the competitiveness channel, with partial reversal over time. Expectation H2 is therefore supported.
Human capital. Both contemporaneous and lagged coefficients are statistically insignificant ($p > 0.58$), reflecting the slow-moving nature of the human capital index over a 24-year window. The point estimates are economically large but very imprecisely estimated due to limited within-country variation. This is the outcome anticipated by expectation H3, and it should be read as a statement about the identification capacity of the sample rather than as evidence against the absorptive capacity mechanism discussed in Section 2.3.
Government consumption. Neither contemporaneous nor lagged effects are significant, suggesting that government size does not directly drive TFP variation in this panel after controlling for common factors.

6.3 Implied Long-Run Elasticities

The long-run elasticities implied by the DCCE model are computed as $(\beta\_k + \delta\_k)/(1 - \varphi)$, where β_k is the contemporaneous coefficient, δ_k is the lagged coefficient, and $\varphi = 0.931$ is the persistence parameter.

Table 9. Implied long-run elasticities from DCCE

Variable	Short-run β	Lag δ	Long-run θ
ln(HC)	-0.4307	0.2899	-2.0275
ln(OPEN)	-0.1778	0.2199	0.6068
ln(GOV)	-0.0525	0.0342	-0.2640
ln(REER)	-0.2081	0.0995	-1.5635

Source. Author's computations from Table 8. The long-run elasticity is $\theta = (\beta + \delta)/(1 - \varphi)$, with $\varphi = 0.931$.

The implied long-run elasticity of TFP with respect to trade openness is 0.607, indicating that a 10% increase in trade openness is associated with approximately 6.1% higher TFP in the long run. This magnitude is consistent with the upper range of estimates in the trade-productivity literature. The long-run REER elasticity is −1.564, suggesting that sustained real appreciation has a substantial negative impact on productivity, a finding with direct implications for exchange rate policy. The human capital elasticity (−2.028) carries a counterintuitive negative sign, but this reflects the imprecision of the underlying estimates rather than a genuine negative effect. Government consumption has a modest negative long-run elasticity (−0.264), consistent with mild crowding-out effects.

6.4 Economic Magnitudes

Elasticities expressed in logarithmic form are difficult to translate into policy terms, so it is worth converting the central estimates into orders of magnitude that relate to observable quantities. Table 10 performs this conversion for a ten percent variation in each determinant, applied to the Moroccan sample mean.

Table 10. Economic magnitude of a ten percent variation in each determinant

Determinant	Variation considered	Short-run effect on TFP	Long-run effect on TFP	Illustration for Morocco
Trade openness	+10 percent, from 0.70 to 0.77 of GDP	−1.8 percent	+6.1 percent	Roughly six years of observed average TFP growth in the panel
Real effective exchange rate	+10 percent appreciation, from 102.4 to 112.6	−2.1 percent	−15.6 percent	Effect of comparable magnitude to the entire Moroccan TFP gap with Portugal
Government consumption	+10 percent, from 17.3 to 19.0 percent of GDP	−0.5 percent	−2.6 percent	Economically modest and statistically indistinguishable from zero
Human capital	+10 percent of the index, from 1.79 to 1.97	Not significant	Not significant	Point estimate uninformative given the imprecision reported in Table 8

Source. Author's computations from Tables 8 and 9 applied to the Moroccan sample means reported in Table 2. Effects are computed as the elasticity multiplied by the proportional variation and are therefore approximations valid for small changes.

Two readings of Table 10 deserve emphasis. The asymmetry between the short-run and long-run openness effects means that a liberalization measure would depress measured productivity for a period before yielding a net benefit roughly three times larger in absolute value, which has evident implications for the political economy of reform. The exchange rate effect, by contrast, is an order of magnitude larger than any other in the model and operates in a single direction, which suggests that the maintenance of external price competitiveness is quantitatively the most consequential of the levers examined here. Both readings must be qualified by the slow adjustment speed documented in Section 6.2, since a long-run effect of this kind is spread over several decades rather than realized within a single policy cycle.

6.5 Cross-Estimator Comparison

Table 11 sets the two sets of estimates side by side so that the convergences and divergences between the static and dynamic specifications can be assessed systematically rather than impressionistically.

Only one divergence in Table 11 is genuinely substantive. It concerns the real effective exchange rate, whose coefficient is positive and borderline significant in the static specification and strongly negative in the dynamic one. The explanation lies in the omission of the lagged dependent variable. With a persistence parameter of 0.93, the static regression attributes to the contemporaneous regressors a large part of the variation that in fact reflects the inherited level of productivity. Because real appreciation in this panel tends to accompany periods of already high productivity, notably during the pre-crisis convergence of the Central European economies, the static estimator recovers a spurious positive association. Once persistence is

ISSN: 2658-8455
Volume 7, Issue 09 (2026), pp. 198-223.
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modeled explicitly, the competitiveness channel emerges with the sign predicted by the framework of Table 1. The openness comparison illustrates a milder version of the same phenomenon, because the static coefficient of 0.137 lies between the negative contemporaneous and positive lagged dynamic effects and is therefore best understood as an average of two opposing forces. The overall conclusion is that the dynamic specification should be given interpretive priority wherever the two disagree.

Table 11. Comparison of CCE and DCCE coefficients

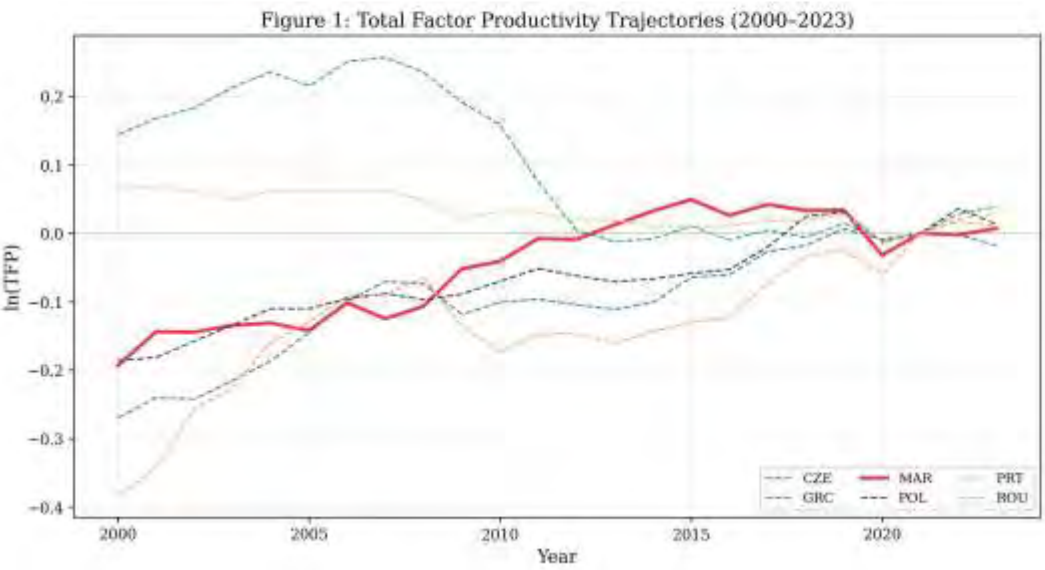
Variable	CCE coefficient	DCCE long-run elasticity	Sign agreement	Interpretation of the divergence
ln(HC)	0.239 (n.s.)	−2.028 (n.s.)	No	Both estimates are statistically indistinguishable from zero, so the sign reversal carries no substantive content
ln(OPEN)	0.137 (n.s.)	0.608	Yes	The static estimate is attenuated because it conflates the negative contemporaneous and positive lagged effects
ln(GOV)	0.314 (n.s.)	−0.264 (n.s.)	No	Neither specification identifies a significant effect, consistent with an ambiguous theoretical prior
ln(REER)	0.424 (p=0.054)	−1.564	No	The most substantive divergence, discussed below

Source. Author's computations from Tables 7 and 9. The abbreviation n.s. denotes a coefficient that is not significant at the 10 percent level.

6.6 Graphical Evidence

Figure 1 situates Morocco within the panel and warrants closer reading than a simple description of trends. Three features stand out. Morocco enters the sample at a productivity level comparable to that of Poland and the Czech Republic but does not share their post-accession acceleration, so that the gap widens progressively from the middle of the decade. Moroccan productivity is also markedly less volatile than that of the Southern European economies, which reflects the fact that the sovereign debt crisis affected Greece and Portugal through channels from which Morocco was largely insulated. The Moroccan series nonetheless exhibits a pronounced cyclical pattern of its own, whose amplitude is consistent with the well-documented sensitivity of Moroccan output to rainfall and to agricultural value added. Taken together, these features indicate that Morocco is neither converging with nor diverging sharply from its European comparators, a configuration that the slow adjustment speed estimated in Section 6.2 would predict.

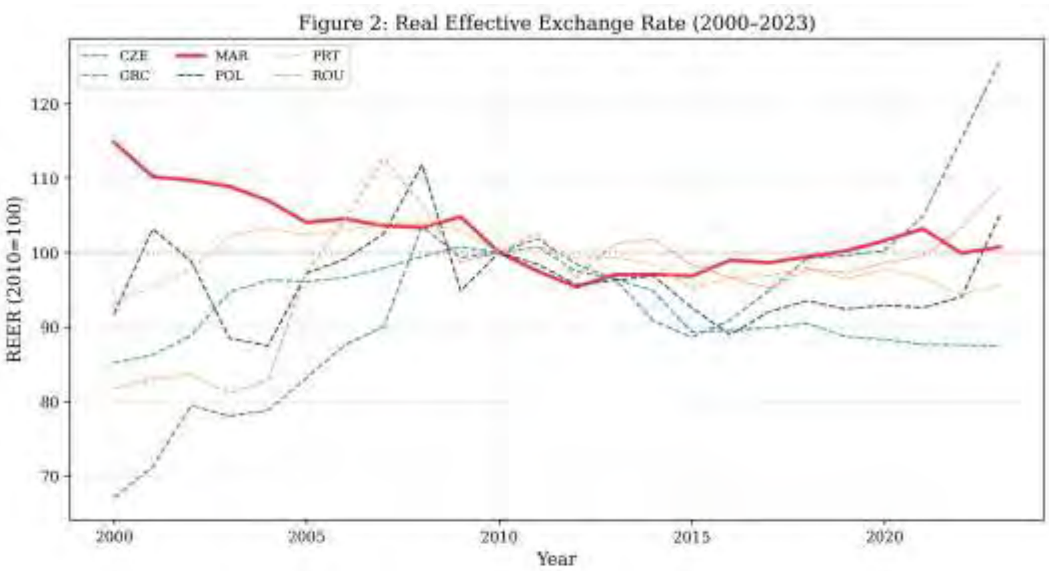
Figure 1. TFP trajectories by country, 2000-2023



Source. Author's elaboration from PWT 10.0.

Figure 2 provides the counterpart on the price side. The Czech Republic displays the strongest and most sustained real appreciation of the panel, a trajectory consistent with the Balassa-Samuelson dynamics expected of a rapidly converging economy. Morocco, by contrast, remains close to the base index throughout, which reflects the managed nature of its exchange rate arrangement. This stability is analytically important for the present paper, since it means that the negative long-run REER elasticity reported in Table 9 is identified principally from the European members of the panel and should be extrapolated to the Moroccan case with corresponding caution.

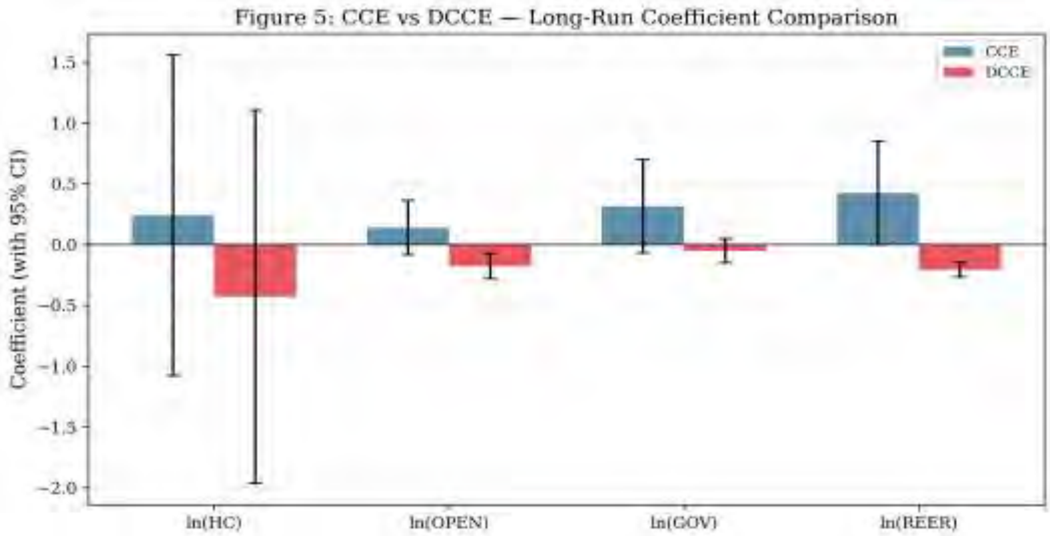
Figure 2. REER trajectories, 2000-2023



Source. Author's elaboration from World Development Indicators.

Figure 3 renders visually the comparison formalized in Table 11. The contraction of the confidence intervals from the static to the dynamic specification is substantial for ln(OPEN) and ln(REER) and negligible for ln(HC), which confirms that the precision gain arises from the modelling of persistence rather than from any change in the information content of the regressors themselves.

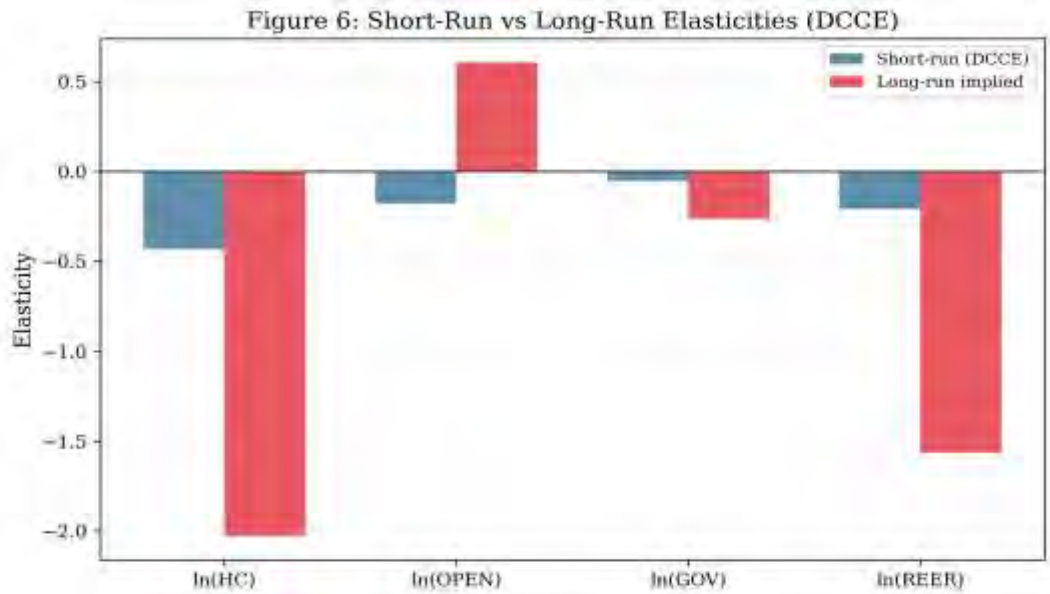
Figure 3. CCE and DCCE coefficient comparison with 95 percent confidence intervals



Source. Author's estimations from Tables 7 and 8.

Figure 4 displays the sign reversal for openness that constitutes the central empirical finding of the paper. The negative short-run and positive long-run elasticities reproduce the J-curve configuration familiar from the trade adjustment literature, and the vertical distance between the two bars provides a direct visual measure of the adjustment cost that liberalization imposes before its benefits accrue.

Figure 4. Short-run and long-run elasticities from DCCE



Source. Author's estimations from Table 9.

7. Discussion and Robustness

7.1 Interpretation of Key Results

Three main findings emerge from the estimation. First, trade openness is the most robust positive driver of long-run TFP in the panel. The significant short-run disruption followed by longer-run gains echoes the J-curve pattern documented in the trade adjustment literature and is consistent with Morocco's experience of trade liberalization under successive EU association agreements. Second, real exchange rate competitiveness matters significantly for productivity.

The negative DCCE coefficient on ln(REER) suggests that economies maintaining competitive real exchange rates achieve higher productivity, likely through sustained manufacturing competitiveness and avoidance of Dutch disease effects. Third, the very slow speed of adjustment ($\varphi \approx 0.07$) indicates that productivity deviations from equilibrium are highly persistent, implying that structural reforms take considerable time to materialize into measurable TFP gains.

7.2 CCE versus DCCE

The stark improvement in fit and significance from CCE ($R^2 = 0.36$) to DCCE ($R^2 = 0.95$) warrants discussion. The CCE model, while controlling for common factors, does not account for the high persistence of TFP. Given the autoregressive coefficient of 0.93, omitting lagged TFP from the specification leads to substantial omitted-variable bias, which inflates the residual variance and attenuates the estimated coefficients. The DCCE specification resolves this by explicitly modeling the dynamic structure, which explains both the higher R^2 and the improved precision of individual coefficient estimates. This pattern is consistent with the Monte Carlo evidence in Chudik and Pesaran (2015), who show that the static CCE can be severely biased in the presence of dynamics.

7.3 Robustness Analysis

The findings reported so far rest on a single estimation strategy applied to a single sample. This section subjects them to five separate challenges. We test whether the long-run relationship is a cointegrating one, whether the effect of openness is constant across levels of human capital, whether alternative heterogeneous estimators reproduce the DCCE elasticities, whether the results survive the addition of a capital intensity control, and whether they hold in restricted time windows. Each subsection closes with an explicit statement of what the exercise confirms and what it qualifies.

7.3.1 Panel Cointegration

Section 5.2 interpreted the combination of non-stationarity in levels and stationarity in differences as evidence of a cointegrating relationship. That inference was indirect. Table 12 reports the error-correction based test of Westerlund (2007), which examines the null of no cointegration directly through the significance of the adjustment term in a country-specific error-correction representation. Because the panel exhibits strong cross-sectional dependence, asymptotic critical values are not appropriate. The p-values reported here come from a block bootstrap with 999 replications in which the cross-sectional vector of innovations is resampled as a unit, so that the contemporaneous dependence structure of the data is preserved under the null.

Table 12. Westerlund (2007) error-correction panel cointegration test

Statistic	Lag order 0	p-value	Lag order 1	p-value
Gt	-1.086	0.956	-1.017	0.817
Ga	-6.079	0.951	41.734	0.941
Pt	-0.718	0.830	-0.925	0.826
Pa	-0.526	0.828	-0.804	0.834

Source. Author's estimations. The null hypothesis is the absence of cointegration. Gt and Ga are group-mean statistics, Pt and Pa are panel statistics. The p-values derive from a block bootstrap with 999 replications preserving cross-sectional dependence.

None of the four statistics rejects the null at any conventional level, and this holds under both lag orders. The Ga statistic turns positive at lag order one because the autoregressive coefficient estimated for Poland exceeds unity, which makes the scaling factor of that statistic change sign. Westerlund himself notes that Ga and Pa are the least reliable of the four in short panels, so we place more weight on Gt and Pt, which are negative throughout but far from their critical region.

ISSN: 2658-8455
Volume 7, Issue 09 (2026), pp. 198-223.
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The implication for the rest of the paper is a narrowing one. The claim of a cointegrating relationship made in Section 5.2 is not corroborated by a direct test and should be softened accordingly. Two readings are possible. Either no long-run equilibrium relation exists, in which case the level specifications are unbalanced, or the test simply lacks power. The second reading is the more plausible one here. Westerlund (2007) documents severe power losses when N is small and the adjustment speed is close to zero, and our own DCCE estimate places that speed at roughly 0.07 per year, which is precisely the configuration in which the test is least able to discriminate. The dynamic specification remains interpretable in either case, since an autoregressive distributed lag model in levels identifies long-run coefficients without requiring cointegration to be established beforehand. We therefore retain the DCCE results but no longer present the cointegration property as established.

7.3.2 Human Capital Threshold

The conceptual framework of Table 1 holds that the productivity benefit of openness is conditional on absorptive capacity. A linear model cannot represent that claim. Table 13 relaxes the linearity by allowing the openness coefficient to switch between two regimes defined by the level of human capital, following the fixed-effects threshold estimator of Hansen (1999). The threshold is located by grid search over the interior 70 percent of the human capital distribution, and its significance is assessed by the fixed-regressor bootstrap with 999 replications.

Table 13. Threshold estimates for the openness coefficient

Specification	Threshold (index)	F statistic	Bootstrap p-value	Openness below	Openness above
Human capital threshold, fixed effects	2.921	150.17	0.001	-0.228 (t = -2.29)	0.168 (t = 2.34)
Human capital threshold, augmented with cross-sectional averages	2.921	169.94	0.002	-0.281 (t = -2.85)	0.129 (t = 1.57)
Openness threshold, fixed effects	0.607	11.97	0.010	0.085 (t = 0.53)	0.207 (t = 2.25)

Source. Author's estimations. Thresholds are reported in levels. Standard errors are clustered by country. The 95 percent confidence interval for the human capital threshold is [2.921, 2.933] and that for the openness threshold is [0.588, 1.105].

The human capital threshold is estimated at an index value of 2.921 and is significant at the 1 percent level. Below it the openness coefficient is negative and significant at -0.228. Above it the coefficient turns positive at 0.168. The sign reversal is the substantive point, and it survives the addition of cross-sectional averages, although the positive coefficient of the upper regime loses precision in that specification and is no longer significant at the 5 percent level. A second threshold estimated on openness itself, reported in the last row, points in the same direction. Below a trade share of about 61 percent of gross domestic product the openness coefficient is indistinguishable from zero, and above it the coefficient is positive and significant.

A threshold is only informative if one knows who falls on either side of it. Table 14 identifies the composition of each regime.

The partition is economically coherent rather than arbitrary. The three economies that acceded to the European Union sit above the threshold for the whole sample. Greece crosses it in 2010, at the onset of the adjustment programmes that raised measured educational attainment while output collapsed. Portugal and Morocco remain below throughout, though for different reasons, because Portugal sits just under a threshold it approaches from below while Morocco is distant from it by a wide margin. The mechanisms that separate the regimes are plausibly institutional and sectoral. Economies above the threshold participate in European production networks in which imported inputs carry embodied technology and in which entry and exit of firms is comparatively unconstrained, whereas the liberalization episodes studied by Currie and Harrison (1997) and by Sekkat (2010) in the southern Mediterranean took place under regulatory conditions that limited the reallocation on which the productivity benefit depends.

Table 14. Regime composition under the human capital threshold

Country	Years in low regime	Years in high regime	Transition	Mean human capital index
Czech Republic	0	24	Above throughout	3.677
Poland	0	24	Above throughout	3.263
Romania	0	24	Above throughout	3.132
Greece	10	14	Crosses in 2010	2.976
Portugal	24	0	Below throughout	2.386
Morocco	24	0	Below throughout	1.786

Source. Author's estimations from the threshold model of Table 13 and the country means of Table 2.

Two things follow. The exercise confirms the two-regime logic set out in Table 1 and gives it a quantitative anchor. It adds the most direct available explanation of the Moroccan paradox described in the introduction, since Morocco is not merely below the threshold but is the furthest of the six economies from it, with a mean index of 1.786 against a critical value of 2.921. On this reading the modest Moroccan productivity response to two decades of trade opening is not evidence that openness fails to raise productivity. It is evidence that the domestic capacity to absorb what openness transmits has not yet reached the level at which the mechanism engages. One caveat must accompany this conclusion. The threshold model is static and does not carry the dynamic structure that Section 6.2 shows to be essential, so the regime coefficients are not directly comparable with the DCCE elasticities and should be read as evidence on the existence of non-linearity rather than as competing magnitudes.

7.3.3 Alternative Heterogeneous Estimators

Table 15 re-estimates the long-run elasticities with two estimators built on different identifying assumptions. The augmented mean group estimator of Eberhardt and Bond (2009) extracts a common dynamic process from a pooled first-difference regression and includes it as an explicit regressor in country-level equations. The dynamic mean group estimator averages country-specific autoregressive distributed lag equations without imposing any common factor structure.

Table 15. Long-run elasticities across estimators

Variable	CCE	DCCE	AMG	DMG (mean)	DMG (median)
ln(HC)	0.239	-2.028	0.133 (t = 0.28)	-0.699 (t = -0.85)	-1.155
ln(OPEN)	0.137	0.607	0.079 (t = 1.17)	0.403 (t = 2.77)	0.416
ln(GOV)	0.314	-0.264	-0.017 (t = -0.20)	0.967 (t = 0.92)	-0.004
ln(REER)	0.424	-1.564	0.002 (t = 0.01)	0.365 (t = 0.43)	-0.156

Source. Author's estimations. AMG follows Eberhardt and Bond (2009) and DMG averages country-specific ARDL(1,0) equations, with long-run coefficients computed as the ratio of the slope to one minus the autoregressive parameter. The mean autoregressive parameter under DMG is 0.665 against 0.931 under DCCE.

Only one coefficient is significant across the two additional estimators, and it is the one that matters most for the argument. The DMG long-run elasticity of openness is 0.403 with a t-statistic of 2.77, positive and significant, and its median across countries is 0.416, which indicates that the mean is not driven by a single outlying economy. The magnitude is smaller

ISSN: 2658-8455
Volume 7, Issue 09 (2026), pp. 198-223.
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than the DCCE estimate of 0.607, a gap that follows mechanically from the lower autoregressive parameter recovered by DMG, 0.665 against 0.931, since the long-run elasticity divides by one minus that parameter. The AMG estimates are uniformly insignificant. This is expected rather than contradictory, because AMG inference relies on the dispersion of six country-specific coefficients and the resulting standard errors are wide almost by construction. Eberhardt and Bond (2009) recommend the estimator for panels with substantially larger cross-sectional dimensions than ours.

The balance sheet of this comparison is mixed. It supports the positive long-run effect of openness, which is the single result that recurs across every estimator that has the power to detect it. It qualifies the exchange rate finding, since neither AMG nor DMG reproduces the large negative elasticity of the DCCE specification. The exchange rate result therefore depends on the modelling of common factors and should be presented as conditional on that specification rather than as an estimator-invariant regularity.

7.3.4 Adding Capital Intensity

A recurring objection to productivity regressions of this kind is that the estimated coefficients capture capital deepening rather than genuine efficiency gains. Although total factor productivity is by construction a residual net of factor accumulation, measurement error in the capital series can leave a correlation between the residual and capital intensity. Column two of Table 16 adds the logarithm of the capital to labor ratio, built from the capital stock and employment series of the Penn World Table to the DCCE specification.

Table 16. Long-run elasticities under alternative specifications and samples

Specification	Observations	Persistence	ln(OPEN)	ln(REER)	ln(GOV)
Baseline DCCE	138	0.931	0.607	-1.564	-0.264
Adding ln(K/L)	138	0.915	0.646	-1.111	-0.397
Excluding the pandemic, 2000-2019	114	0.921	0.799	-1.664	-0.272
Excluding the financial crisis, 2008 and 2009	126	0.925	0.716	-1.656	-0.212
First half, 2000-2011	66	0.775	0.477	-0.178	-0.365
Second half, 2012-2023	66	0.395	-0.108	-0.496	0.358

Source. Author's estimations. Persistence is the coefficient on the lagged dependent variable. The two half-sample specifications omit lagged cross-sectional averages because the time dimension is insufficient to support them.

Capital intensity enters with a significant positive contemporaneous coefficient of 0.291 and a nearly offsetting negative lagged coefficient, so its long-run elasticity is 0.033 and economically negligible. The openness elasticity is essentially unchanged at 0.646 against 0.607 in the baseline. The exchange rate elasticity contracts from -1.564 to -1.111, a reduction of roughly 29 percent, which indicates that part of what the baseline attributes to external competitiveness operates through the capital intensity channel.

7.3.5 Temporal Subsamples

The last three rows of Table 16 examine sample stability. Removing the pandemic years and removing the financial crisis years both leave the picture intact, and in fact strengthen it, because the openness elasticity rises to 0.799 and 0.716 respectively while the exchange rate elasticity remains near -1.66. The two half-sample specifications are a different matter. In the first half the openness elasticity falls to 0.477 and the exchange rate effect nearly disappears. In the second half the openness elasticity turns negative at -0.108.

This apparent instability requires care rather than alarm, because the half-sample estimates are not comparable with the others. Twelve annual observations per country cannot support the lagged cross-sectional averages that the DCCE estimator requires, so those terms were dropped. More decisively, the estimated persistence collapses from 0.931 in the full sample to 0.775 and then to 0.395. A downward bias in the autoregressive parameter of exactly this kind is the expected consequence of shortening the time dimension of a dynamic panel, and because the long-run elasticity is obtained by dividing through by one minus that parameter, any bias in it propagates directly into the elasticities. The second half estimates in particular are computed from a persistence parameter less than half the full-sample value and should not be read as evidence of a genuine structural break.

Here the verdict divides cleanly. Removing the two obvious candidate outlier episodes confirms that neither the global financial crisis nor the pandemic drives the results. The half-sample exercise qualifies the precision rather than the substance of the findings, since it shows that the elasticities cannot be recovered reliably once the time dimension falls below roughly twenty observations per country. Taken together with the cointegration evidence of Section 7.3.1, this points to the same conclusion. The sign and direction of the effects reported in this paper are robust, while their precise magnitudes depend on a time dimension that is adequate but not generous.

7.4 Limitations

Several limitations should be acknowledged. The small cross-sectional dimension (N=6) limits statistical power and may affect the precision of the cross-sectional average approximation to common factors. While finite-sample evidence supports the use of CCE and DCCE in small N settings, our results should be interpreted as indicative rather than definitive. The human capital index, despite being the standard measure in the literature, exhibits very limited within-country variation over a 24-year window, which explains the imprecise estimates for this variable. Finally, the exclusion of Turkey due to missing REER data reduces the panel's geographic diversity.

Four further limitations deserve explicit mention, since each of them bounds the interpretation of the results in a distinct way. The first concerns the exclusive reliance on the Penn World Table for the productivity and human capital series. The residual-based construction of total factor productivity in that source embeds assumptions about factor shares and about capital depreciation that are imposed uniformly across countries, so that any cross-country divergence in these underlying parameters is mechanically transferred into the measured productivity series. The human capital index compounds this concern, because it is built from interpolated schooling data and returns to education estimated outside the sample.

The second limitation concerns the absence of explicit institutional variables. The literature reviewed in Section 2.4 attributes a substantial part of the weak productivity response to liberalization in the MENA region to regulatory barriers to entry and exit, yet no measure of institutional quality enters the specification. To the extent that institutions are slow-moving, part of their influence is absorbed by the country fixed effects, but any time-varying institutional change remains in the error term and could bias the openness coefficient.

The third limitation concerns the measurement of external competitiveness already discussed in Section 3.2, since a consumer-price-based effective index captures relative prices rather than relative production costs and may therefore understate the competitiveness pressure faced by the tradable sector. The fourth limitation concerns the modelling of non-linearity. Section 7.3.2 establishes a single threshold in human capital, but a single abrupt break is itself a strong assumption. Nothing in the theory of absorptive capacity implies that the openness coefficient jumps at one point rather than varying continuously, and the static form of the threshold estimator means its regime coefficients cannot be set alongside the dynamic elasticities that carry the rest of the argument. A fifth limitation emerged from the robustness analysis itself. The Westerlund test of Section 7.3.1 does not reject the absence of cointegration, so the long-

ISSN: 2658-8455
Volume 7, Issue 09 (2026), pp. 198-223.
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run interpretation of the level specifications rests on the autoregressive distributed lag representation rather than on an established equilibrium relation.

8. Conclusion and Policy Implications

This paper provides an empirical investigation of the structural determinants of total factor productivity in Morocco and five peer economies over 2000-2023. Using CCE and DCCE estimators that control for unobserved common factors and cross-sectional dependence, we find that trade openness is the most robust positive driver of long-run productivity, while real exchange rate appreciation is associated with significant productivity losses. The estimated speed of adjustment is very slow, highlighting the persistence of productivity dynamics and the importance of sustained structural reform efforts.
The robustness analysis adds a qualification that changes how the openness result should be read. That effect is not uniform across the panel. A threshold regression places the switching point at a human capital index of 2.92, below which openness reduces measured productivity and above which it raises it. Morocco sits furthest below that threshold of any economy in the sample. The productivity payoff from trade integration is therefore conditional, and the condition is one that Morocco does not currently satisfy.

8.1 Contributions of the Study

The contributions of the paper can be restated along the three dimensions announced in the introduction. The theoretical contribution consists in the articulation of a framework, summarized in Table 1, in which openness, human capital and external price competitiveness operate as complementary rather than independent channels, and in the derivation from that framework of four expectations that the empirical section tests directly. The methodological contribution consists in the joint deployment of static and dynamic common correlated effects estimators on a Morocco-centered comparative panel, accompanied by a full battery of pre-estimation diagnostics and by an explicit justification of the estimator choice against the alternatives set out in Table 4. The empirical contribution consists in four quantified findings. A long-run openness elasticity of 0.61 coexists with a negative contemporaneous effect. A long-run exchange rate elasticity of -1.56 constitutes the largest effect in the model. An annual adjustment speed of approximately 7 percent places the horizon of productivity-enhancing reform well beyond a single electoral or budgetary cycle. And a human capital threshold of 2.92 separates a regime in which openness lowers productivity from one in which it raises productivity, which supplies the quantitative content of the absorptive capacity argument and locates Morocco unambiguously in the first of the two regimes.

8.2 Policy Implications for Morocco

For Morocco, these findings carry several policy implications. First, deepening trade integration, particularly through upgrading the export basket toward higher-complexity goods, is likely to yield meaningful productivity dividends. Second, maintaining a competitive real exchange rate is important for preserving manufacturing sector dynamism and avoiding premature deindustrialization. Third, given the slow pace of adjustment, productivity-enhancing reforms such as investment in education, institutional modernization and innovation support must be sustained over extended horizons to generate measurable TFP gains. Fourth, the strong role of common factors underscores Morocco's sensitivity to global economic conditions, suggesting that macroeconomic stabilization frameworks should explicitly account for external shocks.
These recommendations must nonetheless be qualified by the institutional and budgetary constraints that condition their feasibility, since a recommendation that ignores its own

implementation cost is of limited practical value. The educational investment implied by the absorptive capacity argument competes directly with other claims on a budget already constrained by the financing needs of the generalization of social protection, so the realistic question is not whether to raise educational spending but how to reallocate within a broadly constant envelope towards the levels of schooling that condition technological absorption. The exchange rate recommendation is subject to a distinct constraint, since the gradual widening of the fluctuation band already under way must be reconciled with the external debt exposure of the Treasury and with the inflationary pass-through of any depreciation. The sequencing of the two therefore matters, because the productivity benefit of a more flexible exchange rate is conditional on a tradable sector capable of responding to the price signal, which is itself conditional on the human capital investment discussed above.

The temporal profile of these measures follows directly from the estimated adjustment speed. With approximately 7 percent of the equilibrium gap closing each year, roughly half of the long-run effect of any structural measure materializes only after a decade. Trade and exchange rate measures, whose transmission runs through relative prices, can be expected to produce observable effects within a three to five year horizon and therefore belong to the short term of the reform agenda. Educational measures, whose transmission runs through the composition of the labor force, belong to a horizon of fifteen years or more. Coordination between the industrial acceleration strategy, trade policy and educational planning is consequently not an administrative refinement but a condition of effectiveness, since measures operating on such different horizons will otherwise be evaluated and abandoned before their effects can be observed.

8.3 Limitations and Directions for Future Research

The directions for future work follow from the limitations set out in Section 7.4, and each of the four extensions proposed here addresses one of them directly. First, the reliance on a single data source could be mitigated by replicating the analysis with productivity series drawn from alternative sources, which would establish whether the reported elasticities are robust to the measurement conventions of the Penn World Table. Second, the absence of institutional variables calls for the inclusion of time-varying governance and regulatory indicators, which would allow the openness coefficient to be purged of the institutional change with which liberalization episodes are typically accompanied. Third, the measurement of external competitiveness would be improved by the construction of a unit labor cost based index, at the cost of a shorter sample or a reduced country coverage.

The fourth extension builds on the threshold evidence of Section 7.3.2 rather than merely proposing it. Having established that a single break exists, the natural next step is to ask whether the transition is abrupt or gradual. A smooth transition specification would let the openness coefficient vary continuously with human capital and would dispense with the assumption of one discrete switching point, while a dynamic threshold model would reconcile the non-linearity documented here with the persistence documented in Section 6.2, a reconciliation the static estimator of Hansen (1999) cannot provide. Both strategies need a larger cross-section than six countries, since threshold estimation draws its power from variation in the transition variable across units. Enlarging the panel towards other MENA and emerging economies would serve that purpose and would at the same time bring the augmented mean group estimator into the range where its inference becomes informative, which Section 7.3.3 shows it is not at present. A sectoral decomposition would close the agenda by locating where within the economy the aggregate effects originate.

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