Poland: Growth under scrutiny

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An example of successful economic transition, Poland still enjoys fairly favourable prospects despite the expected slowing of growth against a background of less favourable international conditions. Over the medium to long term, there are factors that will weigh on potential growth and weaken a Polish economic model based on competitiveness and low labour costs. The first section of this article analyses the impact of institutions on productivity, which is a major determinant of the differences in standard of living between countries, as illustrated through the example of Poland. The second section examines the question of Poland's estimated medium-term potential growth, after an analysis of its pathway since the 1990s.

Since the beginning of the 1990s, Poland has conducted a policy of economic liberalisation, which, combined with institutional reforms[1] and political stability, has generated uninterrupted economic growth since 1992, at an average annual rate of 4.2%. According to the World Bank's classification, Poland is an example of a successful transition from a low- to medium-income planned economy (USD 6,600 per capita in purchasing power parity terms, ranking 64th in the world according to the IMF, in 1992) to a market economy highly integrated within the European Union (EU) and global value chains and, since 2009, classified as high-income (USD 32,000 per capita in 2018, ranking 45th).

Per capita income in purchasing parity terms is now close to 70% of the EU-15 average, demonstrating the real convergence between Poland and its European partners. From a low level in the early 1990s, income inequalities expanded rapidly in the first phase of the transition, before narrowing slowly over the past fifteen years. Poland therefore seems to have avoided the 'middle income trap', in contrast with countries such as Argentina, Brazil, Mexico, Turkey and even Romania, which are still classified as "Upper middle income" economies.

In its first section, this article will analyse the link between institutions and productivity, using an efficient frontier model, drawing lessons for the particular case of Poland. The second section will present an analysis of Polish growth in supply terms from the beginning of its transition to a market economy, and will discuss the constraints on medium-term potential growth incorporating, in particular, the link between institutions and productivity.

Institutional quality: a key factor in productivity and growth

The breakdown of growth in supply terms often reveals differences in productivity that are more significant in explaining the differences in standards of living between countries than are the accumulation of factors of production (capital and labour). Empirical research examining the relationship between economic growth and the institutional environment shows that there is a strong link between the latter and productivity[2].

The quality and stability of institutions are key to the confidence of economic agents: encouraging private investment, making an economy more attractive to foreign investors, boosting entrepreneurship and innovation, optimising the allocation of resources and factors of production and thus, in the final analysis, supporting economic growth.

GDP growth

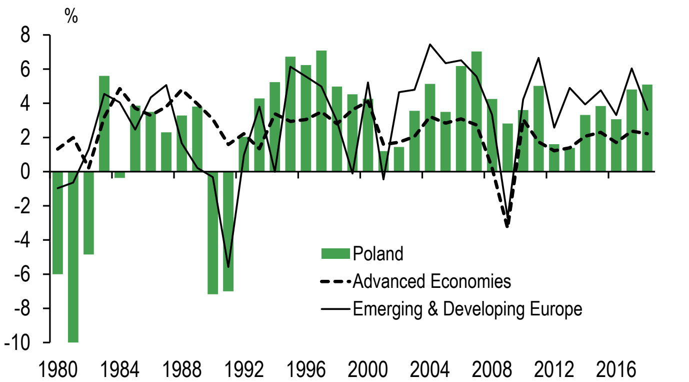

Chart 1 Source: IMF

Poland is relatively well placed in major international rankings of governance and the business environment: 33rd out of 190 countries in the World Bank's 2019 Ease of Doing Business listing; 37th of 135 countries in the WEF Global Competitiveness Index 4.0 2018 edition; 36th of 180 in Transparency International's perceived corruption index. However, despite the supervisory role of the EU, the World Bank's governance indicators and the 'Institutions' component of the WEF-GCI have deteriorated during the recent years.

[1] Adopting Tiffin's definition (2006), the notion of 'institutions' refers in general terms to the formal and informal constraints and incentives that structure the individual's capacity to act in a manner that is productive and cooperative. Typically, an institutional framework favourable to the market will be founded on the rule of law, respect for property rights, legally binding contracts, impartial and transparent government and so on.

[2] For example, Barro (1991), covering 98 countries from 1960 to 1985, showed a positive relationship between growth rates and political stability. Mauro (1995) concluded that the three indicators of corruption, red tape and political instability had a significant negative relationship with productivity and investment. Lastly, Sekkat and Méon (2004) showed that the quality of institutions (tackling corruption and the effectiveness of government) favoured foreign direct investment (FDI).

GDP per capita in purchasing power parity terms (US$)

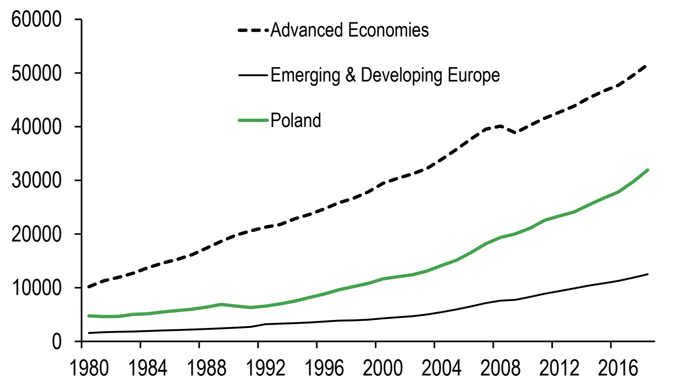

Chart 2 Source: IMF

Ease of Doing Business Indicators

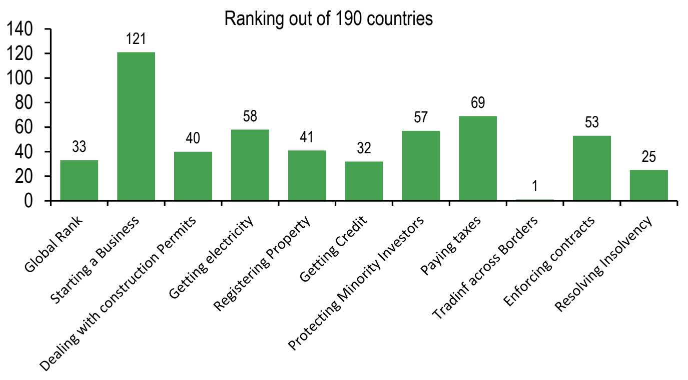

Chart 5 Source: World Bank

GDP per capita (% of EU-15 average)

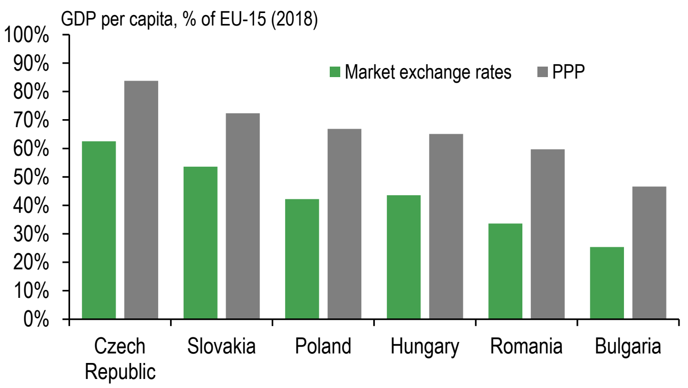

Chart 3 Source: European Commision, BNP Paribas

Real wages and productivity

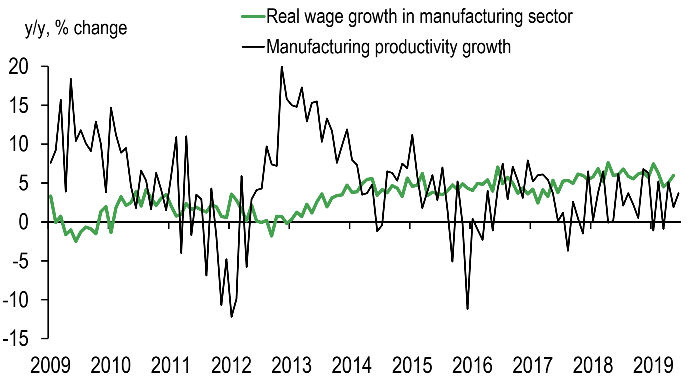

Chart 6 Source: GUS

Governance indicators

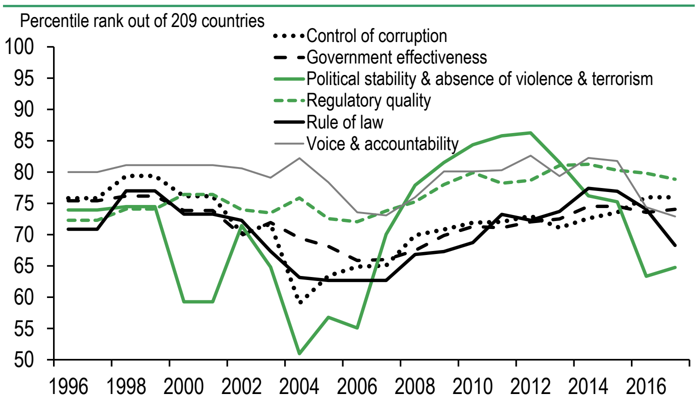

Chart 4 Source : World Bank

The efficiency frontier

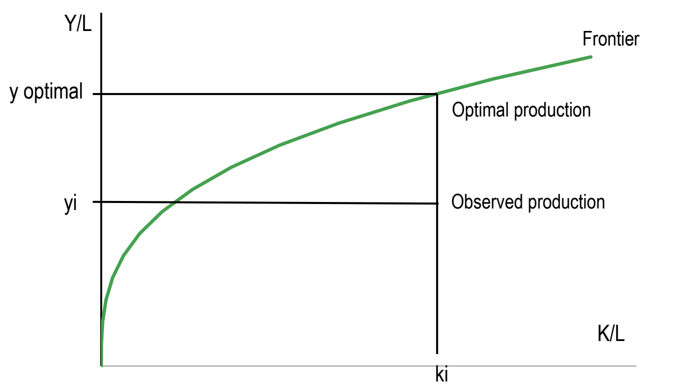

Chart 7 Source: BNP Paribas

Stochastic frontier analysis (SFA)

The stochastic frontier model was introduced by Aigner et al (1977) and Meeusen and Van Den Broeck (1977). Battese and Coelli (1995) used this type of model with panel data, in which inefficiency is expressed as a function of explanatory variables. The SFA approach was used by Adkins et al (2002) to measure the link between the quality of institutions and efficiency.

The idea of SFA is to add to the standard regression model including a random component v, a component of technical inefficiency u, also random.

Standard model: $y = f(x, \beta) + v$
Stochastic model: $y = f(x, \beta) + v - u$

For panel data, the level of production for a country i at date t can be expressed as:

$$y_{i,t} = f(x_{i,t}, \beta) exp(v_{i,t}) * exp(-u_{i,t}) \quad (1)$$

For a Cobb-Douglas log-linear function, (1) can be expressed as:

$$ln(Y/L)_{i,t} = \beta_0 + \beta_k ln(K/L)_{i,t} + \beta_t Trend + v_{i,t} - u_{i,t} \quad (2)$$

with Y/L, K/L respectively representing output per worker and capital per worker. $Trend$ denotes technical progress.

$v_{i,t}$ is a random variable which is assumed to be independently and identically distributed $N(0, \sigma_v^2)$.
$u_{i,t}$ denotes the technical inefficiency of production, a non-negative random variable distributed independently of $v_{i,t}$; $u_{i,t}$ is assumed to be independently distributed as truncation at zero of the normal distribution with mean $m_i = \delta\, z_{i,t}$ z and variance σ_u^2.

Technical inefficiency is specified as:

$$u_{i,t} = \delta z_{i,t} + \delta OG_{i,t} + w_{i,t} \quad (3)$$

Where $z_{i,t}$ is the principal component of governance indicators. δ is the vector of its estimated parameter, which we expect to have a negative sign. $OG_{i,t}$ is the output gap which allows to control cyclical variations. $w_{i,t}$ is a residual term

We define technical efficiency (TE) as:

$$TE_{i,t} = \frac{y_{i,t}\ observed}{y_{i,t}\ optimal} = \frac{f(x_{i,t}, \beta) exp(v) * \exp(-u_{i,t})}{f(x_{i,t}, \beta) exp(v_{i,t})} = exp(-\delta z_{i,t} - \delta OG_{i,t} - w_{i,t})$$

The conditional expectation of $TE_{i,t}$ is given in equation (9) (see Appendix) which can be used to estimate the level of technical efficiency for each country i at date t. $TE_{i,t}$ is between 0 and 1, where 1 indicates a fully efficient country.

To estimate parameters ($\beta, \delta, \gamma, \sigma_u^2$ and σ_v^2) for equations (2) and (3), we use the maximum likelihood estimator (see Appendix). The likelihood function is expressed as a function of the total error ($\sigma^2 = \sigma_u^2 + \sigma_v^2$), and the share of the variance in technical inefficiency $U_{i,t}$ in total variance, or $\gamma = \sigma_u^2/\sigma^2$ with $0< \gamma <1$. The closer γ is to 1, the more the deviations around the frontier are attributed to the inefficiency variable.

The model uses a panel of 51 countries over the 1996 to 2017. GDP (Y), the capital stock (K), the labour (L) and the output gap are provided from the Penn World Table, WEO and AMECO base ; the governance indicators, which constitute the principal component, are provided from the World Bank and have been published since 1996 (political stability, government effectiveness, regulatory quality, rule of law and control of corruption).

The results of our model's estimates are presented in the table 1. The coefficients of the production equation are broadly in line with expectations, with the elasticity of production per capita equal to 0.67 and trend of 2% per year of technical progress. The coefficients of the inefficiency equation are significant, and their signs are as expected. A negative value indicates that an improvement in the institutional variables used is associated with a reduction in inefficiency. The significance of the gamma value (γ) indicates that governance indicators are an important determinant of the production function and the stochastic specification is appropriate. γ being very close to 1 in all the equations, we can conclude that it has a substantial explanatory power for the inefficiency variables of deviations around the efficient frontier.

Estimated stochastic production frontier (SFA)

	Estimate	Std.Error	Pr(>|z|)
Frontier			
(Intercept)	10.34	0.058	< 2.2e-16 ***
Log (K/L)	0.67	0.045	< 2.2e-16 ***
Trend	0.02	0.001	< 2.2e-16 ***
Inefficiency			
(Intercept)	0.37	0.046	1.638e-15 ***
PCA	-0.86	0.039	< 2.2e-16 ***
OG	0.01	0.006	0.396722
gamma (γ)	0.86	0.017	< 2.2e-16 ***

PCA: principal component of governance indicators
**** significant at 5%*

Table 1 Source : BNP Paribas

Conceptual framework: efficient frontiers

Our goal here is to examine the impact of institutional quality, for which the World Bank indicators are considered as the best proxy, on the productivity of nations, and in particular Poland.

Productivity differences between countries are theoretically explained by two factors: technology and technical efficiency. Technology is defined here as all the knowledge available to local producers. This concept is broader than the technologies actually used and can vary substantially from one country to the next, particularly in the context of the Cold War and the countries in transition during the 1990s. Efficiency corresponds to the technical relationship that allows maximal output for a given level of factors of production, independently of demand and prices. According to Tiffin (2006), the rapid dissemination of techniques and knowledge around the world limits the explanatory power of technology for the productivity differences between rich and poor countries. Under this hypothesis, which has become increasingly less restrictive since the collapse of the Soviet bloc and the acceleration of globalisation, analysis of technical efficiency has come to play a central role.

To measure technical efficiency by country and its relationship to the quality of institutions, we have adopted a stochastic frontier analysis (see box). This econometric technique is particularly well suited to situations where economic agents act sub-optimally. It is applied to a standard production function, enhanced by a technical efficiency term plus a trend which traditionally reflects total factor productivity (TFP)[3]. Chart 7 represents the notion of an efficient frontier, which indicates the optimal production level for each combination of capital and labour production factors. Observed production is then expressed as optimal production multiplied by a technical efficiency rate (TE) of between 0 (completely inefficient) and 1 (completely efficient).

The technical efficiency of the Polish economy has improved thanks to its institutions, but the trend has a ceiling

The results of the model's estimates for a panel of 51 developed and emerging economies over the period from 1996 to 2017 (see Box) show that an improvement in the institutional variables used (i.e. the World Bank's five governance indicators) is associated with a reduction in inefficiency and thus reduce the distance from the efficient frontier. Chart 10 illustrates the strong positive relationship between the quality of institutions and efficiency.

[3] The breakdown of growth in terms of supply based on the standard analysis of the production function draws on the Solow model (1956). It provides an estimate of the contributions to growth from the factors of production (capital and labour) and the development of total factor productivity (TFP or the "Solow residual"). TFP is an unobserved variable. It is defined as the technical progress resulting from the degree of efficiency in the allocation and combination of factors of production, the quality of infrastructure and human capital, and R&D investment (this investment is, in part at least, included in the stock of capital), to which the institutional framework and business environment make significant contributions.

Production frontier (2017)

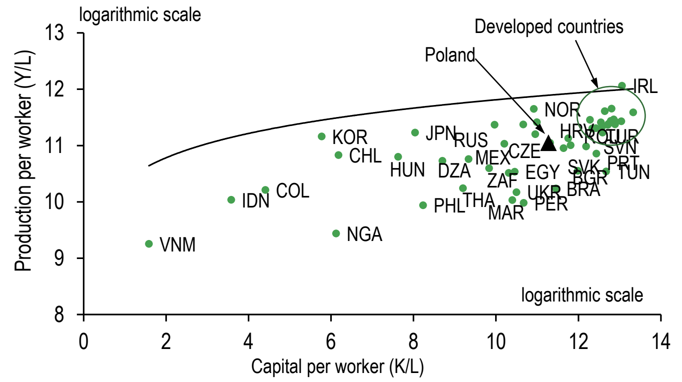

Chart 8 Source: Penn World Table, World Bank, BNP Paribas calculations

Country transitions 1996-2017

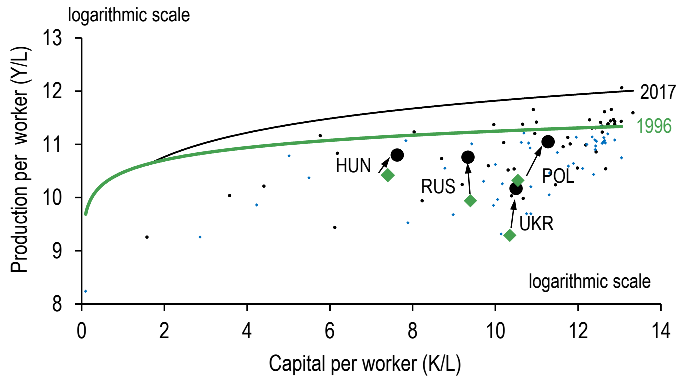

Chart 9 Source: Penn World Table, World Bank, BNP Paribas calculations

Governance and technical efficiency indicators

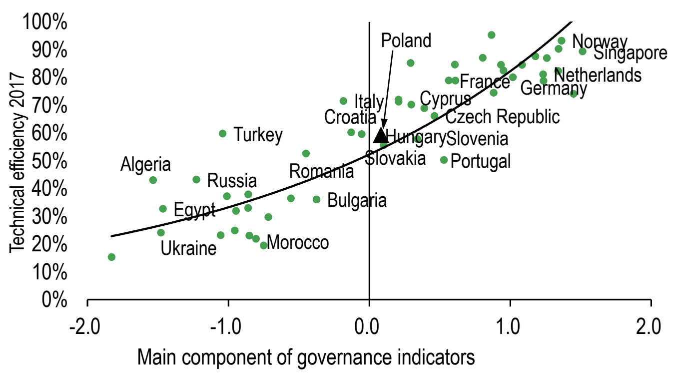

Chart 10 Source: Penn World Table, World Bank, BNP Paribas calculations

According to our estimates (see Box) the average technical efficiency rate (TE) of the eight economies of Central and Eastern Europe in our sample increased from 45% to 50% between 1996 and 2017. Over the same period, the average TE for the whole of our panel of countries remained stable, at around 62%, and that of the reference group of developed economies stayed above 80%. The countries in transition are a very mixed group. From 1996, the Czech Republic and Hungary had TEs of 69% and 68%. These have been falling in recent years, particularly in Hungary (from 65% in 2014 to 60% in 2017). Conversely, Ukraine stands out for its very low, albeit rising, TE of 24% in 2017, from 17% in 1996.

Efficiency estimates (TE)

	1996	2017	Average 1996-2017
United States	92%	87%	
Germany	86%	80%	84%
France	84%	79%	83%
United Kingdom	85%	74%	
Spain	80%	72%	76%
Italy	87%	72%	79%
Czech Republic	69%	66%	65%
World (51 countries)	**61%**	**61%**	**62%**
Hungary	68%	60%	67%
Poland	**50%**	**59%**	**55%**
Slovenia	67%	58%	63%
Slovakia	54%	56%	57%
Romania	26%	53%	36%
Portugal	60%	50%	59%
Russia	31%	43%	39%
Bulgaria	26%	36%	32%
Ukraine	17%	24%	21%

Table 2 Source: BNP Paribas calculations

Estimated technical efficiency rates for Poland

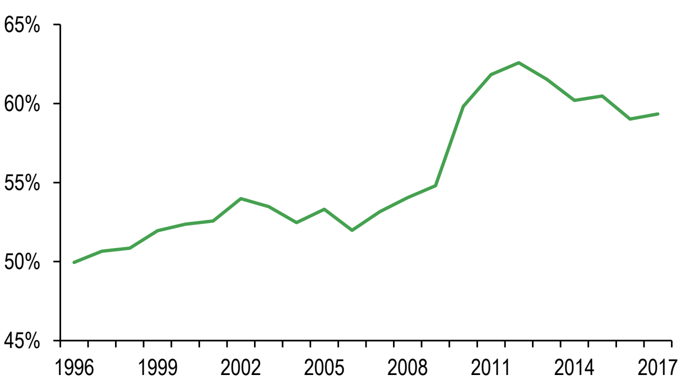

Chart 11 Source: BNP Paribas calculations

For Poland, the picture is positive for both the level and trend in its TE. From around 50% in 1996, the TE has reached 59% in 2017 though it has decreased from its peak of 63% in 2012. Chart 9 shows the progress made by the country which moved towards the efficient frontier between 1996 and 2017.

These results bear out the following stylised facts. Unproductive activity, the production of goods not matched to demand, under-use of resources and poor allocation of factors between sectors were all sources of inefficiency in planned economies. Economic openness and the introduction of institutions compatible with the operation of a market economy have contributed to the improvement in technical efficiency in countries in transition since the 1990s. According Schiffbauer and Varela, *"the progressive integration into the EU bloc boosted growth and productivity because of three key factors: (i) increased openness to trade, investment and talent, (ii) increased domestic competition, and regulatory harmonization with the EU, and (iii) increased certainty in reforms, through a commitment to EU institutions."*

However, our estimates seem to suggest that the technical efficiency rate for Poland and its central and eastern European neighbours is capped at around 60%. The ability of these countries to catch up with the reference group of the most advanced economies is now a major challenge for the next decades.

Breakdown of growth since the economic transition and potential GDP

We set out here the results of our breakdown of growth into factors of production (capital and labour) and changes in total factor productivity (TFP) between 1996 and 2018[4]. We then use this classical analysis framework to estimate potential Polish growth through to 2025.

"Perspiration" from the accumulation of capital and "inspiration" from technical progress

Between 1996 and 2018, 61% of growth came from the accumulation of capital and 34% from TFP, the remainder coming from an increase in the labour factor. These results are broadly in line with those of Schiffbauer and Varela (2019) for the period from 2000 to 2014.

To borrow Paul Krugman's phrase, the "perspiration" behind growth, the accumulation of factors of production, came almost exclusively from physical capital. Alongside private domestic and foreign investment, public investment benefited from European co-financing, particularly in infrastructure projects, as Poland has been the leading recipient of European structural funds. Meanwhile, the "inspiration", a reflection of technical progress, also made a substantial contribution to growth, driven in particularly by improvements in the institutional framework, business environment and human capital.

[4] To estimate TFP we have used a standard Cobb-Douglas function:
$$Y_t = A_t K_t^{\alpha} L_t^{(1-\alpha)}$$
Based on this equation, and under certain conditions (constant returns to scale, perfect competition), GDP growth can be broken down as follows:
$$\frac{\Delta Y}{Y} = \frac{\Delta A}{A} + \alpha \frac{\Delta K}{K} + (1-\alpha)\frac{\Delta L}{L}$$
Where Y represents real GDP, A total factor productivity, K the stock of physical capital calculated using the perpetual inventory method and L the workforce adjusted to reflect the quality of human capital based on the average number of years of education. The coefficient α , the share of capital in production, is normalised at 0.3.

Breakdown of growth and potential GDP

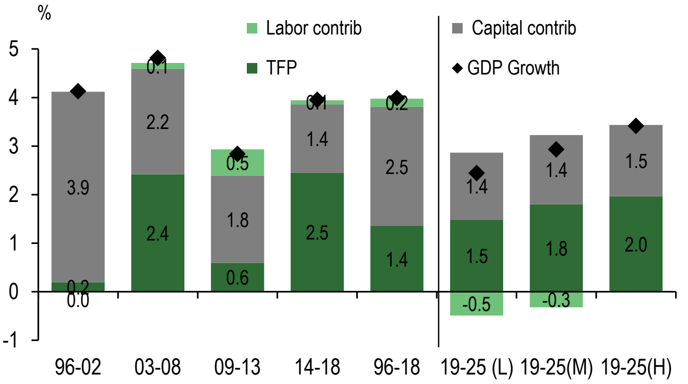

Chart 12 Source: AMECO, World Bank,BNP Paribas

At the same time, demographic constraints have limited growth in the active population and employment: the fertility rate has fallen (1.4 children per woman in 2018, from 2 in 1990), the migratory balance is structurally negative, the natural balance (births less deaths) has been negative since 2013, the population is ageing (17% were aged over 65 in 2018, from 9% in 1990) and the activity rate is below the European average (70% compared to 74% in the EU in 2018 according to Eurostat), particularly amongst women.

In the absence of any significant increase in the quantity of labour, its quality has improved through better standards of education and skills in the labour force that has accompanied the increasing sophistication of production and exports. The share of the active population (aged 15 to 64) educated to degree level or above rose from 10% in 1997 to 27% in 2018 (Eurostat figures), bringing it close to the EU average of 29%.

According to the IMF (Selected Issues, February 2019), an analysis of TFP carried out with data from business suggests that the manufacturing sector made a substantial contribution to the increase in TFP between 2005 and 2016. The retail and construction sectors also made positive contributions to growth in TFP. Meanwhile the productivity trend was negative in the mining and utilities sectors. At the same time, companies with foreign capital and/or exporters performed better than domestic public and private companies, with significantly bigger gains in productivity. Lastly, large companies appear more productive but less dynamic, resulting in a narrowing of the productivity gap as a function of company size over the period considered.

Splitting this period into four sub-periods allows us to flesh out the details of the composition of Polish growth over the economic cycle:
In the initial transitional phase (1996 to 2002), the increase in capital was fundamental, contributing 95% to Polish GDP growth that averaged 4.1%, despite the world economy seeing a cyclical low in 2001 to 2002.

From 2003 to 2008, a period that brought strong growth in the global economy and the formal admission of Poland to the EU (1 May 2004), Polish GDP growth peaked at 4.8% per year. The accumulation of capital remained rapid, albeit slower than in the previous period. The key point of note in this period, however, was the acceleration in growth in TFP, which contributed half of total economic growth.

Between 2009 and 2013,Polish growth slowed significantly (to 2.8% per year), largely due to weaker growth in TFP. According to the IMF, the slowing of TFP growth reflected a slowing of technical progress that began shortly before the international financial crisis against a background of diminishing effects from previous structural reforms, the slowing of innovation at the "technological frontier", along with, perhaps, the ageing of the population.

Lastly, between 2014 and 2018, Poland at first saw GDP growth in line with its long-term average of 4%, followed by stronger growth, of 5% in 2017 and 2018. The slower rate of capital accumulation, whose contribution to growth has slowly fallen from 3.9 points per year between 1996 and 2002 to 1.4 points between 2014 and 2018, was offset by a fresh acceleration in growth of TFP. Over this most recent period, efficiency gains thus returned to their level of contribution to growth seen before the crisis, estimated at 2.5 points per year.

Impediments to potential growth

Over and above the downturn in the global economy, there are some structural factors that will hold back Poland's potential growth over the medium to long term. With a central scenario[5] estimating potential growth of 2.9% through to 2025, we have a low-range estimate of 2.4% and a high-range figure of 3.4% (Chart 12). Even in the most favourable scenario, growth will be below the trend line of the last three decades. This said, even in the most pessimistic scenario, growth remains compatible with the already advanced stage of the country's socio-economic development.

Inherited from the period of economic transition, Poland's economic model of competitiveness and low labour costs is undermined by a zloty, which is considered overvalued by many local industries and the generous social and redistributive policies introduced by the government. The PiS party, which has been in power since 2015, put a huge increase in the minimum wage at the heart of its manifesto for the parliamentary election that it won in mid-October.

Demographic projections

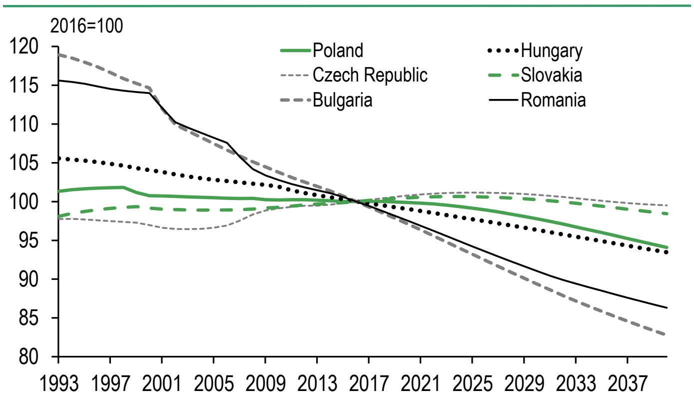

Chart 13 Source: United Nations

Faced with the slow demographic decline seen over the past two decades, the situation of full employment has resulted in labour shortages limiting production capacity, notably in construction and

[5] Our scenarios are based on different investment rate assumptions between 2019 and 2025. The average annual growth rate investment in central, high and low scenarios respectively equal to 4.6%, 5.1% and 4.1%.

industry. To date, the use of foreign workers, notably from Ukraine, has limited the increase in unit labour costs and inflationary pressures thanks to the fall in NAWRU (the non-accelerating wage rate of unemployment). But faced with competition from the rest of Europe, and particularly Germany, in attracting qualified workers, labour shortages must be met with innovation and automation for Poland to make productivity gains and move its products up the value chain.

The main factor differentiating between our three scenarios is the demographic constraint. Demographic projections (Chart 13) established by the Polish Office of Statistics, Eurostat, the United Nations and the US Census Bureau agree on an acceleration of the decline in the Polish population, evident since 2014, over the next few decades (-0.3% per year between now and 2030). Despite family policy measures (family benefits, childcare, etc.) and scope for increases in the activity rate (notably amongst women), against a background of pressure on the labour market, only massive recourse to immigration can help avoid the possibility of the labour factor making a negative contribution to economic growth between now and 2025.

Research and development expenditure

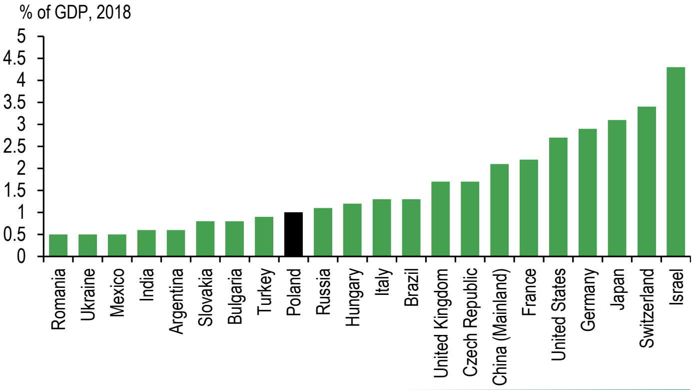

Chart 14 Source: Cornell/INSEAD/WIPO

Moreover, there are cyclical and structural factors arguing for a slowing of investment and thus the accumulation of capital over the short and medium term. The rates of growth in GFCF seen over the past two years are not sustainable given the expected downturn in the cycle (private investment in machine tools and construction) and the expected reduction in payments from European structural funds for 2021-27 (public investment).

Lastly, the quality of the business environment has deteriorated somewhat over recent years. The improvement in the institutional framework, the improvement in human capital, the quest for productivity gains through innovation (Chart 14) and the shift up-market of Polish products will be essential to underpin economic growth in Poland over the medium and long term.

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Poland's macroeconomic performance since its transition from communism in the early 1990s has been remarkable. The reform of its institutions and stability of its politics have come alongside the opening up of its economy. Strong and relatively stable economic growth has allowed it to converge towards the socio-economic standards of advanced economies. After its re-election in the parliamentary vote of 13 October 2019, the government promised prosperity for all. But the structural drags on growth could complicate the efforts that Poland still needs to make if it is to catch up with the income levels of other EU countries.

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Appendix

Estimating efficiency[6]

Consider the following stochastic frontier model:

$$f(x,\beta)+v-u \quad (1)$$

$$\varepsilon = v-u \quad (2)$$

$$v \sim N(0,\sigma_v^2). \quad (3)$$

$$u \sim N^{+}(z\delta,\sigma_u^2) \quad (4)$$

Technical efficiency is specified as:

$$TE = exp(-u) \quad (5)$$

To estimate technical efficiency, we will estimate the conditional expectation $[exp(-u)|\varepsilon]$.

The density function for *u* is truncated at zero of normal distribution:

$$f_u(u) = \left[\sqrt{2\pi\sigma_u}\,\Phi\left(\frac{z\delta}{\sigma_u}\right)\right]^{-1} exp\left[-\frac{(u-z\delta)^2}{2\sigma_u{}^2}\right], u \geq 0 \quad (6)$$

$\Phi(.)$ denote the standard normal distribution function

u and v are random variables of independent distributions, we can be written the joint density function for $\boldsymbol{\varepsilon}$ and u as follows[7]:

$$f_{\varepsilon,u}(\varepsilon,u) = \left[2\pi\sigma_u\sigma_v\,\Phi\left(\frac{z\delta}{\sigma_u}\right)\right]^{-1} exp\left[-\frac{(u-u^*)^2}{2\sigma^{*2}} + \frac{(\varepsilon+z\delta)^2}{\sigma_u{}^2+\sigma_v{}^2}\right] \qquad u \geq 0 \quad (7)$$

where

$$u^* = \frac{\sigma_v{}^2 z\delta - \sigma_u{}^2\varepsilon}{\sigma_v{}^2+\sigma_u{}^2} = (1-\gamma)z\delta - \gamma\varepsilon \;\text{ and }\; \sigma^{*2} = \frac{\sigma_v{}^2\sigma_u{}^2}{\sigma_v{}^2+\sigma_u{}^2} = \gamma(1-\gamma)\sigma^2 \quad (8)$$

$$\sigma^2 = \sigma_v{}^2 + \sigma_u{}^2 \;\text{ and }\; \gamma = \sigma_u^2/\sigma^2 \quad (9)$$

To estimate technical efficiency for each country i at date t, we use the parameter estimates of the equation (8):

$$TE = E[exp(-u)|\varepsilon] = exp(-u^* + \frac{\sigma^{*2}}{2})\left[\Phi\left(\frac{u^*}{\sigma^*} - \sigma^*\right)\right]\left[\Phi\left(\frac{u^*}{\sigma^*}\right)\right]^{-1} \quad (9)$$

[6] Battes & Coelli (1995)), *A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Model for Panel Data*, Empirical Economics

References

Aigner D., Lovell K. and Schmidt P. (1977), *Formulation and Estimation of Stochastic Frontier Production Function Models*, Journal of Econometrics, 6, pp. 21-37

Barro R. J. (1991), *Economic Growth in a Cross Section of Countries*, The Quarterly Journal of Economics, Oxford University Press, vol. 106(2), pages 407-443

Battese G. (1992), *Frontier Production Functions and Technical Efficiency: A Survey of Empirical Applications in Agricultural Economics*, Agricultural Economics, 7, pp. 185-208

Battese G. and Coelli T. (1995), *A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Model for Panel Data*, Empirical Economics, 20, pp. 325 332

Coelli T. (1991), *Maximum Likelihood Estimation of Stochastic Frontier Production Functions with Time Varying Technical Efficiency Using the Computer Program FRONTIER Version 2.0*, Department of Economics, University of New England, Armidale, Australia

Coelli T. (1995), *Estimators and Hypothesis Tests for a Stochastic Frontier Function: A Monte Carlo Analysis*, Journal of Productivity Analysis

Coelli T., Rao P. and Battese G. (1998*), An Introduction to Efficiency and Productivity Analysis*, Kluwer Academic Publishers, Boston

Greene W. (2005b), *The Econometric Approach to Efficiency Measurement*, in K. Lovell, H. Fried and S. Schmidt, eds., The Measurement of Productive Efficiency, 2nd ed., Oxford, Oxford University Press, forthcoming

Greene W. and Misra S. (2003), *Simulated Maximum Likelihood Estimation of General Stochastic Frontier Regressions*, Working Paper, William Simon School of Business, University of Rochester

IMF Selected issues on Republic of Poland (2019), IMF Country Report n° 19/38, February 2019

Kalirajan K. and Obwona M. (1994), *Frontier Production Function: The Stochastic Coefficients Approach*, Oxford Bulletin of Economics and Statistics, forthcoming

Kalirajan K. and Shand R. (1999), *Frontier Production Functions and Technical Efficiency Measures*, Journal of Economic Surveys, 13, pp. 149-172

Kumbhakar S. (1991a), *Estimation of Technical Inefficiency in Panel Data Models with Firm- and Time Specific Effects*, Economics Letters, 36, pp. 43-48

Lovell K. (1993), *Production Frontiers and Productive Efficiency*, in The Measurement of Productive Efficiency, H. Fried, K. Lovell, and S. Schmidt, eds., Oxford University Press

Lovell K. and Sickles R. (1983), *Testing Efficiency Hypotheses in Joint Production: A Parametric Approach*, Review of Economics and Statistics, 65, pp. 51-58

Mauro P. (1995), *Corruption and Growth*, Quarterly Journal of Economics, 110, 681-712

Meeusen W. and Van Den Broeck J. (1977), *Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error*, International Economic Review, 18, pp. 435-444

Méon P.-G., Sekkat K. (2004), *Does the quality of institutions limit the MENA's integration in the world economy?,* World Economy 27 (9), 1475-1498

OECD Economic Surveys Poland (2018), March 2018

Schiffbauer M., Varela G. (2019), *Macro and micro features of successful economic convergence: the case of Poland,* The World Bank Group, MTI discussion paper, n° 11. January 2019

The World Bank Group (2017), Lessons from Poland, *Insights for Poland: a sustainable and inclusive transition to high-income status*

The World Bank Group (2018), *Poland structural policies for competitiveness*, position paper, regulatory policy, November 2018

Tiffin A. (2006), *Ukraine: the cost of weak institutions*, IMF Working Paper WP/06/167

Turk R. (2015), *Financial decisions and investment outcomes in developing countries: the role of institutions*, IMF Working Paper WP/15/38

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