

Sectoral Decomposition of Convergence in Labor Productivity

A Re-examination from a New Dataset

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Abstract

This paper investigates how the sector-specific source or the changing sectoral composition of labor productivity has contributed to aggregate beta convergence, using a newly constructed eight-sector database. The main findings are twofold. First, both within and sectoral reallocation have become important drivers of aggregate convergence in labor productivity. Second, agricultural productivity growth has

been a significant contributor to aggregate convergence, whereas catch-up in other sectors has only contributed a small amount to convergence. The strong growth of the agriculture sector has been the most important driver of aggregate productivity convergence even though agricultural productivity itself in low-income countries is weakly converging to that in advanced economies.

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Sectoral Decomposition of Convergence in Labor Productivity: A Re-examination from a New Dataset*

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1 Introduction

There has been a re-emergence of catch-up in productivity by emerging markets and developing economies (EMDEs) to advanced economies ([World Bank \(2020\)](#)). Understanding how the sector-specific source or the changing sectoral composition (i.e., structural change) has contributed to the aggregate beta convergence in productivity is an area that has so far been under-explored.

In low-income countries (hereafter “LICs”), a high share of employment and low labor productivity in agriculture are mainly responsible for low aggregate productivity.¹ The average share of employment in the agriculture sector in LICs is high, at over 65 percent in 2018, compared to just 3 percent in advanced economies. The level of agricultural productivity in LICs is only 4 percent of advanced-economy productivity (Figures 1 and 2). This reflects that slow technology adoption in the agriculture sector in LICs is due to the high proportion of smallholder ownership and family farms ([Lowder et al., 2016](#)).² However, even if agricultural labor productivity does not converge to the frontier, the labor reallocation to other sectors with higher productivity levels could be an important engine of aggregate convergence. For example, the East Asia and Pacific (EAP) region has experienced a rapid ‘de-agriculturalization’ over 40 years. Within countries, the productivity gaps across sectors in LICs have remained larger than advanced economies over the last 20 years.³

There is a large body of literature on the determinants of structural change using the multi-sector general equilibrium model. Two traditional explanations for structural change are the representative household with non-homothetic preference ([Kongsamut et al. \(2001\)](#)) and the firms with differential productivity growth rates ([Ngai and Pissarides \(2007\)](#)). Their basic mechanism is that the relative price related to the differential productivity allocates total expenditures across any goods and services. Given these demands, relatively higher productivity growth sheds labor and due to gross complementarity, labor shifts to slower-productivity growth. For example, [Alvarez-Cuadrado and Poschke \(2011\)](#), [Duarte and Restuccia \(2010\)](#), and [Herrendorf et al. \(2013\)](#)

¹Unless otherwise indicated, productivity is defined in this paper as value added per worker. The classification by income follows [World Bank \(2021\)](#). Low-income countries are part of emerging markets and developing economies (EMDEs).

²Although mechanization increases agricultural labor productivity due to both capital deepening and total factor productivity (TFP), mechanization in poor countries is hindered by frictions such as untitled land, which is a prevalent feature of poor countries ([Chen, 2020](#)). Furthermore, [Restuccia et al. \(2008\)](#) show that agricultural labor productivity is positively associated with the use of intermediate inputs (e.g., modern fertilizers and high-yield seeds) and argue that certain distortions in factor markets may severely dampen the incentives for their use.

³As agricultural workers often do not work full time in agriculture, the sectoral gap is diminished if productivity is measured per hours instead of per worker ([Gollin et al., 2014](#)). However, even after taking hours and human capital per worker by sector, a large sectoral gap remains for a large number of countries [Hamory et al. \(2021\)](#).

with non-homothetic preference consider “Engel’s law” which refers to low income elasticity for food produced by the agriculture sector. They show that the productivity improvement in the agriculture sector combined with Engel’s law explains most of the declines in agricultural employment share.

Given the ongoing structural change in Africa and low-income countries (as shown by [Diao et al. \(2017\)](#) and [Rodrik \(2018\)](#)), understanding the role of structural change in aggregate convergence is the focus of this paper. In assessing the contribution of structural change to convergence, it is important to recognize that industry and service sectors are made up of a highly heterogeneous set of activities that vary widely in their skill- and capital-intensity as well as their productivity. Understanding these differences is essential to help the policies that can foster sustained productivity growth. This paper investigates how the sector-specific source or the changing sectoral composition (i.e., structural change) has contributed to the aggregate beta convergence. This paper extends the literature in two dimensions:

1. It constructs a new sectoral dataset for 8 sectors and 91 countries over 1995-2018 (and for 60 countries over 1975-2018). This is the first comprehensive database covering a broad range of both advanced economies and emerging and developing economies (EMDEs) over a long time period. This more detailed dataset and a more recent sectoral decomposition improves the scope to assess the contribution of structural change in productivity convergence, particularly as the estimates are sensitive to the level of aggregation ([Üngör \(2017\)](#)).
2. This paper is the first to decompose aggregate beta convergence into contributions from within-sector productivity growth and from between-sector productivity growth, for a large number of countries ranging from advanced economies to low-income countries, whereas [Wong \(2006\)](#) have only focused on advanced economies.

The paper starts by describing the new dataset. Then this data is used to decompose aggregate productivity growth into within- and between-sector contributions. The main section examines convergence across countries and examines the extent within and between sectoral reallocation are contributing to convergence. Two robustness exercises are undertaken which support the main findings. The final section concludes with a summary of major findings, policy implications and a discussion of future research directions.

2 Data and empirical strategy

2.1 Data

The database consists of sectoral and aggregate labor productivity statistics for 91 countries, and 8 sectors covering the period up to 2018.⁴ Compared with the literature using sectoral datasets, it employs a large and diverse sample of countries.⁵ The database combines data from the APO Productivity Database, the OECD STAN database, the OECD National Accounts, and the GGDC/UNU-WIDER Economic Transformation Database (ETD, [de Vries et al. \(2021\)](#)) for value-added data and employment. In addition, this database is extrapolated backwards using annual growth rates from KLEMS, the GGDC 10-Sector database (GGDC, [de Vries et al. \(2015\)](#)) or the Expanded Africa Sector Database (EASD, [Mensah and Szirmai \(2018\)](#)) to construct a long time series dataset. Also, if there is no available employment data, ILO modelled estimates are supplementary employed. See the Appendix for more details.

2.2 Within sector and between sector effects

Following [de Vries et al. \(2012\)](#), [McMillan et al. \(2014\)](#) and [Diao et al. \(2017\)](#), we start by employing a shift-share-analysis which decomposes aggregate labor productivity into the within sector and between sector effects:

$$\underbrace{\frac{\Delta y}{y}}_{\text{Aggregate}} = \underbrace{\sum_{j=1}^k \frac{Y_j}{Y} \left[\frac{\Delta y_j}{y_j} \right]}_{\text{Within-}j} + \underbrace{\sum_{j=1}^k \left[\frac{y_j}{y} \right] \Delta s_j}_{\text{Static}} + \underbrace{\sum_{j=1}^k \left[\frac{y_j}{y} \right] \left[\frac{\Delta y_j}{y_j} \right] \Delta s_j}_{\text{Dynamic}} \quad (1)$$

Between

where y is aggregate labor productivity, y_j is labor productivity of sector j , Y_j is initial value-added of sector j , s_j is the employment share of sector j . Between sector effects are driven by the change in employment share. They are further decomposed into those which are due to the reallocation of sources to sectors with higher productivity levels (static sectoral effect), and those due to reallocation toward sectors with higher productivity growth (dynamic sectoral effect). Within-sector productivity growth may reflect the effects of improvements in

⁴The eight sectors distinguished in the dataset are agriculture, mining, manufacturing, utilities, construction, trade services, transport and financial services, and government and personal services. According to Economic Transformation Database, Business services include “Information and communication” whereas those in other databases are included in transport service.” Hence, we combined transport and financial services to construct a long time series database.

⁵[McMillan et al. \(2014\)](#) and [Diao et al. \(2017\)](#) employ 38 and 39 countries; [Martins \(2019\)](#) use 7 sectors and 169 countries, [IMF \(2018\)](#) use 10 sectors and 62 countries.

human capital, investments in physical capital, technological advantages, or the reallocation of resources from the least to the most productive firms within each sector.

2.3 Decomposition of aggregate convergence

The unconditional (beta) convergence hypothesis suggests that productivity catch-up growth may occur fastest where productivity differentials are the largest across countries. Following [Wong \(2006\)](#), this aggregate beta unconditional convergence can be decomposed into the contribution of the within-sector growth and that of sectoral reallocation.⁶ The decomposition consists of two steps: First, regressing aggregate labor productivity growth ($\Delta y/y$) on the logarithm of initial aggregate labor productivity (y) gives the aggregate beta ($\beta_{aggregate}$) convergence.⁷

$$\frac{\Delta y}{y} = \alpha_{aggregate} + \beta_{aggregate} \ln(y) + \varepsilon_{aggregate} \quad (2)$$

Second, replacing the dependent variable in the first regression with decomposed components from equation (2), a regression on the logarithm of initial aggregate labor productivity is undertaken:

$$\left\{ \begin{array}{l} Within_j = \alpha_{within-j} + \beta_{within-j} \ln(y) + \varepsilon_{within-j} (j = 1, \dots, 8) \\ \sum_{j=1}^k Static_j = \alpha_{static} + \beta_{static} \ln(y) + \varepsilon_{static} \\ \sum_{j=1}^k Dynamic_j = \alpha_{dynamic} + \beta_{dynamic} \ln(y) + \varepsilon_{dynamic} \end{array} \right. \quad (3)$$

The summation of the left-hand-side in regression (3) is equal to the left-hand-side in regression (2). Hence, rearranging the right-hand-sides in regression (2) and (3) gives:

⁶Other studies decomposing convergence employ an accounting approach. They calculate the difference of each component (1) between the frontier and all sample countries. (e.g., [Bernard and Jones \(1996\)](#) and [Harchaoui and Üngör \(2016\)](#) use the United States as the frontier and [Caselli and Tenreyro \(2005\)](#) use France. In contrast, [Wong \(2006\)](#) employs an econometric approach. Its advantage is to understand that the components are statistically significant or not.

⁷Following [McMillan et al. \(2014\)](#), local currency value-added is converted to U.S. dollars using the PPP exchange rate obtained from the Penn World Table for initial labor productivity (y). [Van Biesebroeck \(2009\)](#) builds an expenditure-based sector-specific PPP in OECD countries, using detailed price data.

$$\begin{aligned}
& \alpha_{aggregate} + \beta_{aggregate} \ln(y) + \varepsilon_{aggregate} \\
&= \sum_{j=1}^k \alpha_{within-j} + \alpha_{static} + \alpha_{dynamic} \\
&+ (\sum_{j=1}^k \beta_{within-j} + \beta_{static} + \beta_{dynamic}) \ln(y) \\
&+ \sum_{j=1}^k \varepsilon_{within-j} + \varepsilon_{static} + \varepsilon_{dynamic}
\end{aligned} \tag{4}$$

If $\alpha_{aggregate} = \sum_{j=1}^k \alpha_{within-j} + \alpha_{static} + \alpha_{dynamic}$ and $\varepsilon_{aggregate} = \sum_{j=1}^k \varepsilon_{within-j} + \varepsilon_{static} + \varepsilon_{dynamic}$,

$$\beta_{aggregate} = \underbrace{\sum_{j=1}^k \beta_{within-j}}_{\text{Within}} + \underbrace{\beta_{static} + \beta_{dynamic}}_{\text{Between}} \tag{5}$$

Hence, the beta $\beta_{aggregate}$ coefficients obtained in the first step can be decomposed into a sum of coefficients of the within sector effect $\sum_{j=1}^k \beta_{within-j}$, the static β_{static} and dynamic $\beta_{dynamic}$ sector effects. The summation of the static β_{static} and dynamic $\beta_{dynamic}$ sector effects is the contribution of between sector effects.

We also examine the regressions for sector-specific convergence;

$$\frac{\Delta y_j}{y_j} = \alpha_j + \beta_j \ln(y_j) + \varepsilon_j \tag{6}$$

Even if sector labor productivity itself has not converged to the corresponding frontier across sectors, the labor reallocation to other sectors with higher productivity levels could be an important engine of aggregate convergence.

3 Results

3.1 Within sector and between sector effects

Figure 3 shows the decomposition of the aggregate productivity into within-sector productivity growth and between-sector productivity growth. Productivity growth in advanced economies had been almost entirely driven by within-sector productivity growth mainly in the manufacturing, transport and finance sectors. However, since the 2000s both within-sector and between-sector productivity growth have slowed. In contrast, in EMDEs, productivity growth has been supported by both within-sector and between-sector changes over 40 years. The

within sector growth has been broad-based-including in agriculture as well as manufacturing, trade, transport and finance services, while the between-sector productivity gains mainly reflected a move out of agriculture into services. In particular, the share of workers employed in agriculture fell from about 70 percent in 1975 to about 30 percent in 2018. In LICs, between-sector productivity gains in LICs reflected a broad-based shift out of agriculture into services such as trade, transport and finance. During the 2010s, the contribution of between-sector slowed down due to small movement to higher productivity sectors such as manufacturing and trade.

Figure 4 shows that contributions of the between-sector effect have been non-negligible in the East Asia and Pacific (EAP), European and Central Asia (ECA), South Asia (SAR) and Sub-Saharan Africa (SSA) regions whereas those in Latin America and Caribbean (LAC) and Middle East and North Africa (MENA) have been small.

3.2 Baseline regression

3.2.1 Aggregate convergence

Table 1 and Figure 5 show the results with three different balanced panel datasets: 60 countries in 1975-2018, 60 countries in 1975-1995, and 91 countries in 1995-2018. At the aggregate level, regression (2) shows there has been weak unconditional convergence prior to 1995. However, since the late 1990s aggregate convergence emerges (Table 1 and Figure 5, World Bank (2020)). Over this period, countries with lower initial levels of productivity have begun to catch up to high-productivity economies. Nonetheless, at the estimated rate of convergence it would take about 140 years for countries at the bottom 10 percent of the productivity distribution to reach the level of the top 10 percent.⁸

3.2.2 Decomposing within and between sector convergence

Even though many sectors are not converging to the frontier, the reallocation of labor to other sectors with higher productivity levels could be an important engine of aggregate convergence. Estimating the decomposition of aggregate convergence from regression (3) suggests that since 1995 both within and between sector effects

⁸137 years $\equiv (\ln(0.9)/\ln(0.1)-1)/0.00695$, using Table 1.

have become important drivers of aggregate convergence in labor productivity (Table 1 and Figure 5). This reflects larger productivity improvements in many sectors in EMDEs (especially the LICs) compared to advanced economies as well the fact that many EMDEs experienced rapid sectoral shifts from agricultural sectors over the last few decades.

Looking across the sectors, agricultural productivity growth has been a significant contributor to aggregate convergence, whereas catch-up in other sectors has only contributed a small amount to convergence. Given the share of value-added in the agriculture sector in LICs is large (Figure 1), the strong growth of the agriculture sector has been the most important driver of the aggregate productivity convergence. Our result is in line with [Ivanic and Martin \(2018\)](#) and [Ligon and Sadoulet \(2018\)](#) which illustrate that the increase in agricultural productivity has a larger poverty-reduction effect than increases in other sectors.

3.2.3 Sectoral convergence

The same exercise is undertaken to examine convergence across sectors (Table 2 and Figure 5). Examining this using this study's extensive data suggests the following:

- **Agriculture sector:** Over the first half of the sample and the over the entire sample, there is no evidence for unconditional convergence in the agriculture sector. This is line with [KinfeMichael and Morshed \(2019\)](#). However, over the second half of the sample (1995-2018) there is convergence. This seems to some degree to be due to the commodity price boom during the 2000s. Nonetheless, the estimated convergence rate is very low, implying that it would take about 750 years for the bottom 10 percent of the productivity level to reach the top 10 percent.⁹
- **Industry sectors (Mining, Manufacturing, Utilities and Construction):** There is evidence of unconditional convergence in many of the industry sectors. The finding of unconditional convergence in the manufacturing sector is line with [Rodrik \(2013\)](#) using UNIDO data.¹⁰ However, the estimated convergence rate is low. [Diao et al. \(2021\)](#) reveal a dichotomy between larger firms in the manufacturing sector that exhibit

⁹750 years $\equiv (\ln(0.9)/\ln(0.1)-1)/0.00127$, using Table 2.

¹⁰However, [Rodrik \(2013\)](#) acknowledges that the “convergence results that follow should be read as applying to the more formal, organized parts of manufacturing and not to micro-enterprises or informal firms. In developing countries, enterprises with fewer than 5 or 10 employees are often not included.” UNIDO reported that there is a significant difference between UNIDO and the national account.

superior productivity performance but do not expand employment much in countries such as Tanzania and Ethiopia.

- **Service sectors (Trade, Transport and Finance and others):** There is evidence of unconditional convergence across many service sectors (IMF (2018); Kinfemichael and Morshed (2019)). The transport and financial services sectors show convergence across three different balanced panel datasets. In contrast, there has been no evidence of convergence in trade services (wholesale, retail trade, accommodation, and food services) over 1995-2018 despite having shown unconditional convergence over an earlier time-period. Lagakos (2016) argued that in the retail trade sector, developing countries rationally choose “traditional technologies” with low measured labor productivity instead of “modern technologies” with high productivity across two dimensions. First, low car ownership rates among households in poor countries cause modern stores to locate further than traditional stores from residential centers less attractive. This situation is related with “appropriate technology” suggested by Basu and Weil (1998) and Acemoglu and Zilibotti (2001). Second, traditional retail technologies offer an opportunity for entrepreneurs to operate informally, thus earning a price advantage over modern retail technologies, which are larger in scale and cannot evade taxes as easily as smaller, traditional stores.

3.3 Robustness analysis

3.3.1 Robustness 1: Time-varying regression

The baseline results were based on three sample periods (1970-2018, 1970-1995, and 1995-2018). For robustness and to provide further insights, a rolling window methodology is employed in which regressions (2) and (3) are estimated with OLS over the 10-year rolling window. This results in 34 regressions. Figure 6 shows the time-varying contributions of within and between sector effects on aggregate convergence. The result is line with the baseline regressions. The between sector effects have contributed to aggregate convergence largely and continuously since 1990s. In addition, the within sector growth has played an important role in aggregate convergence since 2000. Furthermore, agricultural productivity growth has been a significant contributor to aggregate convergence since the late 1980s (Figure 6). Finally, due to the commodity price boom during the 2000s, the productivity in the mining sector had also contributed although its contribution subsequently

declined.

3.3.2 Robustness 2: Catch-up to the United States

Following [Bernard and Jones \(1996\)](#), another robustness check examines the accounting decomposition for each country relative to the United States. A measure of within and between-sector catch-up is computed by subtracting the productivity growth in the other countries for each sector as follows:

$$\frac{\Delta y_{other}}{y_{other}} - \frac{\Delta y_{us}}{y_{us}} = \sum_{j=1}^k (Within_{other,j} - Within_{US,j}) + \sum_{j=1}^k (Between_{other,j} - Between_{US,j}) \quad (7)$$

where the notations are the same as in equation (1).

Figure 7 shows the between sector effects in EMDEs and LICs have contributed to convergence largely since 1995 while that was not the case between 1975 to 1995. This finding is in line with the baseline. Figure 8 shows that both East Asia and Pacific (EAP) and South Asia (SAR) experienced both within- and between-sector catch-up whereas there has been divergence of the within sector effect in the Latin America and Caribbean (LAC), Middle East and North Africa (MENA) and Sub-Saharan Africa (SSA) regions before 2010. In those countries, the within sector effects in the manufacturing sector have not been converging to the U.S. ([Kinfe Michael and Morshed \(2019\)](#) and [Diao et al. \(2021\)](#)).

4 Conclusion

This paper investigates how the sector-specific source or the changing sectoral composition has contributed to aggregate productivity and convergence, constructing a new 8-sector database. The main findings are twofold. First, both within and sectoral reallocation have become important drivers of aggregate convergence in labor productivity. This reflects larger productivity improvements in many sectors in EMDEs (especially the LICs) compared to advanced economies as well the fact that many EMDEs experienced rapid sectoral shifts from agricultural sectors over the last few decades. Second, agricultural productivity growth has been a significant contributor to aggregate convergence. The strong growth of the agriculture sector has been the most important driver of aggregate productivity convergence even though agricultural productivity itself in LICs is weakly converging to advanced economies. Our result is in line with the literature that illustrates that the increase in

agricultural productivity has a larger poverty-reduction effect than increases in other sectors.

Although the potential productivity gains from sectoral reallocation have become more challenging to achieve, there would still be important payoffs from policies that supported diversification, including developing human capital, including at the tertiary level; promoting good governance and easing the cost of doing business; strengthening institutional capabilities; reducing distortions such as uncompetitive regulations and subsidies; supporting R&D; and promoting exports and developing stronger managerial capabilities. Removing barriers to migration can also help to facilitate structural transformation.¹¹ Given the low level of productivity in EMDE agricultural sectors and its role as the primary employer in LICs, policies to raise agricultural productivity would pay significant dividends. These policies would include improving infrastructure and land property rights.

Future research could investigate the endogeneity of sector allocation. As the shift-share decomposition is an accounting exercise, it should be noted that within sector growth could also directly affect sector reallocation. An improvement in agricultural productivity increases incomes and the demand for other goods, encouraging a shift of labor into other sectors (Eberhardt and Vollrath (2018), Gollin et al. (2007), and Diao et al. (2018)). It could result in facilitating between-sector productivity growth. Hence, the contribution of agricultural productivity could be larger and that of sectoral reallocation could be smaller.

¹¹ Artuc et al. (2015) show the estimated labor mobility costs caused by labor market frictions in EMDEs are a larger burden than those in advanced economies, using the data with eight major sectors. Bryan and Morten (2019), using Indonesia data show that reducing migration costs to the US level, a high-mobility benchmark, leads to a 7 percentage point increase in productivity growth. Empirically, regress the structural-term on employment rigidity index and raw materials' share in exports and so on and find that there is a statistically significant impact of the employment rigidity.

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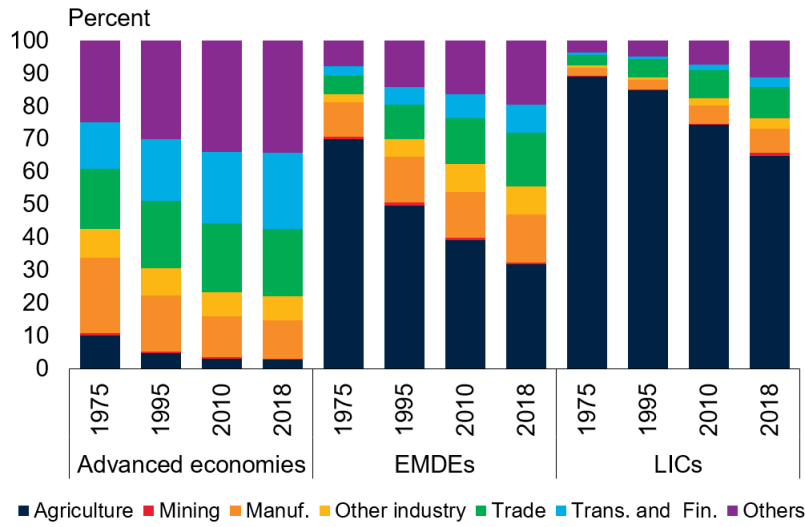
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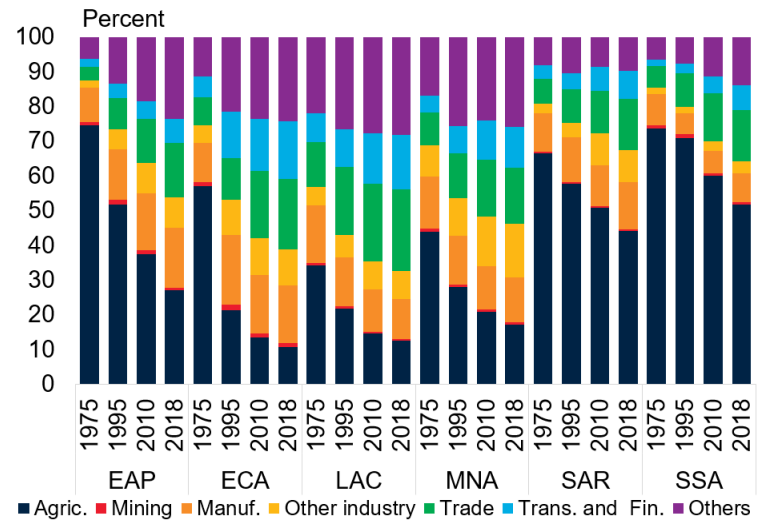
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Figure 1: Employment share

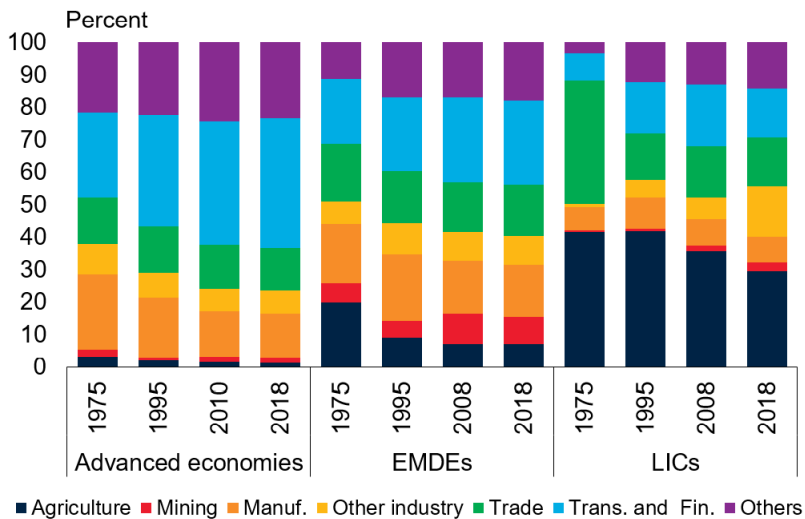
A. Composition of employment by sector



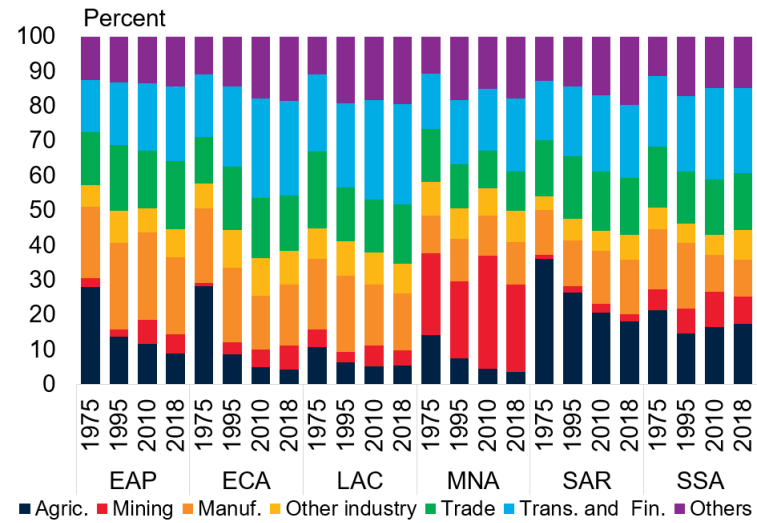
B. Composition of employment by sector (EMDEs Regions)



C. Composition of value-added by sector

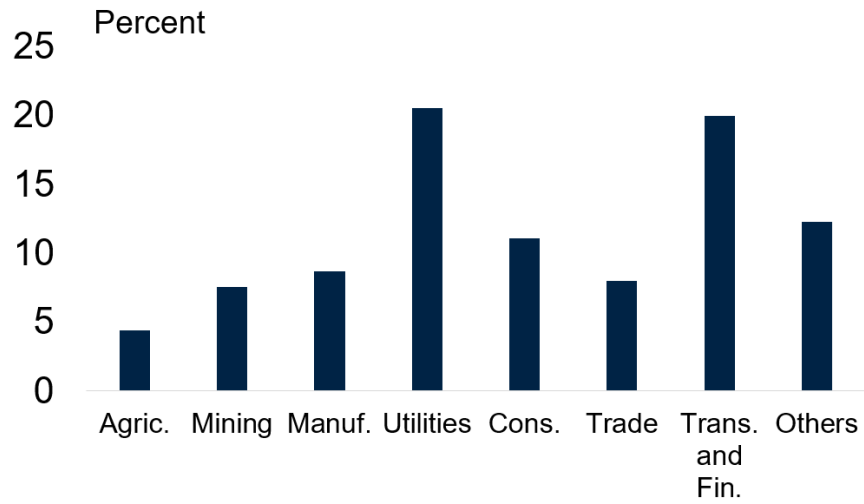


D. Composition of value-added by sector (EMDEs Regions)

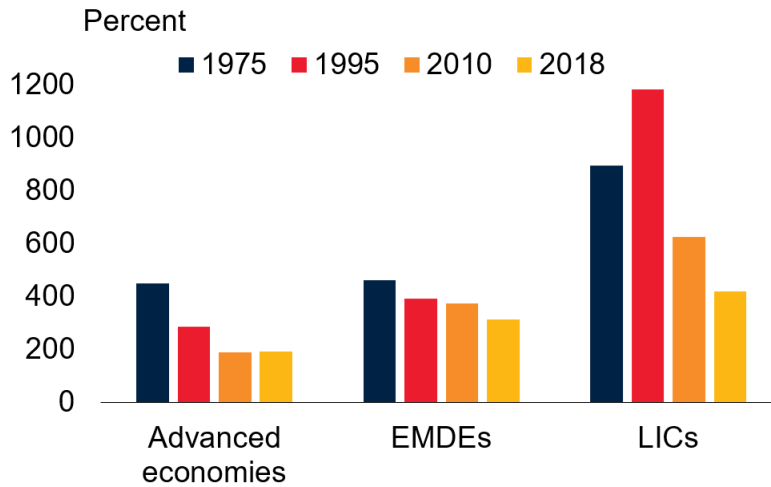


Notes: "Trans. and Fin." illustrate transport and finance services; "Other industry" includes utilities and construction; "Others" include government and personal services.

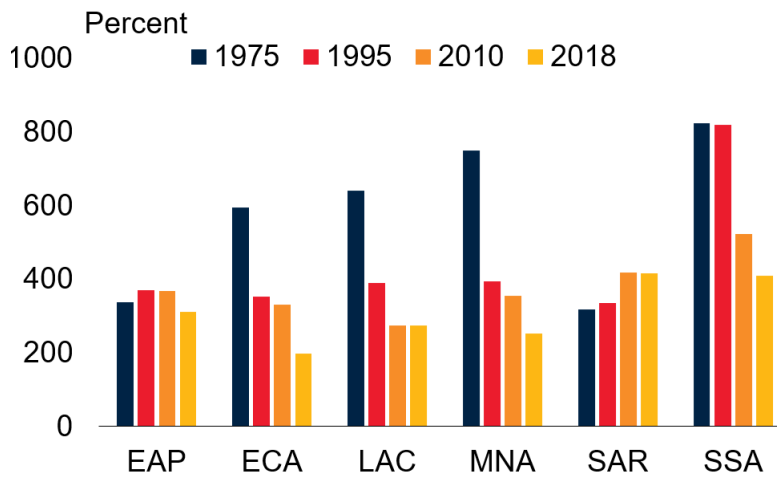
Figure 2: Sectoral gap across countries and within countries
 A. Sectoral productivity gap between advanced economies and LICs



B. Agricultural productivity gap

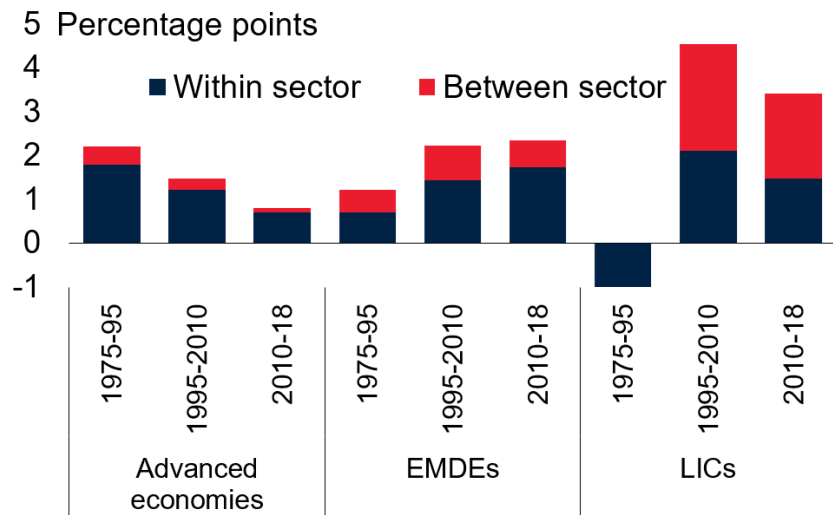


C. Agricultural productivity gap (EMDEs Regions)

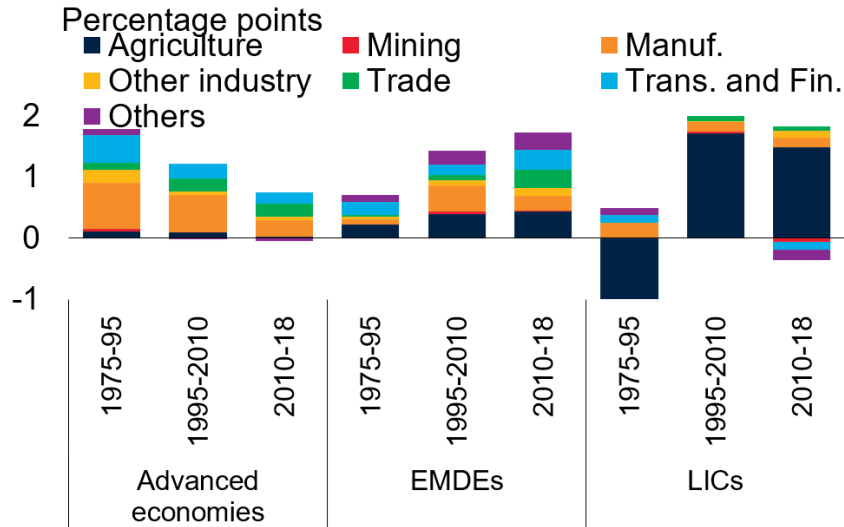


Notes: A. Sectoral gap is defined as the ratio of median of sectoral productivity in LICs to that in advanced economies. B.C Agricultural productivity gap is defined as the ratio of non-agricultural productivity to agricultural productivity. "Others" include government and personal services.

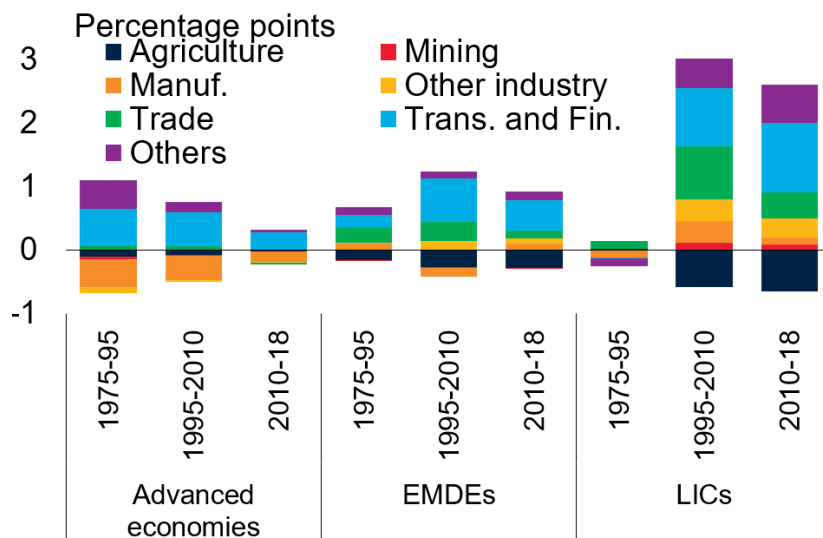
Figure 3: Within sector and between sector effects
 A. Within and between-sector contributions



B. Contributions of within-sector growth



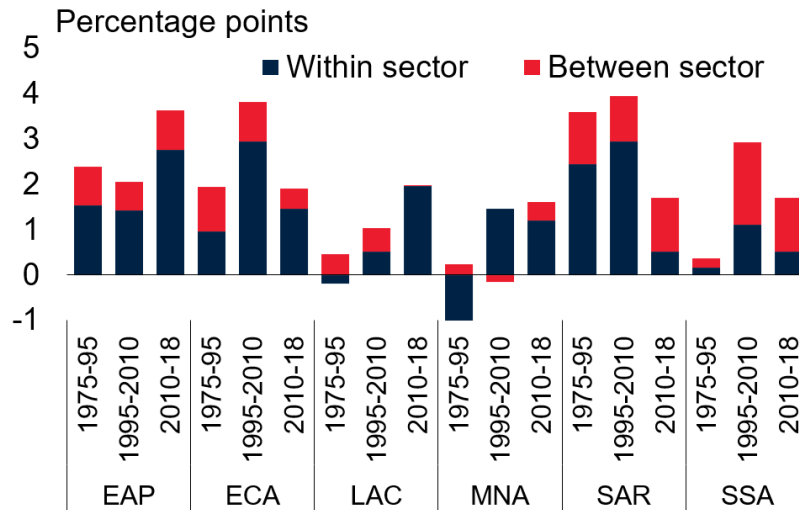
C. Contributions of between-sector growth



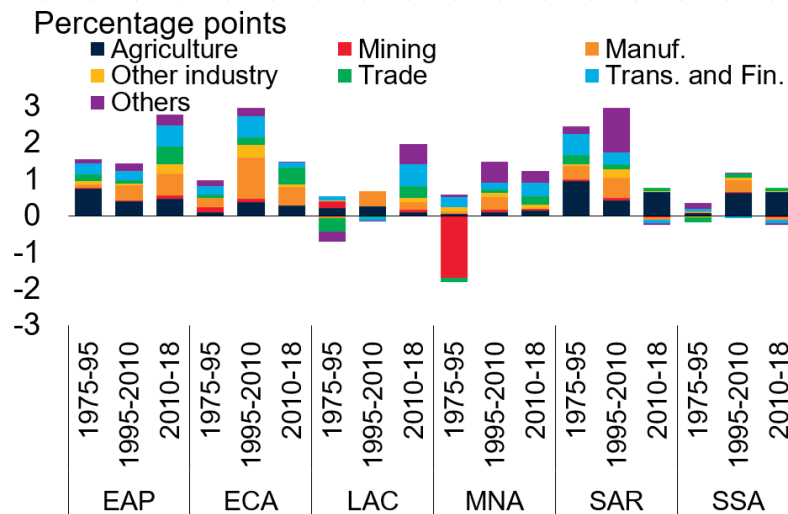
Notes: A.B.C. The decomposition is based on the equation(1). Median contribution to productivity growth. "Trans. and Fin." illustrate transport and finance services; "Other industry" includes utilities and construction; "Others" include government and personal services.

Figure 4: Within sector and between sector effects (EMDEs Regions)

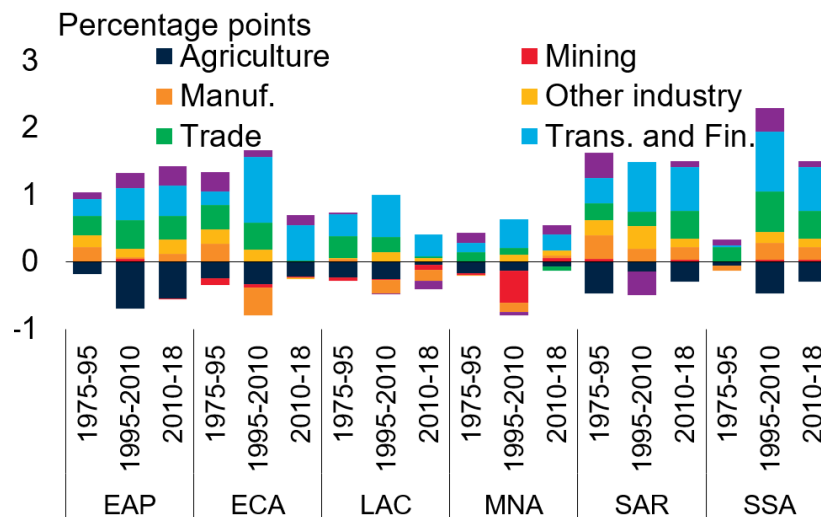
A. Within and between-sector contributions



B. Contributions of within-sector growth (EMDEs Regions)



C. Contributions of between-sector growth (EMDEs Regions)



Notes: A.B.C. The decomposition is based on the equation(1). Median contribution to productivity growth. "Trans. and Fin." illustrate transport and finance services;"Other industry" includes utilities, and construction; "Others" include government and personal services.

Table 1: Decomposition of aggregate convergence

| Sector | 1975-2018 | | 1975-1995 | | 1995-2018 | |
|---|----------------------------|-------|----------------------------|-------|---------------------------|-------|
| | β | R^2 | β | R^2 | β | R^2 |
| Aggregate | -0.00976** (0.00484) | 0.238 | -0.00289* (0.00155) | 0.088 | -0.00695*** (0.00234) | 0.266 |
| 1. Agriculture | -0.00255*** (0.000493) | 0.308 | -0.000874*** (0.000316) | 0.113 | -0.00181*** (0.000270) | 0.331 |
| 2. Mining | -0.000264 (0.000212) | 0.025 | -2.13e-05 (0.000304) | 0.000 | -0.000388 (0.000254) | 0.025 |
| 3. Manufacturing | -0.00122*** (0.000460) | 0.105 | -0.000231 (0.000223) | 0.018 | -0.000628* (0.000361) | 0.032 |
| 4. Utilities | -0.000138 (9.67e-05) | 0.033 | 1.34e-05 (4.18e-05) | 0.002 | -0.000162** (7.98e-05) | 0.043 |
| 5. Construction | -9.95e-06 (5.34e-05) | 0.001 | 2.63e-05 (8.02e-05) | 0.002 | -4.48e-05 (7.22e-05) | 0.004 |
| 6. Trade services | -0.000300** (0.000118) | 0.097 | -0.000174 (0.000149) | 0.022 | -0.000251 (0.000155) | 0.028 |
| 7. Transport and Finance services | -0.000633*** (0.000206) | 0.137 | -0.000142 (0.000203) | 0.008 | -0.000520** (0.000229) | 0.054 |
| 8. Other services | -0.000399* (0.000236) | 0.046 | -7.98e-05 (0.000156) | 0.004 | -0.000507** (0.000298) | 0.044 |
| Total within sectoral effect (1+2+3+4+5+6+7+8) | -0.00551*** (0.00139) | 0.207 | -0.00148 (0.000953) | 0.039 | -0.00431*** (0.000995) | 0.171 |
| Static sectoral effect | -0.00148 (0.00162) | 0.014 | -0.000516 (0.00207) | 0.001 | -0.00277** (0.00138) | 0.043 |
| Dynamic sectoral effect | -0.00276* (0.00155) | 0.050 | -0.000890 (0.00179) | 0.004 | 0.000134 (0.00115) | 0.000 |
| Observations | | 60 | | 60 | | 91 |

Notes: Regressions (2) and (3) are estimated. The standard errors are reported in parentheses. The constant terms are not reported. ***p<0.01, *p<0.05, *p<0.1

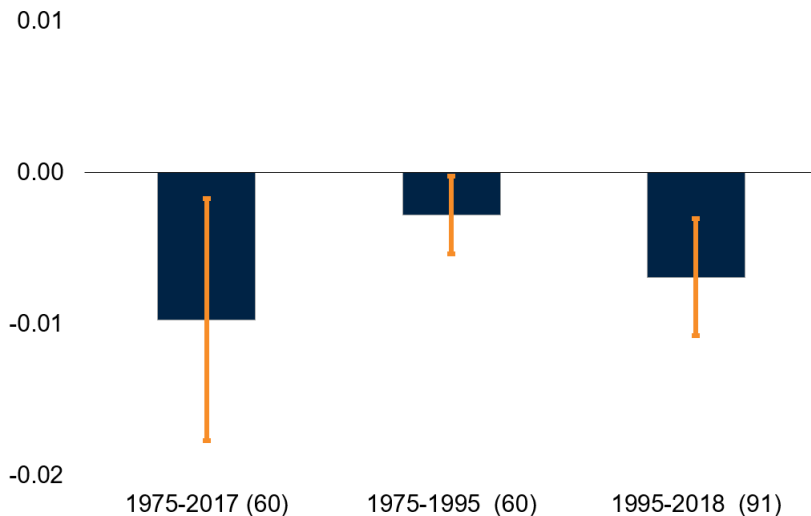
Table 2: Sector-specific convergence

| Sector | 1975-2018 | | 1975-1995 | | 1995-2018 | |
|-------------------------------|---------------------------|-------|--------------------------|-------|---------------------------|-------|
| | β | R^2 | β | R^2 | β | R^2 |
| Agriculture | -0.000588 (0.000621) | 0.015 | 0.000587 (0.000885) | 0.005 | -0.00127** (0.000623) | 0.022 |
| Mining | -0.00377** (0.00152) | 0.093 | -0.00272 (0.00165) | 0.027 | -0.00681*** (0.00220) | 0.123 |
| Manufacturing | -0.00244*** (0.000777) | 0.130 | -0.00175 (0.00106) | 0.038 | -0.00221*** (0.000829) | 0.054 |
| Utilities | -0.00300** (0.00132) | 0.087 | -0.00251* (0.00147) | 0.045 | -0.00463*** (0.00172) | 0.091 |
| Construction | -0.00172* (0.000982) | 0.070 | -0.00373* (0.00208) | 0.123 | 3.72e-05 (0.00113) | 0.000 |
| Trade services | -0.00226*** (0.000732) | 0.136 | -0.00253** (0.000976) | 0.077 | -0.00157* (0.000938) | 0.031 |
| Finance and business services | -0.00315*** (0.000776) | 0.246 | -0.00246** (0.00104) | 0.095 | -0.00309*** (0.000810) | 0.129 |
| Other services | -0.00154** (0.000741) | 0.096 | -0.000230 (0.000730) | 0.001 | -0.00293*** (0.00275) | 0.125 |
| Observations | | 60 | | 60 | | 91 |

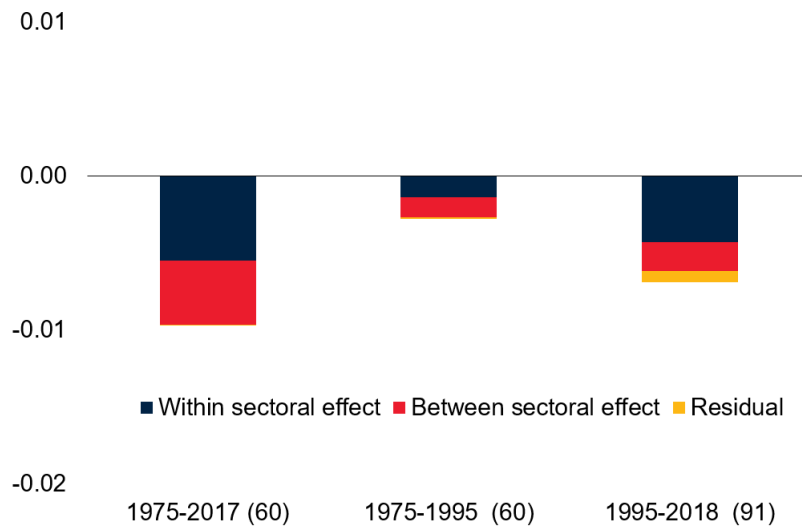
Notes: Regression (6) is estimated. The standard errors are reported in parentheses. The constant terms are not reported. ***p<0.01, *p<0.05, *p<0.1

Figure 5: Decomposition of aggregate convergence

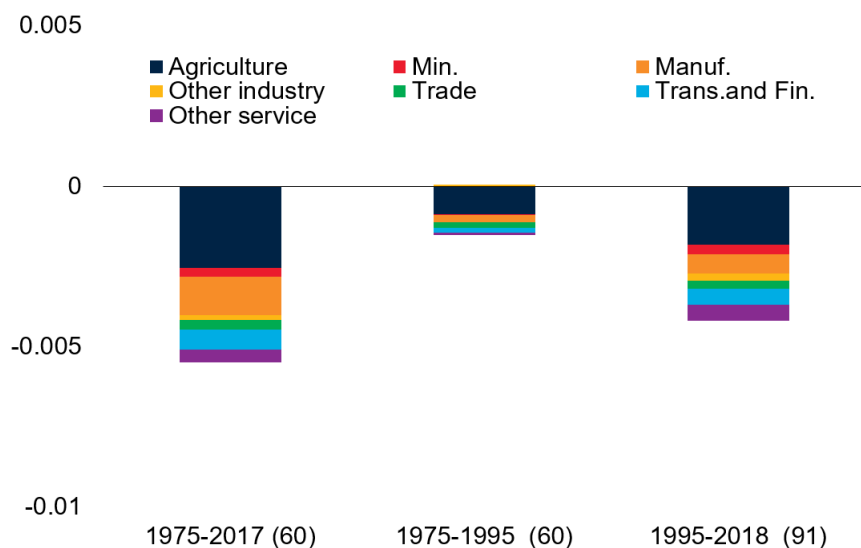
A. Aggregate convergence



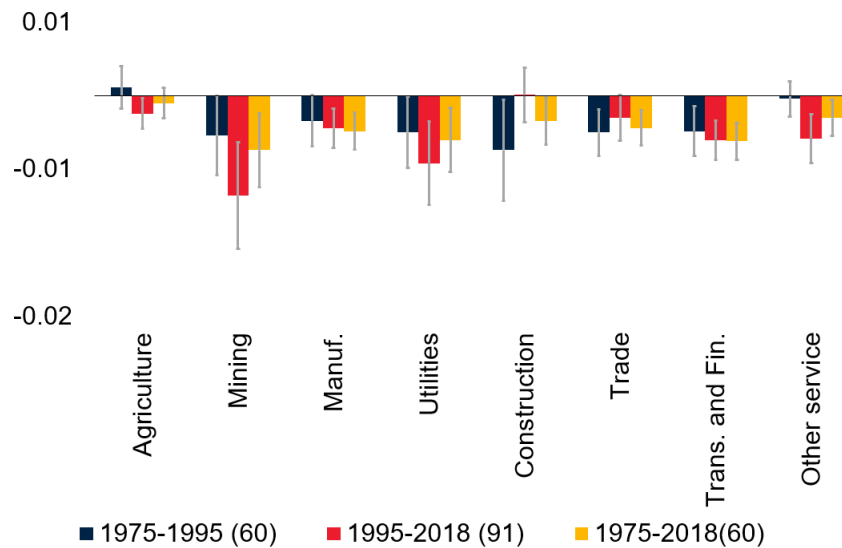
B. Decomposition of aggregate convergence



C. Contributions of sector-specific within effects on aggregate convergence

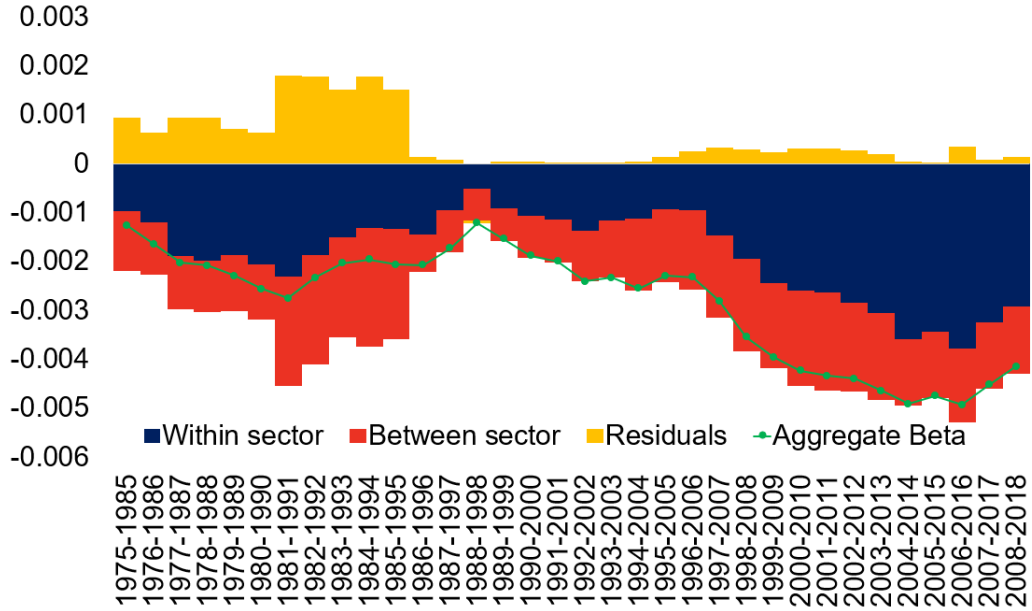


D. Sector-specific convergence

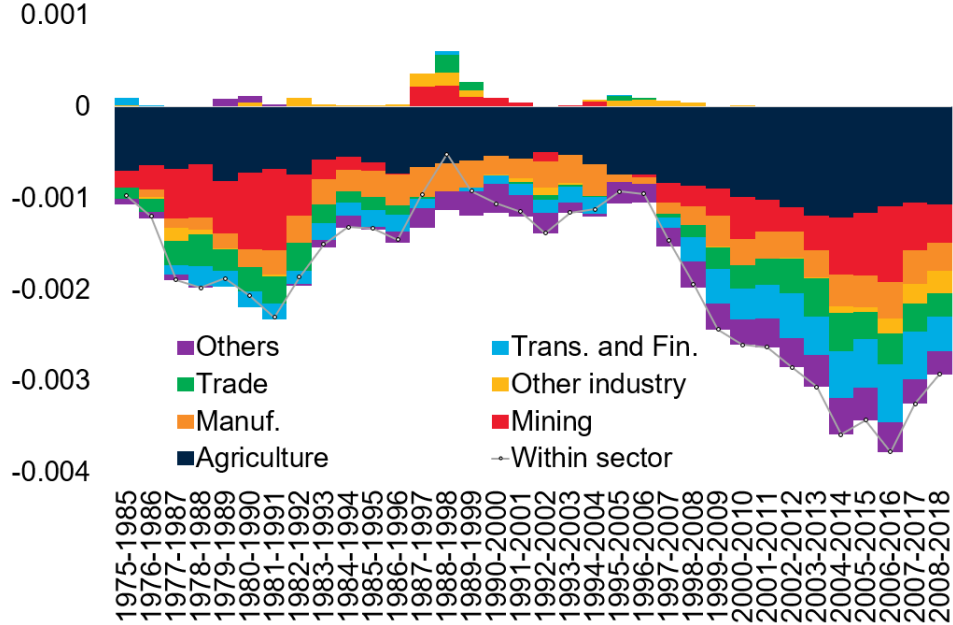


Notes: A. Cross-section regressions (2) are estimated with OLS. The sample size is reported in parentheses. Vertical lines denote 90 percent confidence intervals. B.C. The decomposition is based on the Cross-section regressions with OLS (3). "Trans. and Fin." illustrate transport and finance services; "Other industry" includes utilities, and construction; "Other service" include government and personal services. Residual is the difference between the aggregate beta and the sum of estimated between and within effects. D. Cross-section regressions (6) are estimated with OLS.

Figure 6: Robustness check 1: Time-varying contributions
 A. Decomposition of aggregate convergence

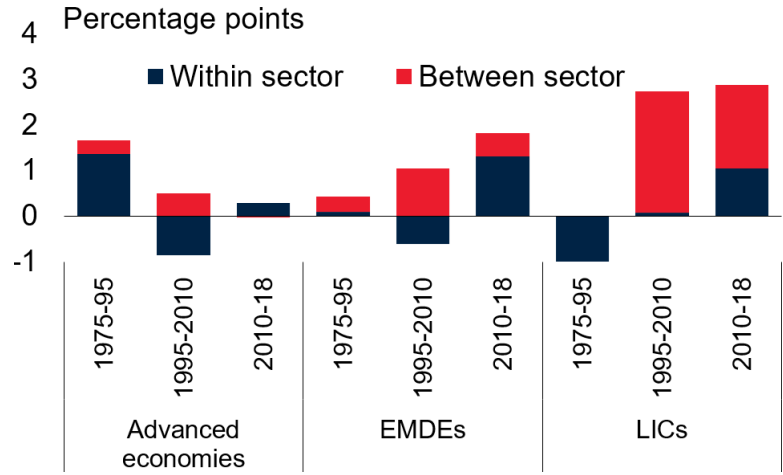


B. Contributions of sector-specific within effects on aggregate convergence

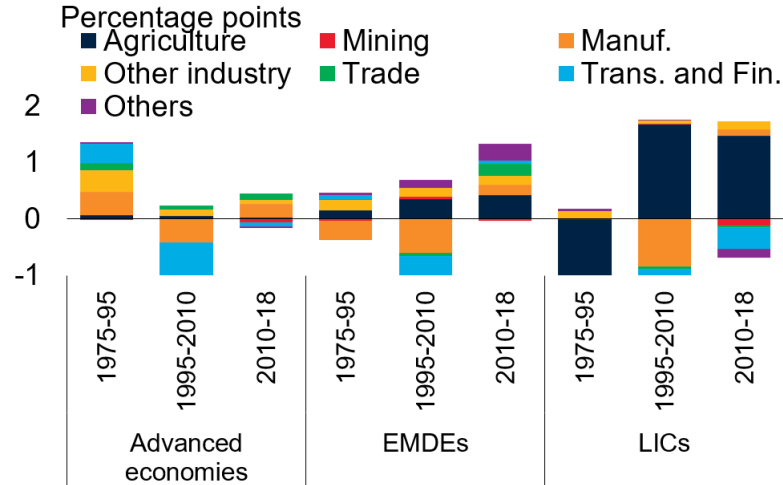


Notes: A. B. Cross-section regressions (2) and (3) are estimated with OLS over the 10-year rolling window. The sample size varies through overlapping windows. Residual is the difference between the aggregate beta and the sum of estimated between and within effects. B. "Trans. and Fin." illustrate transport and finance services; "Other industry" includes utilities and construction; "Others" include government and personal services.

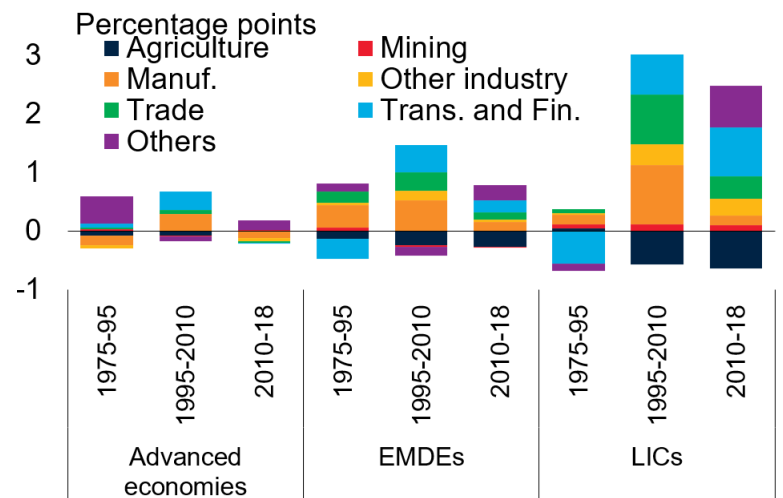
Figure 7: Robustness check 2: Catch-up to the United States
 A. Contributions of between-sector growth



B. Contributions of within-sector growth



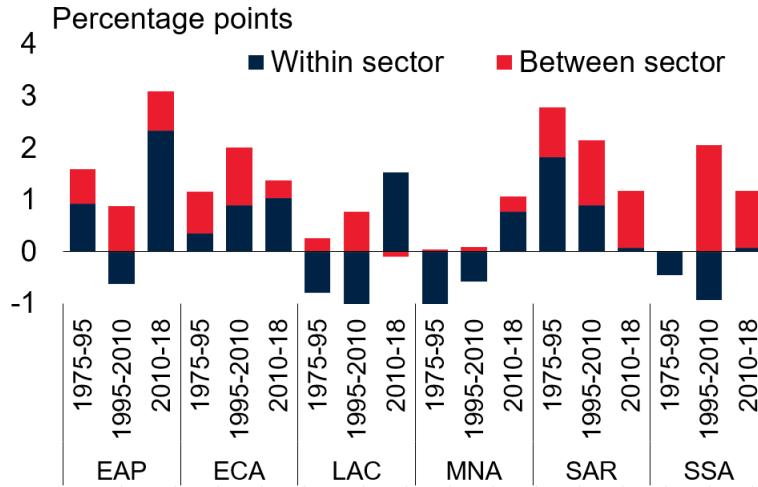
C. Contributions of between-sector growth



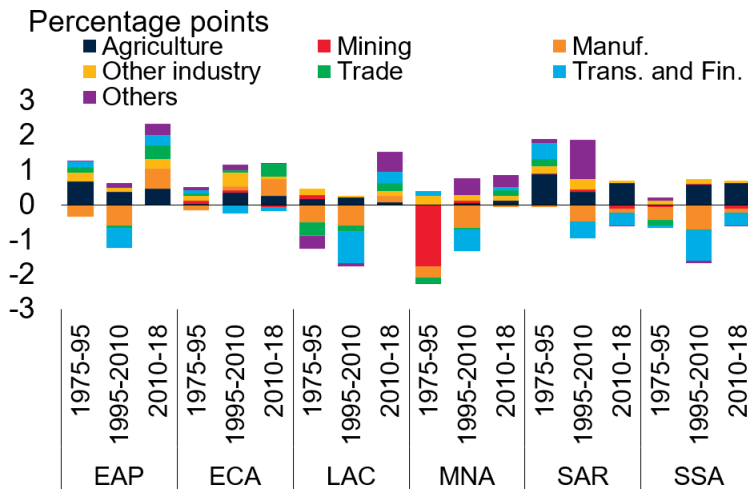
Notes: A.B.C. The decomposition is based on the equation(7). Median contribution to productivity growth. "Trans. and Fin." illustrate transport and finance services; "Other industry" includes utilities and construction; "Others" include government and personal services.

Figure 8: Robustness check 2: Catch-up to the United States (EMDEs Regions)

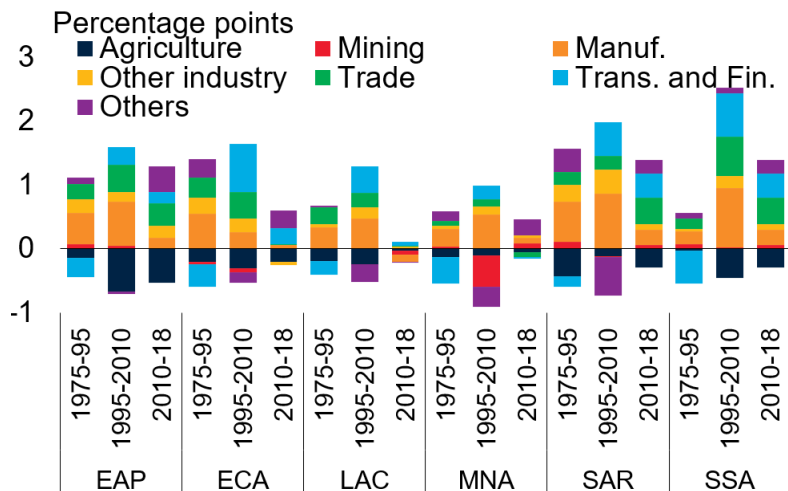
A. Contributions of between-sector growth



B. Contributions of within-sector growth



C. Contributions of between-sector growth



Notes: A.B.C. The decomposition is based on the equation (7). Median contribution to productivity growth. "Trans. and Fin." illustrate transport and finance services; "Other industry" includes utilities and construction; "Others" include government and personal services.

Appendix

Table A.1: Comparison with other studies using sectoral dataset

| | Period | Country coverage | Group coverage |
|------------------------|-----------|------------------|-----------------|
| This study | 1995-2018 | 91 | 31 AEs 60 EMDEs |
| | 1975-2018 | 60 | 17 AEs 43 EMDE |
| IMF (2018) | 2000-2010 | 62 | 19 AEs 43 EMDEs |
| McMillan et al. (2014) | 1990-2005 | 38 | 13 AEs 25 EMDEs |
| Diao et al. (2017) | 2000-2010 | 39 | 13 AEs 26 EMDEs |

Table A.2: Comparison with other studies decomposing convergence

| | Period | Country coverage | Group coverage |
|-----------------------------|-----------|------------------|-----------------|
| This study | 1995-2018 | 91 | 31 AEs 60 EMDEs |
| | 1975-2018 | 60 | 17 AEs 43 EMDEs |
| Wong (2006) | 1970-1990 | 13 | 13 AEs |
| Bernard and Jones (1996) | 1970-1987 | 14 | 14 AEs |
| Harchaoui and Üngör (2016) | 1970-2010 | 11 | 11 EMDEs |
| Caselli and Tenreyro (2005) | 1960-2000 | 27 | 22 AEs 5 EMDEs |

Notes: AEs=advanced economies, EMDEs=emerging markets and developing economies. LICs: low-income countries.

Table A.3: 8-sector categories

| Sector name | Description |
|---------------------------------------|---|
| 1.Agriculture | Agriculture, forestry and fishing |
| 2.Mining | Mining and quarrying |
| 3.Manufacturing | Manufacturing |
| 4.Utilities | Electricity, gas, steam and air conditioning supply |
| 5.Construction | Construction |
| 6.Trade services | Wholesale and retail trade; repair of motor vehicles and motorcycles; Accommodation and food service activities |
| 7.Transport and Financial services | Transportation and storage; Information and communication; Financial and insurance activities; Real estate activities; Professional, scientific and technical activities; Administrative and support service activities |
| 8.Other services | Public administration and defense; compulsory social security; Education; Human health and social work activities; Arts, entertainment and recreation; Other service activities; Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use; Activities of extraterritorial organizations and bodies |

Sources: APO; EASD; ETD; GGDC; KLEMS; OECD.

Table A.4: Sectoral database

| Country | Group1 | Group2 | Period | Source |
|--------------------|--------|--------|-----------|----------------------------------|
| Australia | AEs | AEs | 1975-2018 | APO |
| Austria | AEs | AEs | 1970-2018 | OECD STAN/KLEMS |
| Belgium | AEs | AEs | 1970-2018 | OECD STAN/KLEMS |
| Czech Republic | AEs | AEs | 1993-2018 | OECD National Accounts |
| Cyprus | AEs | AEs | 1995-2019 | OECD National Accounts/ILO |
| Denmark | AEs | AEs | 1970-2018 | OECD STAN |
| Estonia | AEs | AEs | 1995-2018 | OECD STAN |
| Finland | AEs | AEs | 1975-2018 | OECD STAN |
| France | AEs | AEs | 1970-2018 | OECD STAN/OECD National Accounts |
| Germany | AEs | AEs | 1970-2018 | OECD STAN/KLEMS |
| Greece | AEs | AEs | 1995-2019 | OECD National Accounts |
| Ireland | AEs | AEs | 1995-2019 | OECD National Accounts |
| Israel | AEs | AEs | 1990-2018 | ETD |
| Italy | AEs | AEs | 1970-2018 | OECD STAN/KLEMS |
| Japan | AEs | AEs | 1970-2018 | APO |
| Latvia | AEs | AEs | 1995-2018 | OECD STAN |
| Lithuania | AEs | AEs | 1995-2018 | OECD STAN |
| Luxembourg | AEs | AEs | 1970-2018 | OECD STAN/KLEMS |
| Netherlands | AEs | AEs | 1970-2018 | OECD STAN/KLEMS |
| New Zealand | AEs | AEs | 1989-2018 | OECD STAN |
| Norway | AEs | AEs | 1970-2018 | OECD STAN |
| Portugal | AEs | AEs | 1995-2018 | OECD STAN |
| Korea, Rep. | AEs | AEs | 1970-2018 | APO |
| Slovak Republic | AEs | AEs | 1995-2018 | OECD STAN |
| Slovenia | AEs | AEs | 1995-2018 | OECD STAN |
| Spain | AEs | AEs | 1970-2018 | OECD STAN/KLEMS |
| Sweden | AEs | AEs | 1970-2019 | OECD National Accounts |
| Switzerland | AEs | AEs | 1995-2018 | OECD STAN |
| Taiwan, China | AEs | AEs | 1970-2018 | APO |
| United Kingdom | AEs | AEs | 1970-2018 | OECD STAN/KLEMS |
| United States | AEs | AEs | 1970-2018 | OECD STAN/KLEMS |
| Cambodia | EMDEs | EAP | 1970-2018 | APO |
| China | EMDEs | EAP | 1970-2018 | APO |
| Fiji | EMDEs | EAP | 1970-2018 | APO |
| Indonesia | EMDEs | EAP | 1970-2018 | APO |
| Lao PDR | EMDEs | EAP | 1970-2018 | APO |
| Malaysia | EMDEs | EAP | 1970-2018 | APO |
| Mongolia | EMDEs | EAP | 1970-2018 | APO |
| Philippines | EMDEs | EAP | 1970-2018 | APO |
| Myanmar | EMDEs | EAP | 1970-2018 | APO |
| Thailand | EMDEs | EAP | 1970-2018 | APO |
| Vietnam | EMDEs | EAP | 1970-2018 | APO |
| Bulgaria | EMDEs | ECA | 1995-2019 | OECD National Accounts/ILO |
| Croatia | EMDEs | ECA | 1995-2019 | OECD National Accounts/ILO |
| Hungary | EMDEs | ECA | 1995-2018 | OECD STAN |
| Poland | EMDEs | ECA | 1995-2019 | OECD National Accounts |
| Romania | EMDEs | ECA | 1995-2018 | OECD National Accounts |
| Russian Federation | EMDEs | ECA | 1995-2018 | OECD National Accounts/KLEMS/ILO |
| Serbia | EMDEs | ECA | 1995-2018 | OECD National Accounts/ILO |
| Turkey | EMDEs | ECA | 1970-2018 | APO |

Table A.5: Sectoral database (continued)

| Country | Group1 | Group2 | period | Source |
|----------------------|--------------|--------|-----------|----------|
| Argentina | EMDEs | LAC | 1990-2018 | ETD |
| Bolivia | EMDEs | LAC | 1990-2018 | ETD |
| Brazil | EMDEs | LAC | 1990-2018 | ETD |
| Chile | EMDEs | LAC | 1951-2018 | GGDC/ETD |
| Colombia | EMDEs | LAC | 1950-2018 | GGDC/ETD |
| Costa Rica | EMDEs | LAC | 1950-2018 | GGDC/ETD |
| Ecuador | EMDEs | LAC | 1990-2018 | ETD |
| Mexico | EMDEs | LAC | 1950-2018 | GGDC/ETD |
| Peru | EMDEs | LAC | 1990-2018 | ETD |
| Bahrain | EMDEs | MNA | 1970-2018 | APO |
| Egypt, Arab Rep. | EMDEs | MNA | 1960-2018 | GGDC/ETD |
| Iran, Islamic Rep. | EMDEs | MNA | 1970-2018 | APO |
| Morocco | EMDEs | MNA | 1970-2018 | GGDC/ETD |
| Oman | EMDEs | MNA | 1991-2018 | APO |
| Qatar | EMDEs | MNA | 1986-2018 | APO |
| Saudi Arabia | EMDEs | MNA | 1991-2018 | APO |
| United Arab Emirates | EMDEs | MNA | 1970-2018 | APO |
| Tunisia | EMDEs | MNA | 1990-2018 | ETD |
| Bangladesh | EMDEs | SAR | 1970-2018 | APO |
| Bhutan | EMDEs | SAR | 1970-2018 | APO |
| India | EMDEs | SAR | 1970-2018 | APO |
| Nepal | EMDEs | SAR | 1970-2018 | APO |
| Pakistan | EMDEs | SAR | 1970-2018 | APO |
| Sri Lanka | EMDEs | SAR | 1970-2018 | APO |
| Cameroon | EMDEs | SSA | 1965-2018 | EASD/ETD |
| Ghana | EMDEs | SSA | 1960-2018 | EASD/ETD |
| Kenya | EMDEs | SSA | 1969-2018 | EASD/ETD |
| Lesotho | EMDEs | SSA | 1970-2018 | EASD/ETD |
| Mauritius | EMDEs | SSA | 1970-2018 | EASD/ETD |
| Namibia | EMDEs | SSA | 1965-2018 | EASD/ETD |
| Nigeria | EMDEs | SSA | 1960-2018 | EASD/ETD |
| Senegal | EMDEs | SSA | 1970-2018 | EASD/ETD |
| South Africa | EMDEs | SSA | 1960-2018 | EASD/ETD |
| Tanzania | EMDEs | SSA | 1960-2018 | EASD/ETD |
| Zambia | EMDEs | SSA | 1965-2018 | EASD/ETD |
| Burkina Faso | EMDEs (LICs) | SSA | 1970-2018 | EASD/ETD |
| Ethiopia | EMDEs (LICs) | SSA | 1961-2018 | EASD/ETD |
| Malawi | EMDEs (LICs) | SSA | 1966-2018 | EASD/ETD |
| Mozambique | EMDEs (LICs) | SSA | 1970-2018 | EASD/ETD |
| Rwanda | EMDEs (LICs) | SSA | 1970-2018 | EASD/ETD |
| Uganda | EMDEs (LICs) | SSA | 1990-2018 | ETD |

Notes: AEs: advanced economies. EMDEs: emerging markets and developing economies. LICs: low-income countries. EAP: East Asia and Pacific, ECA: European and Central Asia, LAC: Latin America and Caribbean, SAR: South Asia, MNA: Middle East and North Africa, SSA: Sub-Saharan Africa

Table A.6: Data construction from multiple sources

| Country | Description |
|--|--|
| 1 Austria, Belgium, Germany, Italy, Luxembourg, Netherlands, Spain, United Kingdom, United States | OECD STAN or National Accounts data is backwards extrapolated using annual growth rates from EU KLEMS. |
| 2 Chile, Colombia, Costa Rica Mexico, Arab Republic of Egypt, Morocco, Burkina Faso, Cameroon, Ghana, Ethiopia, Kenya, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Nigeria, Rwanda, Senegal, South Africa, Tanzania, Zambia | ETD data is backwards extrapolated using annual growth rates from GGDC or EASD. |
| 3 Cyprus, Bulgaria, Croatia, Serbia | As OECD Employment data is not available, ILO modelled estimates are supplementarily employed. |
| 4 France | OECD STAN data in 2018 is forwards extrapolated using annual growth rates from OECD national Accounts data. |
| 5 Russian Federation | OECD National Accounts data is backwards extrapolated using annual growth rates from KLEMS and ILO modelled estimates. |

Table A.7: Data sources

| Database | URL |
|---|---|
| APO Productivity Database | https://www.apo-tokyo.org/wedo/productivity-measurement/ |
| OECD STAN database and National Accounts | https://stats.oecd.org/ |
| WORLD KLEMS Data | http://www.worldklems.net/data.htm (Russia, March 2017 Release) |
| EU KLEMS Growth and Productivity Accounts | http://www.euklems.net/ (November 2009 Release) |
| GGDC/UNU-WIDER Economic Transformation Database (ETD) | https://www.rug.nl/ggdc/structuralchange/etd/ |
| GGDC 10-Sector database (GGDC) | https://www.rug.nl/ggdc/structuralchange/previous-sector-database/10-sector-2014 |
| Expanded Africa Sector Database (EASD) | https://www.merit.unu.edu/docs/EASD.xlsx |
| ILOSTAT databases | https://ilostat.ilo.org/data/bulk/ (ILO modelled estimates, Nov. 2020) |
| Penn World Table version 10.0 | https://www.rug.nl/ggdc/productivity/pwt/?lang=en |