CONJONCTURE

The cryptocurrency economy

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Depending on the source, estimates of the number of 'cryptocurrencies' vary between 1,600 and 3,000. These crypto-assets struggle to fulfil the three economic functions of money, and so cannot be considered as such. Although their fairly modest uptake currently limits their economic impact, increased use could create risks in the transmission of monetary policy, money creation and financial stability. Several central banks are looking at the introduction of a 'central bank digital currency' (CBDC) in response to these challenges. However, far from being simply a substitute for private cryptocurrencies, these CBDCs would carry specific risks in terms of financial stability, most notably that of a 'digital bank run'. We believe that their possible introduction, and the associated details, will require meticulous analysis.

Laurent Quignon

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.

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Eco
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ECONOMIC RESEARCH DEPARTMENT

BNP PARIBAS

The bank for a changing world

The cryptocurrency economy

Laurent Quignon

Depending on the source, estimates of the number of 'cryptocurrencies' vary between 1,600 and 3,000. These crypto-assets struggle to fulfil the three economic functions of money, and so cannot be considered as such. Although their fairly modest uptake currently limits their economic impact, increased use could create risks in the transmission of monetary policy, money creation and financial stability. Several central banks are looking at the introduction of a 'central bank digital currency' (CBDC) in response to these challenges. However, far from being simply a substitute for private cryptocurrencies, these CBDCs would carry specific risks in terms of financial stability, most notably that of a 'digital bank run'. We believe that their possible introduction, and the associated details, will require meticulous analysis.

'Cryptocurrencies' or, less commonly but more accurately, crypto-assets are, for the time being at least, not as widely used as their media coverage might suggest. As a result, for most of us our view of them is dominated by a perception of their high level of technological sophistication and remains fairly vague. Although some professionals and fans of new technologies are very enthusiastic, an economist examining the topic might be more circumspect.

These contrasting positions led us to draw up an initial taxonomy in an attempt to define what they are and, more importantly, what they are not (genuine currencies). This economic definition serves as a preamble to a section on the state of the science. This is still relatively sketchy, but pathways can be drawn with the debate opened up by Friedrich August von Hayek's arguments for competing currencies at the end of the 1970s.

Our thought process then leads us naturally on towards 'central bank digital currencies'. Often presented by central banks themselves as substitutes for private 'cryptocurrencies', in reality there are significant differences in terms of the consequences they could have for the financing of the economy and for financial stability. By virtue of their similarities with 'narrow banking' or the Swiss 'sovereign money' proposals (convincingly rejected by Swiss voters in 2018), 'central bank digital currencies' could change the money creation process as we know it today and affect the cost and volume of financing. They would also create the risk of a run on 'digital' banks. Their possible adoption, and their characteristics when adopted, will need to be carefully considered in order to reduce these risks.

Are 'cryptocurrencies' currencies at all? (no)

Three shared characteristics allow us to define 'cryptocurrencies'. Two criteria are universal, the virtual nature and the cryptographic technique of these assets, whilst one – decentralisation – is common but optional. The first stage is to develop a taxonomy of 'private' crypto-assets, according to their main characteristics, and consider the extent to which they are currencies.

Shared characteristics

The origins of 'cryptocurrencies' date back to the aftermath of the financial crisis of 2008[1]. They were initially supported by an upswelling of libertarian current, in turn underpinned by a desire to enable the settlement of transactions in a way that avoided commercial, and to a lesser extent, central banks. They were also encouraged by a desire to avoid major established currencies like the dollar and euro. In such circumstances, it is natural that the main innovation of the original 'cryptocurrencies' lies in the removal of the trusted third party, a role hitherto played by commercial banks for transactions denominated in official currencies, and the option of conducting direct 'peer-to-peer' transactions.

'Cryptocurrencies' are virtual

'Cryptocurrencies' are first and foremost virtual, with no material reality. Unlike other forms of digital money (electronic money in digital wallets, script money in bank accounts), they are not regulated.

Use of cryptography

Decentralisation is a common, but not systematic, feature of 'cryptocurrencies'. Whilst real currencies are managed centrally by a central bank, each participant (associated to a 'node', in reference, among other things, to a computer on a network) can offer or approve transactions in a distributed ledger (see Diagram 1). In the absence of a trusted third party (financial intermediary or bank), the security of transactions is provided by cryptography, that is to say by encryption algorithms.

For example, the Bitcoin cryptocurrency, which has been in existence since 2009, has so far proved itself extremely resistant to attacks and falsification. The whole community of developers has succeeded, thanks to the blockchain, in collectively ensuring the security of transactions. The procedure of validating and authenticating transactions is known as 'mining'. This involves making computer

[1] Nakamoto S. (2008), *Bitcoin: A Peer-to-Peer Electronic Cash System*, November 1st.

processing power available to the network to solve complex mathematical problems. Blocks of transactions are recorded in a public distributed ledger (which can be read by all members of the network) listing all Bitcoin transactions since this digital currency was launched.

The use of cryptography seeks to secure transactions made over the internet by allowing access to information only to members of the distributed ledger (including new entrants). In most cases ‘cryptocurrencies’ operate as a distributed register from which all the information is simultaneously accessible to all the participants. Transactions are thus validated by ‘consensus’.

Some networks are known as ‘permissioned’ which is to say that access to networks is limited to authorised members, who have been pre-designated or who meet certain criteria. Almost all ‘cryptocurrencies’ are based on blockchain technology (see Box).

The dynamic of the amount of currency issued is determined by protocols that vary from one cryptocurrency to another. Thus, in the case of Bitcoin, the flow of new issuance (through mining) is halved every four years, with a ceiling on issuance capped at 21 million units, a limit that is set to be reached in 2140.

The blockchain

Blockchain is a secure information storage and transmission technology that operates without any central control structure. It is secured by encryption. It also refers to a database containing the complete history of all transactions conducted by users since its creation. This database is secured and distributed: it is shared between users, without intermediary, which allows each user to assess the validity of the chain.

Some blockchains are public, open to all, whilst others are private or ‘permissioned’ with access limited to a certain number of users.

Imagine a community each of whose members owns a magic notebook. As soon as anyone writes in one notebook, the writing will appear immediately in all the others. Moreover, the ink used is indelible. As a result, all the magic notebooks will contain exactly identical texts. Any individual attempt to change an entry in the notebook will be detected immediately, making it impossible to achieve.

The first blockchain emerged in 2008. It represents the underlying architecture of the Bitcoin crypto-asset. Its inventor has not revealed his or her identity, going by the pseudonym Satoshi Nakamoto.

The operation of the blockchain

Any public blockchain operates by definition through the use of coins or programmable tokens.

Transactions between users of the network are grouped into blocks. Each block is validated by nodes on the network, known as ‘miners’, using techniques that vary from one blockchain to the next. In the bitcoin blockchain, the technique used is known as ‘Proof-of-Work’, and requires complex algorithmic problems to be solved. Payment for this service (in the form of Bitcoins) provides an incentive for miners to compete to solve the algorithmic problems. Only the first to solve the problem receives payment, and the simultaneous deployment of computing resources by competing miners is energy-intensive.

Once a block has been validated it is time stamped and added to the blockchain.

As the software is open source, many crypto-assets are based on the blockchain model. The blockchain may however be used for a much wider range of applications than ‘currencies’, as it is a protocol that allows secure direct transfer of information (for instance traceability of food, gemstones or luxury goods (to protect against counterfeiting), or energy trading networks involving producers and consumers).

The blockchain

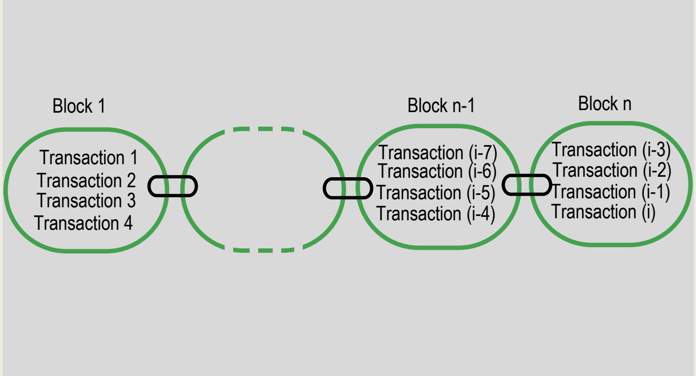

Diagram 1 Source: BNP Paribas

Example of a payment transaction in the blockchain

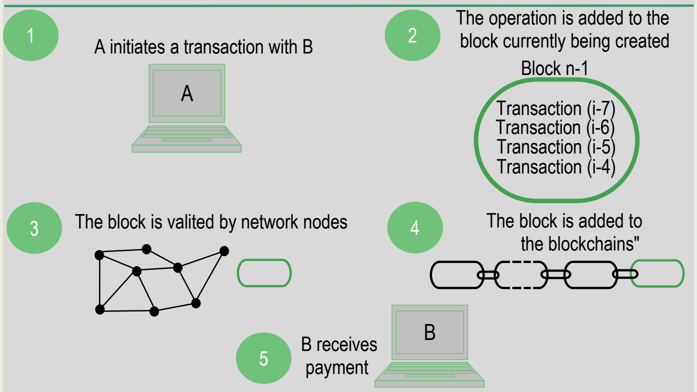

Diagram 2 Source: BNP Paribas

Distributed and centralised registers

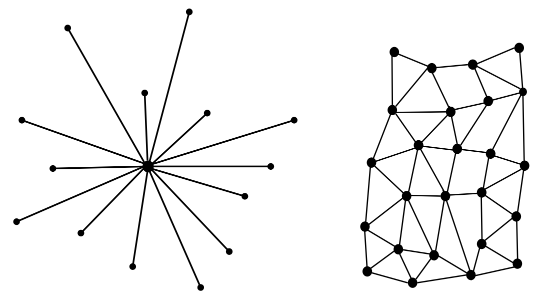

Diagram 3

Source: Landau J.-P. (2018) Cryptocurrencies Ministry of Economics and Finance Report, 4July

Taxonomy of crypto-assets

As demonstrated by the collapse in the value of Bitcoin after the peak reached in December 2017 (see Chart 1), the highly volatile nature of the early crypto-assets crystallised the criticisms that crypto-assets are unable to function as a 'store of value' and to offer a low-risk asset to its users. The puzzlement of authorities and central banks led to the development of characteristics of a new generation of crypto-assets, which have received a somewhat warmer welcome: stablecoins. These digital assets are typically backed by a basket of stable assets (Libra) or a guarantee of convertibility (JPM coin), giving them an intrinsic value.

Prices of top 6 crypto-assets

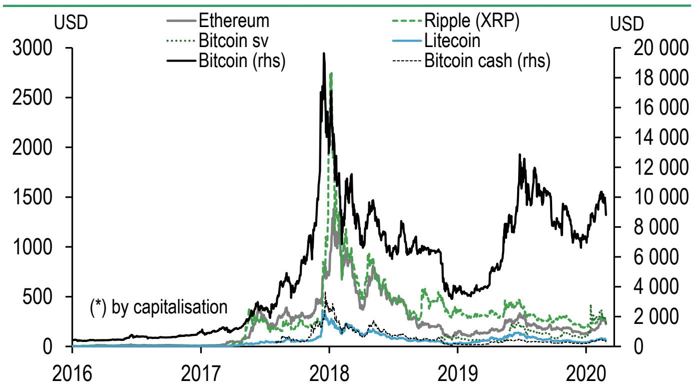

Chart 1

Source: Coin Metrics

First-generation crypto-assets (Bitcoin-type)

This type of digital asset is not a claim held on its issuer, unlike official currencies which represent a claim on the central bank (commercial bank deposits with the central bank, fiat money) or the issuing credit institution (bank deposits). By virtue of this first characteristic a real currency has the *de facto* backing of balance sheet assets, albeit that these can be of variable quality or liquidity (the balance sheet of the central bank or issuing commercial bank). In the case of a commercial bank, assets are, on average, significantly less liquid than bank deposits are for their holders. Prudential regulations require banks to create reserves at the central bank equivalent to a certain percentage of customer deposits (1% in the euro zone since 2012).

Conversely first-generation 'cryptocurrencies' have no intrinsic value and thus nothing, other than the trust their users placed in them, serves to guarantee their value over time. Their relative scarcity is not a sufficient condition to ensure that their value remains within an acceptably narrow range to ensure a relative stability of their price. Thus, the fall in demand for Bitcoin in 2018 resulted in a brutal collapse in its price.

Stablecoins

Stablecoins, issued by entities which back them with stable assets in one way or another, were looked on more favourably by central banks. For example, the 'JPM Coin', from US bank JP Morgan, which completed its test phase in February 2020, falls into this category. This is a 'wholesale' crypto-asset (for use by financial institutions wishing to make use of a dedicated blockchain) which is tradeable at parity with the dollar and backed by the issuer's guarantee. Facebook's Libra project seems, however, to have dented the central banks' more positive view of stablecoins. Like official currencies stablecoins represent a claim on their issuers, the quality of whose balance sheet is, more or less, that of a basket of more or less stable assets. They are thus similar to units in a fund. In any monetary analysis, it should be stressed that units issued by money multual funds in the eurozone are included in the M3 broad money aggregate. Their issuers are part of the Monetary Financial Institution (MFI) sector alongside credit institutions. Stablecoins differ in at least two respects. First, their issuers are not necessarily money market funds and are therefore not subject to the same regulations as the latter. Secondly, stablecoins are designed to be used (at least for those who accept them) as a means of settlement of a transaction or to extinguish a debt; to be used for these purposes, money market fund units need to be sold or redeemed for cash in the narrower definition (M1, consisting of sight deposits, notes and coins).

Facebook's Libra project is perhaps the best known of these stablecoins. This is intended, over time, to become a virtual means of payment backed by a basket of stable assets denominated in the main global currencies. The 'exchange rate' with the basket will be, by construction, maintained. The issuance of any additional quantity of Libra will require the purchase of the same combination of stable assets in an amount determined by the exchange rate. This represents an initial limit for Libra: sellers of stable assets may accept Libra in settlement. But under such circumstances, all newly issued Libra would be issued to these sellers. This would not allow demand for new Libra in exchange for currency from new buyers to be satisfied, unless the issuing entity purchased these from a third party for cash.

The most likely approach would therefore be for sellers of stable assets to be paid in one of the major currencies. Thus, the issuance of a Libra would have as its counterparty the receipt of a quantity of currency determined by the Libra exchange rate, which would then be used to settle the purchase of stable assets. This situation would create an unbreakable link between the major currencies and Libra, which might seem paradoxical for a new instrument that aims to compete with precisely these currencies (see Diagram 4).

Stablecoin tightly linked to official currencies

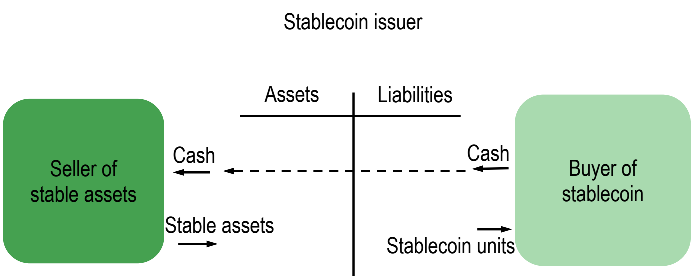

Diagram 4 Source: BNP Paribas

In the final analysis, a stablecoin is broadly comparable to a money market fund in which the units are digitised and can be traded on a blockchain. Unlike official currencies pegged to the dollar under the Bretton Woods agreements (1944 to 1971), stablecoins are not directly linked to a currency, but backed by 'stable' assets. As in the case of Libra, these can be in a range of currencies. This diversification naturally creates an exchange rate risk, not only with reference to any given user's domestic currency but more importantly relative to any of the benchmark currencies making up the basket.

The particular case of tokens

Another innovation in crypto-assets lies in the digitisation of certain physical assets (such as works of art) or intangible assets (patents, copyright) in the form of tokens, which are digital assets that represent a right to a future service (native token) or existing item (non-native token). Under the same principles as 'cryptocurrencies', these tokens can be exchanged on the internet without the intervention of a third party. The ledger for each protocol can function independently of the tokens, whereas primary crypto-assets (bitcoin, ether, ripple, etc.) are indivisible from it. A specific type of transaction, the Initial Coin Offering (ICO), allows the raising of funding in 'cryptocurrency'.

In France, the Autorité des Marchés Financiers (AMF) defines such deals as *"a fundraising transaction carried out through a distributed register system (or "blockchain") and resulting in a token issue. These tokens can then be used to obtain goods or services, as the case may be."* In common with share-based funding rounds, these transactions allow companies to raise funds at an early stage of their development.

However, they differ from Initial Public Offerings (IPOs), with which they are often compared, to the extent that, unlike shares, tokens do not give their holders rights over the company's share capital but over the products or services that will be provided by the company in future. The can thus be considered as pre-sales (or pre-financing), allowing the company to receive cash in advance of the completion of the project and the subscriber – demonstrating their confidence in the company – to receive, on relatively attractive terms, rights over the products or services offered by the company. Although it has been used primarily by start-up companies so far, this solution is a potential option for any company planning to sell a new product or service in the future. Tokens thus span a wide range from digitised assets to pre-financed projects, making the market for them more narrow and less liquid than that for -*coins*[2].

In France, Law 2019-486 of 22 May 2019 (the 'PACTE Act'[3]) introduced a specific regime for ICOs, establishing the principle of approval by the AMF. This new regime, designed to encourage the development of ICOs, does not apply to the issue of tokens which can be considered as financial securities (Security Token Offerings, or STOs) but only to so-called utility token issues. Article 26 thus created a legal framework for ICOs, with the possibility of the AMF providing approval for proposals that it believes to be serious. It is worth noting that this approval is not required, and issuers are free to seek it or not. However, those who have not received approval may not solicit investment from the general public. The AMF issued its first approval to French-ICO, a financing platform for cryptocurrency projects, in December 2019. The approval will be valid until the end of the subscription period, which is expected to be on 1 June 2020.

Simplified matrix of currencies and crypto-assets

		Currencies and crypto-assets	
		Physical	Digital
Legal status	Unregulated	Some local currencies	Crypto-assets
	Regulated	Fiduciary currency, coins and notes	Electronic money Script money

Table 1 Source: Virtual currencies schemes, ECB, October 2012

What does the economic theory say?

'Cryptocurrencies' fulfil the functions of a currency only very imperfectly. 'cryptocurrencies' promoters sometimes lay claim to Hayek's proposals, but it is clear that one of the main arguments on which these were based (the inflation associated with official currencies), whilst powerful in the 1970s is much weaker in current conditions (see Chart 2). Indeed, the European Central Bank is working hard to bring the annual inflation rate back to its target level (below, but close to 2%) without much success so far (inflation was an estimated +1.2% in February 2020).

The three traditional functions of a currency

Money has taken many forms down the ages: shells (cowrie or porcelain money, the first traces of use of which date back to the Chang Dynasty in China [1600-1046BC]), stone money on the Micronesian island of Yap (large circular carved aragonite stone disks with pierced centres brought from the island of Palau some 400 kilometers

[2] The liquidity of coins should nevertheless be seen in context, as demonstrated by the significant volatility in the price of Bitcoin.
[3] PACTE – Action Plan for Business Growth and Transformation

away)between the end of the 17th century and the 1970's, shell bead necklaces (or *wampum*) in northeast America between the early 17th century and mid 18th century, or cocoa beans in Mesoamerica (covering the modern countries of Central America and Mexico), first used by the Mayans in the first millennium and still in use by the Aztecs in the 16th century. Money in the form of coins, still in use today, was probably invented in the 7th century BC by the Greeks of Asia Minor (Byzantium).

Inflation
Annual change in consumer prices

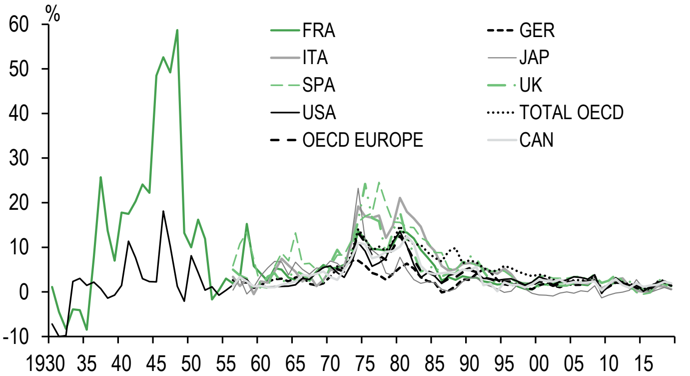

Chart 2 Source: OECD

Looking beyond this non-exhaustive list, all different forms of money shared the fact that they fulfilled, to a greater or lesser extent, the three major functions that the economics textbooks attribute to money:

- Store of value function. This implies that money will retain most of its purchasing power over time and that inflation (which results in erosion of monetary value) remains under control. The in-built control over the quantity of bitcoin issued (via algorithms) and, eventually, its upper limit, have not so far demonstrated their ability to stabilise its value (even in relative terms), as shown by the volatility of the price of bitcoin (see Chart 1). 'Stablecoins' will no doubt have little difficulty in demonstrating their superiority on this criterion, which will allow them to stake a more legitimate claim to be a 'store of value'.
- Means of exchange function. A currency must be recognised and accepted as a means of payment. This acceptance can also be imposed by positive law. Thus, in France, the 'legal tender' nature of cash forbids shopkeepers from refusing payment in this form for sales below a certain amount[4] (article R. 642-3 of the criminal code).
- Unit of account function. Money must serve as a yardstick for the comparison of value of the objects being transacted for, which assumes that it is sufficiently widely used and its value is sufficiently stable for it to be a unit of measurement that is accepted by a large community if not universally. The extremely modest take-up of 'cryptocurrencies' and the small number of companies and merchants who accept them as a means of payment make it impossible to claim that they fulfil the unit of account function.

Hayek and 'competing currencies'

It seems highly likely that the designer of one of the early 'cryptocurrencies' was aware of the work of the Austrian School. Nick Szabo (who some suspect of being the creator of bitcoin, known only by the pseudonym Satoshi Nakamoto) invented a decentralised, digital currency, 'Bit Gold', as a theoretical exercise. He has referred to the work of Carl Menger, the economist and founder of the Austrian School.

A number of cryptography professionals freely refer to the 1976 work The Denationalization of Money[5] by Friedrich von Hayek (Nobel Prize, 1974) as a theoretical basis for their innovations. Hayek argues for the creation of deregulated monetary conditions, under which private issuers would issue competing currencies.

According to Hayek, such a solution would help protect economies against inflation and monetary erosion, which he identified as the root of the problems of modern societies. Issuers, who would need to ensure that their currency attracted users, would be encouraged to protect its value and restrict its issuance. Hayek stressed that his proposal was not incompatible with Gresham's Law, summarised pithily by W.S. Jevons as "Bad money drives out good". This economic law applies in circumstances where there are two distinct currencies in circulation. An increase in the value of the underlying precious metal will lead to the good money (whose metal value is higher than its nominal value) being hoarded or used for other purposes, whilst the circulation of the bad money (with a lower metal value) is encouraged. *"What Jevons, as so many others, seems to have overlooked, or regarded as irrelevant,"* wrote Hayek, "*is that Gresham's Law will apply* only *to different kinds of money between which a fixed rate of exchange is enforced by law."*

And yet, with all due respect to the *cypherpunk*[6] community, it is hard to consider Hayek's work as providing a theoretical base for 'cryptocurrencies'. First, and in the most general terms, Hayek did not share their libertarian worldview – far from it. Indeed, he recognised the legitimate role of government in many areas (other than money): social protection, education and the support of certain business activities[7]. Meanwhile, the Austrian School was the source of a number of sometimes contradictory opinions on the subject of money. Hayek's proposals, for example, suffered a chilly reception, to the extent of being considered naive, even within the Austrian School. Some economists

[4] They must, however, refuse cash payments of over EUR 1,000 where the customer has their tax residence in France or is making the purchase for professional or business purposes; this limit is EUR 15,000 when the customer can prove they are not tax resident in France and is not making the purchase for business purposes.

[5] Hayek F. (1976), *The Denationalization of Money*, Institute for Economic Affairs, London

[6] A crypto-anarchist or libertarian capitalist movement of the 1980s in the USA. The originators of the first crypto-currencies promoted freedom of expression, free trade and privacy (enabled by cryptography) as means of overturning the social model based on a system of centralised power.

[7] Hayek F. (1960), *The Constitution of Liberty*

have suggested even more radical changes, which perhaps provide an interesting theoretical framework when considering the future of 'cryptocurrencies'. According to Murray Rothbard and Hans Hoppe, the most important function of money is as a medium of exchange, and it is only natural that economic actors will spontaneously choose the currencies that they believe will be used by other economic actors[8]. They therefore viewed Hayek's proposal as transitional in nature. These authors believed that were these proposals to be put in place, they would lead to a trend of unification towards a single global currency: gold.

Impacts on monetary policy

Notwithstanding their highly speculative nature and the substantial risk to which investors are exposed, the ECB does not believe that crypto-assets pose any threat to the financial stability of the euro zone[9]. Their relative value remains modest compared to standard economic aggregates, and the cumulative indirect exposure of financial institutions, particularly banks, to these instruments is vanishingly small (EUR 20,000 in the third quarter of 2018), with ownership reserved almost exclusively to individuals (for a total of just over one billion euros). The IMF also judges that the development of 'cryptocurrencies' and the exposure of economic actors to them remain modest given the absence of any impact on financial stability or monetary policy[10].

However, none of this means that wider use of these new instruments will not have effects in the longer term.

Even a perfect mastery of the technology of crypto-assets does not give a full understanding of their economic and social function. In the current context of monetary creation and fractional-reserve banking, the quantity of money is influenced rather than fully controlled by the central bank (despite the powerful tools available to the latter). Moreover, the supply of money, its velocity of circulation and levels of output inter-react, such that perfect price stability is something of a pipe dream (hence central banks giving themselves a safety margin in their inflation targets).

Even if we suppose that use of crypto-assets will become more widespread, it is hard to see this happening with issuance rules set by 'protocols' alone. According to Danielson (2019)[11], a crypto-asset whose protocol sets out a slow mining process, which converges to zero (such as that used by bitcoin), would sow the seeds of persistent deflation. If the growth, through mining, of the quantity of a crypto-asset in circulation is lower than economic growth over the long term, then unless there is a steady increase in the velocity of its circulation there will be a fall in prices, which in turn will depress activity. Growth in the supply of money (or a substitute) must at least match economic growth if deflation is to be prevented.

Over and above the rate of money creation in the medium term, there is also the question of its adjustment to circumstances. Within a distributed ledger, the rules for issuance of crypto-assets would, by their nature, be unable to reproduce the pragmatic approach taken by monetary authorities in response to exogenous shocks. This lack of flexibility can exacerbate the situation, as was the case in the aftermath of the 1929 crisis. Friedman and Schwartz (1963)[12] demonstrated how the economic crisis of the 1930s was preceded, in the USA, by a fall in broad measures of money supply (M2, M3), whilst the M0 and M1 measures continued to rise. The central bank would have provided insufficient liquidity to the banking system to tackle the fall in deposits, limiting its open market operations at the beginning of the crisis, in late 1929, and then again briefly in the summer of 1932. The resulting squeeze on the supply of bank lending would have amplified, in its turn, the economic slowdown. They argue that the Federal Reserve's inability to respond effectively to this shock in demand for money was a powerful factor in aggravating the recession. More recent works support this analysis (ECB, 2004[13]).

However, this reasoning would only hold in circumstances where there was only a single crypto-asset. As Bofinger (2018)[14] highlights, whilst the total number of units issued by a private issuer may be capped in a bid to protect the value of its crypto-asset, the principle of free competition between private issuers does not limit the number of issuers. It follows that there is no limit in the total quantity of crypto-assets taken across all issuers. Over and above the risk of loss inherent in holding any given crypto-asset, the overall quantity of crypto-assets would quickly become uncontrollable. In such circumstances, the opposite problem – that of inflation – would be the threat.

This transposition of the quantitative theory of money to crypto-assets nevertheless relates to an imaginary scenario in which the use of 'cryptocurrencies' as a means of payment has expanded considerably. It is first necessary to consider the possibility of a long-lasting coexistence of several competing private currencies. This topic was widely debated as long ago as the late 1970s within the Austrian School (see above). In addition, there is the question of the effectiveness of monetary policy in a situation where an official currency exists alongside one or more crypto-assets. Benigno (2019)[15], amongst others, have shown, through an analysis of different models of the coexistence of an official currency and currencies issued by private issuers, that competitive 'currencies' could reduce the central bank's ability to use

[8] Hoppe H.-H. *How Is Fiat Money Possible?--or, the Devolution of Money and Credit*, The Review of Austrian Economics, 7, (2), 49–74, 1994. Hoppe quotes Ludwig Von Mises p. 51 "(…) *there would be an inevitable tendency for the less marketable of the series of goods used as media of exchange to be one by one rejected until at last only a single commodity remained, which was universally employed as a medium of exchange; in a word, money*"

[9] European Central Bank, *Crypto-Assets: Implications for financial stability, monetary policy, and payments and market infrastructures*, Occasional Paper Series, ECB Crypto-Assets Task Force, n° 223, May 2019

[10] Franks J., *Crypto-currencies and monetary policies*, International Monetary Fund, Europe Office, 22 January 2019

[11] Danielson, *Cryptocurrencies: Policy, economics and fairness*, London School of Economics, July 2019

[12] Friedman M. and Schwartz A., *A monetary history of the United States 1867-1960*. Princeton University Press, 1963

[13] Christiano L., Motto R., Rostagno M., *The Great Depression and the Friedman-Schwartz Hypothesis*, ECB Working Paper 326, March 2004

[14] Bofinger, Digitalisation of money and the future of monetary policy, VOX EU, CEPR Policy Portal, 12 June 2018

[15] Benigno P., *Monetary policy in a World of crypto-currencies*, EIEF working Paper 19/05, April 2019

the interest rate tool, and make it more difficult to achieve a balanced level of inflation. The entrance into the market of multiple private issuers, whose aim would be to maximise their profit, would in fact strip the central bank of any control over interest rates and the inflation rate, which would become dependent only on exogenous factors (time preference, market entrance and exit costs, etc.)

The specific issue of the possible impact of stablecoins (see below) on monetary policy is perhaps more acute, as these instruments clearly have the greater potential for growth. In the event that 'deposits' in the form of stablecoins earned interest (the Calibra Association has indicated that Libra deposits will not earn interest), the possible consequences for the transmission of monetary policy would depend on the level at which the interest rate was set (G7 Working Group on Stable Coins, 2019[16]).

Let us suppose that this rate reflects the yield on the basket of assets used to back the coin. If the assets in question are denominated only in domestic currency, there will be little or no effect on monetary policy. However, if the basket of assets includes assets in other currencies (as is the case with Libra), the link between the central bank policy interest rate and the stablecoin interest rate will be all the looser as the share of assets in the domestic currency falls, perhaps even to zero. Moreover, the rate of return on holdings of stablecoins would have an impact on the outstanding amount of deposits, and thus on deposit and lending rates in the economy as a whole. The G7 working party noted that this effect would be fairly similar to that currently seen in countries affected by high levels of dollarization, but that it would extend to countries with lower dollarization levels.

In addition, a substitution of bank deposits by stablecoins would increase the dependence of commercial banks on market resources. As the costs of such resources are more elastic than bank deposits to money market conditions, adjustments to monetary policy would certainly be accurately transmitted by the vector of bank lending, but this would play a smaller role. At the same time, and on a more structural level, coupled with greater volatility in client deposits, the increased dependence of banks on market resources could incite them either to cut lending volumes, or to increase the risk and extend the maturities of lending in response to the increase in the average cost of resources. The first response would affect the financing of the economy; the second, financial stability.

So far we have considered that the stablecoin' is an alternative form of savings, but that banking and financial intermediation would continue in the domestic currency. Let us assume instead that financial intermediaries would emerge that would lend and borrow in 'stablecoins'. This new form of intermediation would again weaken the transmission of monetary policy because the rate of return on holdings and the interest rate on such loans would be more clearly uncoupled from monetary policy.

[16] G7 Working Group on Stable Coins, *Investigating the Global Impact of Global Stable Coins*, G7, IMF, BIS, October 2019

Some orders of magnitude

Depending on the source used, estimates of the number of crypto-assets vary between 1,600 and over 3,000. Their total capitalisation saw exponential growth in 2017, taking it to more than USD 800 billion at the beginning of 2018[17] (Chart 3). By 26 January 2019, it had fallen back to USD 237.5 billion. At this point, bitcoin accounted for USD 156.3 billion, or 66%, of the total. However, its share of total capitalisation is itself highly volatile (Chart 4). It peaked at over 80% in early 2017, before the development of rival crypto-assets later that year, and then fell to less than 40% of the total when the value of bitcoin collapsed in early 2018. Since then it has seen a recovery marked by significant fluctuations, oscillating around 65% in January and February 2020. Since 2016, the top six crypto-assets have accounted for between 70% and 100% of total capitalisation. Their share is, however, trending downwards and fluctuating with increasing amplitude as competing crypto-assets take off.

Crypto-assets are in no sense currencies. However, given their shared ambition to fulfil the functions of a currency, as reflected in their inaccurate designation as 'cryptocurrencies', there is a significant temptation to compare their capitalisation with real currencies.

We calculate that in December 2018, the aggregate money supply (in the broadest sense of the term) of the OECD nations and China was more than USD 88,000 billion.

Even narrow measures of money aggregrates, consisting solely of assets available immediately to settle transactions or extinguish debts (sight deposits and fiduciary money) have a value of a completely different order of magnitude than that of crypto-assets. By way of illustration, on 31 January 2020, M1 money supply in the euro zone was EUR 8,975.5 billion whilst in the USA it was USD 3,968.6 billion[18]. Despite the significant (if uneven) growth in their capitalisation since 2016, crypto-assets have gone only a tiny fraction of the journey they will need to take to rival official currencies. Perhaps the realisation of the Libra project, due to its scale and the fact that it is a stablecoin, will be a more decisive step along this path. But this project is experiencing some vicissitudes.

What about central bank digital currencies?

The arguments

Against the background of the emergence of numerous crypto-assets and falling demand for fiat money (which is part of base money), several issuing institutions have begun to consider making central bank deposits available to non-banking actors.

In his comments of 4 December 2019[19], the Governor of the Banque de France identified three goals for the possible creation of a central bank

[17] Source: Coinmarketcap
[18] 27 January 2020, Federal Reserve
[19] Speech by François Villeroy de Galhau, *A central bank digital currency and innovative payment solutions*, Paris, 4 December 2019

digital currency (CBDC). The first is the preservation of the link between citizens and the official currency, something made necessary in societies, such as Sweden, where the use of cash is in decline. The second is a reduction in intermediation costs in the central currency. The third and "most important" purpose lies in "*the confirmation of the sovereignty [of the political authorities] faced with private initiatives such as Libra.*"

Other arguments have also been put forward. For Dyson and Hogson (2016)[20] and Rogoff (2017)[21], the substitution of a CBDC for cash would allow the removal of the 'zero lower bound' which limits the effectiveness of negative interest rate policies that these authors expect to persist.

Total capitalization of crypto-assets

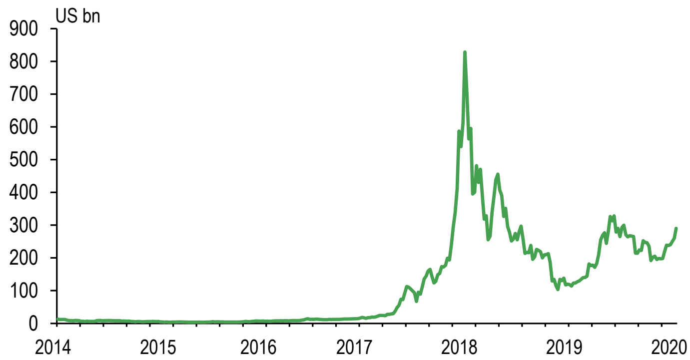

Chart 3 Source: CoinMarketCap

Share of total crypto-asset capitalization, %

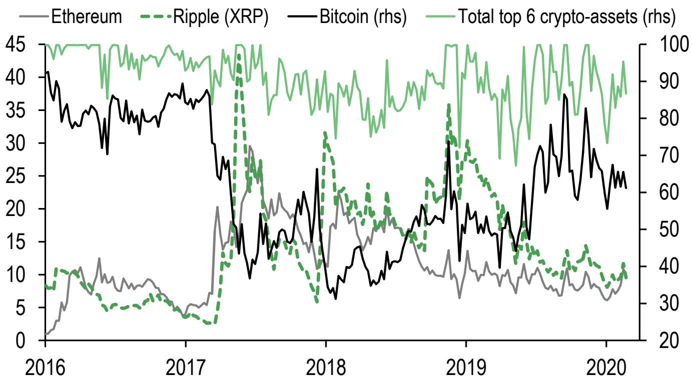

Chart 4 Source: CoinMarketCap, Coin Metrics, BNP Paribas

[20] Dyson B. and Hodgson G., *Digital cash : why central banks should start issuing electronic money*, Positive Money, 2016

[21] Rogoff, *Dealing with Monetary Paralysis at the Zero Bound*, Journal of Economic Perspective, September 2017

The risks

A central bank digital currency should not be thought of only as an official alternative to private-issuer 'cryptocurrencies'; the reality would be much more far-reaching. By making central bank money available to non-bank actors (non-bank financial intermediaries for so-called 'wholesale' CBDCs, or even individual consumers or companies for 'retail' CBDCs) in a form other than cash alone, the central bank digital currency would become an alternative to cash. At the same time, if it is held in the form of accounts in a centralised register, it would also become an alternative to script money held as deposits with commercial banks (broad money).

In order to assess the issues related to such a proposal, one needs to draw a distinction between two types of money:

- Central bank money (high-powered money), consisting of commercial bank deposits at the central bank and fiat money;

- broad money supply, consisting of the part of central bank money in the form of banknotes and coins and to a much larger extent the money created in script form by credit institutions (the amount recognised in ledgers of bank deposits). If we exclude non-conventional monetary policy (quantitative easing) or, to a lesser extent, open market operations, all creation of money in its broad sense (M3 in the euro zone) has as its counterparty the simultaneous creation of a debt: the bank pays out the loan by crediting the account of the borrower. The broad money thus created allows to pay for the purpose of the loan and then circulates in the economy.

Sovereign money proposals, such as the Sigurjonsson parliamentary report in Iceland in March 2015 and the Swiss Vollgeld proposals of December 2015, sought to strip commercial banks of their ability to create money, reserving that right to the central bank alone. Far from being novel, these solutions dug up ideas that first saw the light of day in the thinking of Chicago School economists in the 1930s.

To achieve their main objective, supporters of these proposals favoured splitting client deposits currently recorded as liabilities by lending establishments into two separate types of account. "Transaction accounts," which can be used to settle transactions and make transfers, would be recorded as liabilities on the central bank balance sheet whilst term deposits (Investment Accounts) would remain on the balance sheet of commercial banks, as they are at present. Money created by the central bank would exclusively be paid into transaction accounts, from which transfers could then be made to Investment Accounts.

The banks – which would only provide an interface between account holders and the central bank, and would have their role limited to that of a financial intermediary in payments, in the style of PayPal. However, they would retain Investment Accounts on their balance sheets. These would continue to be intermediated by the banking system, which would use these resources to make medium- and long-term loans.

Thus the creation of a 'retail' central bank digital currency displays significant similarities with these 'narrow banking' or 'sovereign money' concepts. Indeed, CBDCs are sometimes presented as a partial restriction on the banking system, albeit one that is less radical than the proposal that 'narrow' banks must back all customer deposits with their own deposits at the central bank (Gouveia et al. (2017)[22]).

The creation of a CBDC differs from a sovereign money solution in its intensity. So long as the proportion of clients who transform their bank deposits into CDBC remains limited, the money creation process will be unaffected, and loans will continue to 'create deposits'. However, this supposes that customers are not encouraged to move their deposits into the central bank currency, which in turn would require that deposits with commercial banks earn an adequate rate of interest. An increase in the rate paid on deposits would result in higher average costs for bank resources. This would either put pressure on the supply of credit, or it would be passed through into lending rates, thus reducing demand. In any event, the new equilibrium would coincide in reduced money creation, which could complicate central bank efforts to tackle deflationary pressures. This risk of substitution would be exacerbated in the event of a "digital" run on the bank (conversion of customer bank deposits into the CBDC) and could heighten the threat to financial stability from a 'normal' bank run (flight of deposits of fiduciary money).

The "money flower", taxonomy of money and crypto-assets

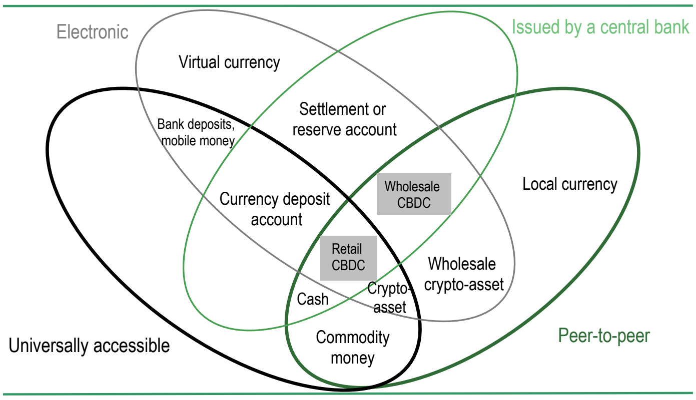

Diagram 5 Source: Bech et Garatt (2017), BIS

Some aspects remain unresolved

As CBDCs are still in the early stages of consideration, some of their core features have yet to be determined. In a document reporting the work of a Banque de France in-house working part[23] (which *"expresses the views of the authors and not those of the Banque de France or Eurosystem"*), the characteristics, benefits and risks of the two main categories of central bank digital currencies are discussed.

Wholesale CBDCs are defined as digital currencies accessible only to financial institutions, or perhaps only to some of them. Retail CBDCs are accessible to all. As identified by Bech and Garatt (2017)[24], the only distinguishing criterion between wholesale and retail CBDCs is accessibility (Chart 5). It is nonetheless important to analyse the very different issues raised by these two forms of CBDC.

Retail CBDC

The report's authors believe that the model of accounts held directly with the central bank would be more beneficial for the CBDC. However, this model would carry the risk of disintermediation of banking system deposits (see below) and the authors highlight that a token-based model would make this retail CBDC a simple "virtual complement to cash", which would be more in keeping with its philosophy.

Irrespective of the means of circulation (transfers from account to account or tokens), the report's authors believe that the distribution of a CBDC could take place via intermediaries. Even in the event of a CBDC in the form of tokens, which would not, strictly speaking, involve CBDC deposits substituting for bank deposits, holdings of the latter for the Keynesian transaction motive would necessarily diminish. The effect on bank deposits would therefore be significantly less pronounced than for an account-based CBDC but would be far from neutral. Lastly, there is the question of interest. Some authors have argued for the benefits of a society in which cash become scarcer (Rogoff (2017)[25]), highlighting the more effective transmission of negative interest rates and the improved transmission of monetary policy that would result. But we believe that such an approach is incompatible with the spirit of a retail CBDC, which, in its roles as a digital equivalent to fiat money, would not by any logic earn interest.

Wholesale CBDC

The main social advantage expected from a wholesale CBDC lies in the benefits of a blockchain-type technology (traceability if desired, cost, speed). Lending establishments already have access to central bank money in electronic form (reserves).

A wholesale CBDC also raises the issue of scope (whether it would be accessible to banks only or also to other non-financial institutions). Historically, access to central bank money has been limited to registered deposit-taking establishments. In return they are obliged to retain reserves in central bank money as a certain proportion of their short-term client deposits (in the euro zone the required reserves ratio has, since 2012, been 1% of the deposits which form the base). This constraint saw a *de facto* tightening under Basel III and the introduction of the Liquidity Coverage Ratio, or LCR. This makes central bank money held by lending establishments a coercive tool for the transmission of monetary policy.

Some new actors, for example Fintech companies, seeking to invest in the payments market or take advantage of the opportunities created by the blockchain could have their activities facilitated by access to the central bank balance sheet. These conditions would require in-depth consideration given the redefinition of payment circuits and the modification of the respective roles of banks and payment

[22] Gouveia, Olga Cerquiera et al., *Central Bank Digital Currencies: assessing implementation possibilities and impacts*, BBVA, Working Paper n° 17/04, March 2017
[23] Internal working group at Banque de France, *La monnaie Digitale de Banque centrale*, 8 January 2020
[24] Bech M.L., Garatt R., *Central bank cryptocurrencies*, BIS Quarterly Review, 17 September 2017
[25] Rogoff, *Dealing with Monetary Paralysis at the Zero Bound*, Journal of Economic Perspective, September 2017

intermediaries that could result (settlement in central bank money). The possible risks that these changes would create in terms of the operation of payment infrastructure, the transmission of monetary policy and financial stability would have to be taken into consideration.

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The extent to which crypto-assets fulfil the functions of a real currency leaves considerable scope for improvement. They should not therefore be viewed as such. One desirable development would be to legislate to prevent issuing networks from promoting such assets to users as a 'currency'. This would mean that users would still be free to use the assets as a means of exchange, but would be less likely to misunderstand their true nature. From this point of view, stablecoins, which are backed by baskets of stable assets, clearly offer greater certainty as to their value. Their design makes them structurally dependent on official currencies, in a similar fashion to currencies linked to the dollar under the Bretton Woods agreements (1944-1971), distancing them from the libertarian approach that motivated the first generation of crypto-assets. The Libra stablecoin initiative and the perception of a possible threat to monetary sovereignty have accelerated the consideration of the creation of central bank digital currencies. However, these would not just be official alternatives to privately-issued 'cryptocurrencies'. Some of their features, notably those giving access to individuals (retail CBDC) in the form of accounts, or opening access to non-bank intermediaries (wholesale CBDC), would bring structural changes in the operation of the banking system and have structural consequences for the process of money creation (in the real rather than virtual sense) and the vectors of transmission of monetary policy. In particular, a retail CBDC would introduce the risk of a 'digital bank run', which would have deleterious effects on financial stability. For these reasons alone further reflection is called for, and central banks would do well to "hurry up slowly". Nor should the process of reflection concentrate solely on central bank digital currencies. It would benefit from being extended to the digital forms of script money issued by lending establishments that could provide users with the same services as a CBDC but without the same disadvantages.

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Poland: Growth under scrutiny

Tarik Rharrab & Sylvain Bellefontaine

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

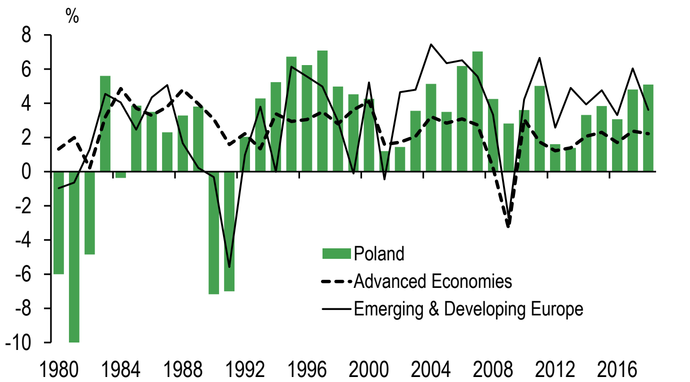

Chart 1 Source: IMF

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$)

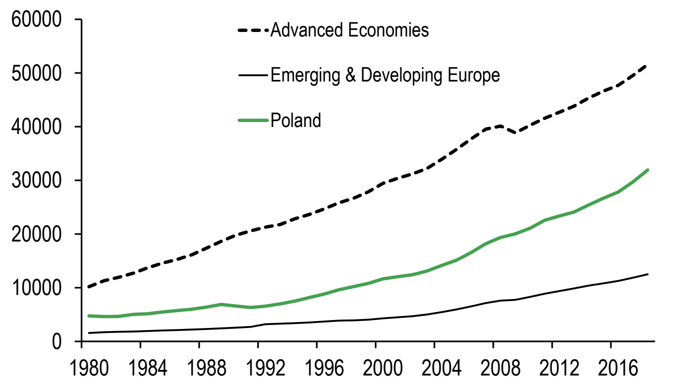

Chart 2 Source: IMF

Ease of Doing Business Indicators

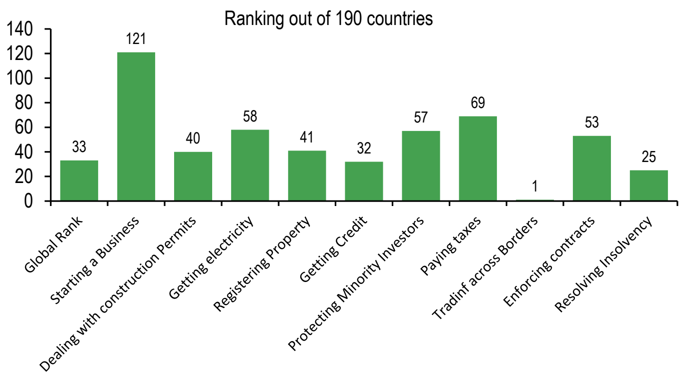

Chart 5 Source: World Bank

GDP per capita (% of EU-15 average)

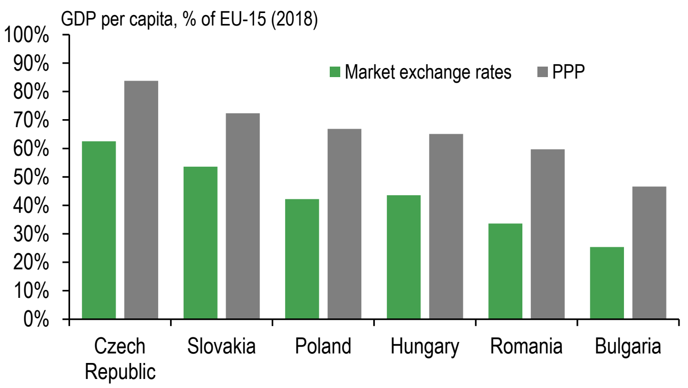

Chart 3 Source: European Commision, BNP Paribas

Real wages and productivity

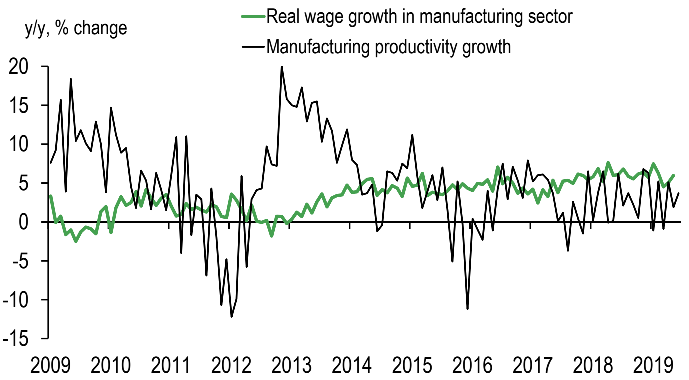

Chart 6 Source: GUS

Governance indicators

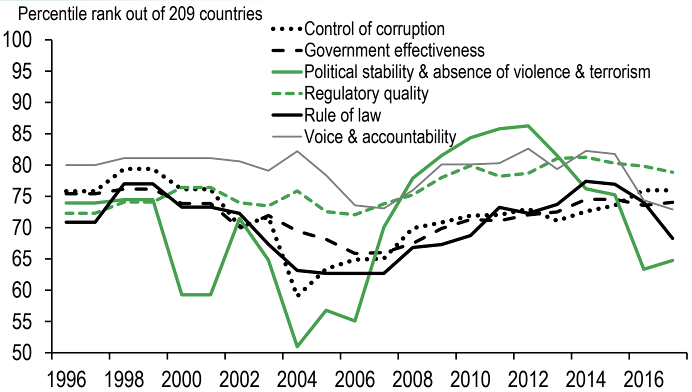

Chart 4 Source : World Bank

The efficiency frontier

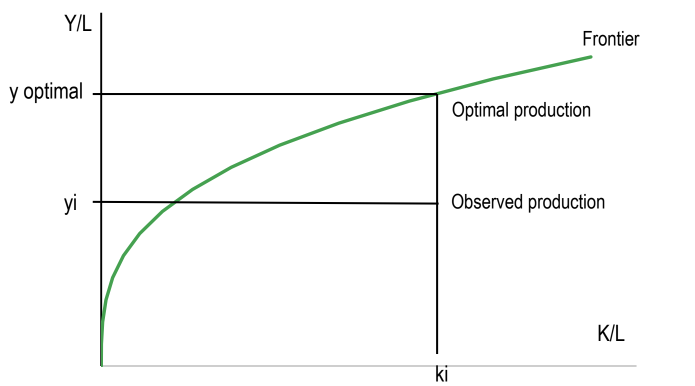

Chart 7 Source: BNP Paribas

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.

Production frontier (2017)

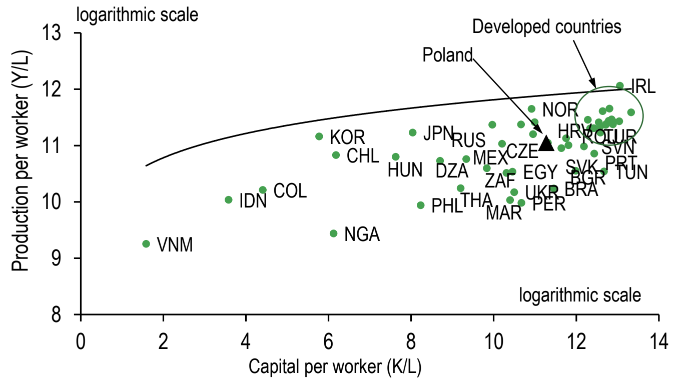

Chart 8 Source: Penn World Table, World Bank, BNP Paribas calculations

Country transitions 1996-2017

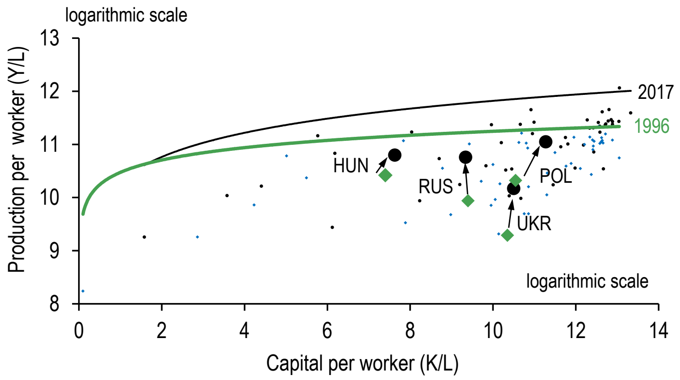

Chart 9 Source: Penn World Table, World Bank, BNP Paribas calculations

Governance and technical efficiency indicators

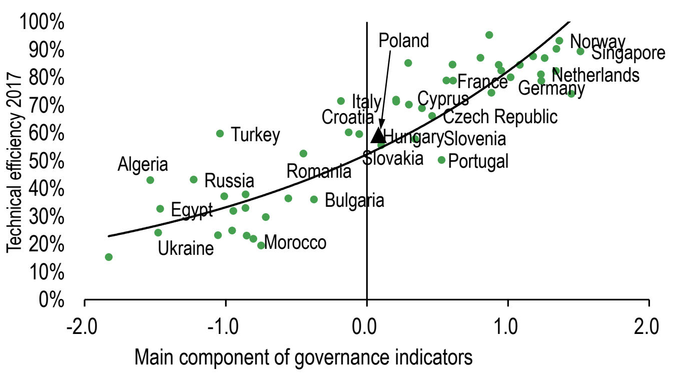

Chart 10 Source: Penn World Table, World Bank, BNP Paribas calculations

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,

[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.

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

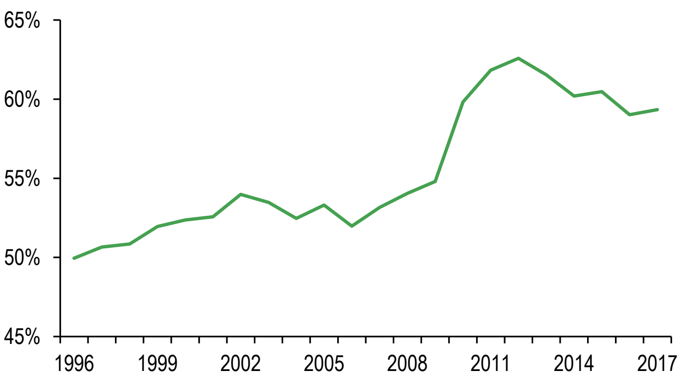

Chart 11 Source: BNP Paribas calculations

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

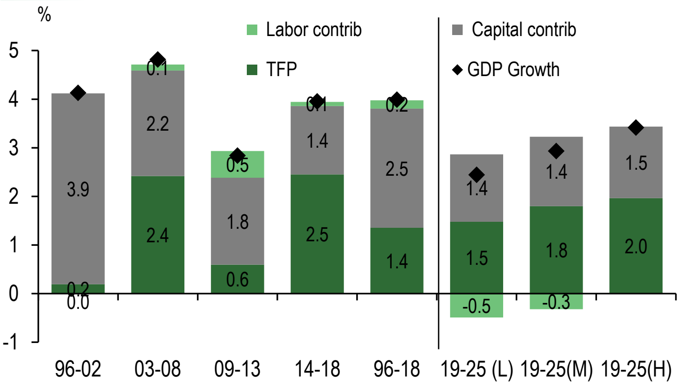

Chart 12 Source: AMECO, World Bank,BNP Paribas

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

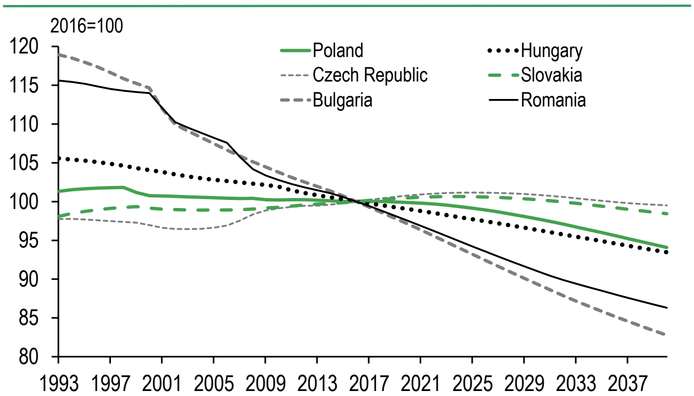

Chart 13 Source: United Nations

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

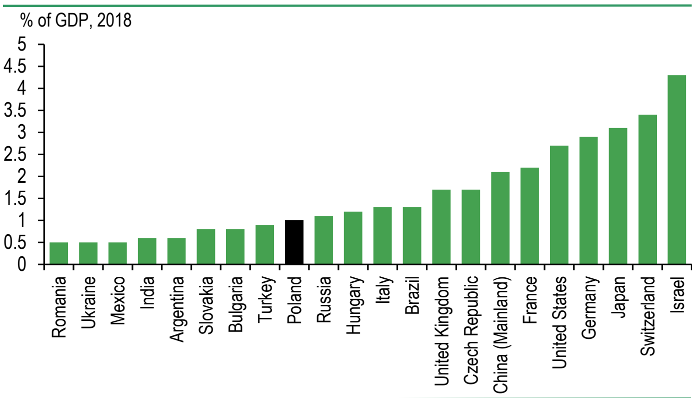

Chart 14 Source: Cornell/INSEAD/WIPO

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.

***

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.

Sylvain Bellefontaine & Tarik Rharrab

Appendix

Estimating efficiency[6]

Consider the following stochastic frontier model:

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

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

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

$$u \sim N^+(z\delta, \sigma_u^2) \qquad (4)$$

Technical efficiency is specified as:

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

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

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