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Seven Issues Facing Central Banks Today*

Willem H. Buiter

The central bank is a fiscal and financial agent of the government, its beneficial owner. Their accounts should be consolidated and there should be no private ownership of central bank equity. Central banks should have a symmetric profit and loss-sharing or recapitalisation arrangement with the government. Central bank money is a liability in name only. This should be recognised in the intertemporal budget constraints of the central bank and of the consolidated State. The fiscal theory of the price level is a logical fallacy. Average inflation targeting is potentially costly and has no support from economic theory. Operationally independent central banks will monetise public debt to prevent sovereign default and associated serious financial instability, even when this is incompatible with the price stability mandate. The effective lower bound must be eliminated by abolishing paper currency and creating an interest-bearing retail central bank digital currency, usable in online and offline transactions, and without caps on the size of accounts or transactions.

Journal of Economic Literature (JEL) codes: E42, E52, E58

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1. Introduction

This paper discusses seven issues that should be of interest to central banks. First, the central bank is a fiscal and financial agent of the State. The government is its beneficial owner. The central bank's accounts should be consolidated with those of the government. All semi-private formal ownership structures should be terminated and replaced with 100-per cent ownership by the government. Second, central bank money is a liability in name only. This has important implications for the

* The papers in this issue contain the views of the authors which are not necessarily the same as the official views of the Magyar Nemzeti Bank.

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intertemporal budget constraints of the central bank and the consolidated State. Third, there should be a symmetric treatment of central bank profits and losses by its beneficial owner. Fourth, the Fiscal Theory of the Price Level is a logical fallacy. Fifth, average inflation targeting is potentially costly economic nonsense. Sixth, there can be fiscal dominance even if the central bank is operationally independent. Preserving financial stability, the primary mandate of any central bank, may force it to monetise government debt on a scale that it knows to be incompatible with price stability. Seventh, it is time to eliminate the effective lower bound (ELB) on nominal interest rates by abolishing zero interest fiat coin and paper currency and replacing them with an interest-bearing retail central bank digital currency (CBDC), usable in both offline and online transactions and without a cap on the size of accounts or transactions.

2. The central bank is a fiscal and financial agent of the State

The central bank is a fiscal and financial agent of the State. In most countries, the central or federal government is the beneficial owner of the central bank. Lower-tier public entities may share the beneficial ownership. The accounts of the central bank should be consolidated with those of its beneficial owner for a proper analysis of the debt sustainability of the State and for proper policy planning. For proper public debt sustainability analysis and policy planning, general government debt held by the central bank (and other central bank claims on the general government) should be netted out. Central bank liabilities other than liabilities to the general government should be added, but it should be recognised that central bank monetary liabilities are liabilities in name only (as discussed in *Section 3*).

Some central banks have bizarre and confusing ownership structures, that may obscure their role as fiscal and financial agents of the government and may appear to justify the exclusion of central banks from the accounts of the government. Examples are the Federal Reserve System whose 12 Federal Reserve Banks are set up as private corporations, the Bank of Japan, the Swiss National Bank, the Banca d'Italia, the National Bank of Belgium and the Bank of Greece, all of which have (some) private shareholders. The only sensible ownership structure – 100 per cent ownership by the government – is found in the Bank of England (BoE) (since 1946), the Bundesbank, the Banque de France, De Nederlandsche Bank, the Swedish Riksbank and most others. Although I know of no central bank whose private shareholders collectively take part in monetary policy decision-making or in microprudential or macroprudential regulation and supervision, it is time to get rid of confusing private shareholdings in central banks. In the US, the fact that the 12 regional Federal Reserve Banks that hold all financial assets and liabilities of the Federal Reserve Systems are private corporations, leads to frequent assertions that the Fed is controlled by private interests (see e.g. *Zarlenga 2023*)

Recognising that the central bank is a fiscal and financial agent of the State (and the liquid window of the Treasury) does not undermine central bank independence. Operational independence and (for some central banks) limited target independence are quite consistent with the Treasury being the beneficial owner of the central bank. Nor does central bank operational independence rule out central bank cooperation with the Treasury or the coordination of monetary and fiscal policy. Operational independence only means that the Treasury (or any other official entity or person) cannot tell the central bank what to do and what not to do. Operational independence likely requires legal institutional independence. It certainly requires personal independence of the members of the committee controlling the monetary policy instruments.

3. Central bank money is a liability in name only

Central bank money is irredeemable: *X* dollars of central bank money is a claim only on *X* dollars of central bank money[1]. Therefore, central bank money, while an asset to its holders, is a liability in name only. When assessing the solvency of the central bank or of the consolidated State, we should focus on its ability to service its *non-monetary liabilities*. A key issue is whether the minimum present discounted value (PDV) of current and future net seigniorage required to ensure the solvency of the central bank (and of the consolidated State) is consistent with price stability.

The true intertemporal budget constraint (IBC) of the central bank (and of the consolidated State) is quite different when central bank money is not treated as a true liability. In the comprehensive balance sheet (or IBC) of the central bank (and of the consolidated State) at any time *t*, there is one fewer liability – the outstanding stock of central bank money. In addition, there is one more asset: the PDV of current and future net seigniorage. The difference this makes to the comprehensive net worth of the central bank can be large. Fed currency in circulation was USD 2.4 trillion at the end of 2024. Reserve balances with Federal Reserve Banks were USD 3.2 trillion. The PDV of net seigniorage could easily exceed the value of the current stock of central bank money (*Buiter 2021a*).

Because central bank money is a liability in name only, a central bank can have significant negative equity on a conventional balance sheet without being at risk of default on its contractual obligations (see *Buiter 2024*). If a central bank has no significant foreign-currency-denominated liabilities or commodity-denominated liabilities that require physical delivery, it can always service its debt by creating additional central bank money and raising the PDV of current and future net seigniorage. However, the magnitude of the additional money issuance required

[1] See *Buiter* (*2007*) and *Buiter* (*2021a*).

to ensure equitable solvency may be inconsistent with its price stability mandate. Recapitalisation of the central bank by the Treasury may resolve this dilemma, if the solvency of the Treasury is not threatened by this.

The conventional balance sheet of the central bank treats central bank money (currency in circulation plus central bank reserves held by commercial banks and other financial institutions) as a liability. Because central bank money is a liability in name only, equitable solvency concerns are present only if the equity of the central bank plus the stock of central bank money is negative. Even if the value of the central bank's non-monetary liabilities exceeds the value of its assets, there is a problem only if (1) the current and future central bank money creation required to maintain equitable solvency is larger than the amount consistent with price stability, and if in addition (2) the central government (typically the Treasury) is unwilling or unable to recapitalise the central bank to the point that central bank net worth (equity) is again consistent with its price stability mandate.

4. The asymmetric treatment by some Treasuries of central bank profits and losses

The treatment of central bank losses by its beneficial owner often is not symmetric with that of profits. The United Kingdom stands out by addressing BoE losses symmetrically in two ways. First, there is a profit and loss sharing agreement with HM Treasury for the Asset Purchase Facility – currently around 79 per cent of the BoE's assets. Second, the BoE has a recapitalisation and income sharing agreement with HM Treasury. It specifies a Target, a Floor and a Ceiling for the loss-absorbing capital (LAC) of the BoE. If actual LAC is above the Ceiling, all net profits are paid to the Treasury. With LAC between the Target and the Ceiling, half of net profits are paid to the Treasury. With LAC between the Floor and the Target, the BoE keeps all the net profits. With LAC below the Floor, the BoE receives a capital injection from the Treasury that returns its capital to the Target. The Sveriges Riksbank has a recapitalisation arrangement with the Swedish parliament.

The Fed has no loss-sharing or recapitalisation arrangement with the US Treasury. There are (capped) US Treasury guarantees (through equity investments) for some of the emergency facilities created by the Fed following the outbreak of the Covid pandemic. The European Central Bank (ECB) likewise does not have loss-sharing or recapitalisation agreements with its beneficial owners – the national central banks of the euro area and, through them, the national fiscal authorities of the euro area member states.

4.1. The deferred asset fudge

The Fed adds any losses that would take its CET1[2] capital or equity below some threshold level, either as a positive "deferred asset"[3] or as a negative liability[4] on its balance sheet[5]. The ECB engages in the deferred asset gimmick. This deferred asset represents the reduction in the central bank's future transfer of profits ("remittances") to the Treasury until its capital is again at or above a threshold level. It is true that the PDV of current and future net payments to the Treasury is a liability on the comprehensive balance sheet (in the IBC) of the central bank. It is, however, not at all obvious that, whenever the central bank makes losses that would reduce its capital below a threshold level, the Treasury will agree to a reduction of equal value in the expected PDV of net remittances from the central bank. This could require positive transfers from the Treasury to the central bank, or even a negative expected PDV of transfers from the central bank to the Treasury. The Fed's and ECB's treatment of the deferred asset assumes that, no matter how large the central bank losses are, there will be no need for an increase in a key asset on the comprehensive balance sheet (or IBC) of the central bank – the expected PDV of current and future net seigniorage – central bank money issuance net of interest paid on the outstanding stock of central bank money. Instead, there is assumed to be a reduction in the PDV of current and future net remittances to the Treasury that preserves the equitable solvency (or cash flow solvency) of the central bank without any central bank recourse to additional seigniorage. This is clear from this statement by the Fed[6]: "A deferred asset has no implications for the Federal Reserve's conduct of monetary policy or its ability to meet its financial obligations".

The deferred asset fudge turns a conventional balance sheet with only legal, contractual assets and liabilities – what I call explicit assets and liabilities – into an *incomplete* and misleading comprehensive balance sheet or IBC. It adds an implicit liability (the PDV of current and future central bank net remittances to the Treasury), but fails to include a key implicit asset (the PDV of current and future net seigniorage). It fails to recognise that central bank equitable insolvency may only be avoided by boosting current or future seigniorage, if the Treasury is unwilling or unable to make large enough positive remittances to the central bank.

[2] Common Equity Tier 1
[3] https://www.federalreserve.gov/aboutthefed/files/quarterly-report-20241122.pdf
[4] https://www.federalreserve.gov/releases/h41/current/h41.htm#h41tab9
[5] The negative liability is Other liabilities and capital (https://www.federalreserve.gov/releases/h41/current/h41.htm#h41tab9), which "includes the liabilities for earnings remittances due to the US Treasury".
[6] https://www.federalreserve.gov/newsevents/pressreleases/other20240112a.htm

5. The Fiscal Theory of the Price Level is a logical fallacy

The Fiscal Theory of the Price Level (FTPL) (see *Cochrane 1999, 2001, 2005, 2023*) is a logical fallacy (see *Buiter 2002, 2021a, 2023*; *Buiter and Sibert 2018*). This is not a question of the FTPL being based on unrealistic assumptions or rejected by empirical evidence. The FTPL takes an identity – the IBC of the consolidated State (a weak inequality that holds for all possible values of the endogenous variables) – and imposes it, holding with equality, as an additional equilibrium condition, without also adding another endogenous variable. The IBC of the consolidated State says that the PDV of current and future real primary (non-interest) State budget surpluses, plus the PDV of current and future real net seigniorage revenue is at least equal to the real value of the outstanding stock of government non-monetary debt (bonds)[7]. Fiscal-financial policies that ensure that the ICB of the State is always satisfied are called Ricardian policies by *Cochrane*, and government fiscal and financial policies that are not required to always satisfy the IBC of the State – fiscal pathologies – are called *non-Ricardian* fiscal-financial policies.

Any economic model that is determinate without the IBC of the State, holding with equality, being treated as an equilibrium condition, becomes overdetermined (logically inconsistent) when the IBC of the State, holding with equality, is imposed as an equilibrium condition. This holds for all old-Keynesian and New-Keynesian models with sticky prices and/or sticky nominal wages. There is, however, a *nominal* indeterminacy associated with standard flexible nominal wage and price models where the monetary authority sets the short (nominal) interest rate, and the nominal money stock is endogenous. In this flexible price model, the real stock of money balances is determinate, but the price level and the nominal money stock are not. With the government pursuing a non-Ricardian fiscal-financial policy, the FTPL uses the IBC of the State, holding with equality, to determine the price level. The price level takes on the value required to ensure that the real value of the outstanding stock of non-monetary nominal government debt is equal to the PDV of current and future real government primary surpluses plus current and future real net seigniorage revenue. The IBC of the State is treated as a government debt valuation equation.

The FTPL does not render the flexible price model with an exogenous nominal interest rate overdetermined, but it creates anomalies that make no sense. First, the price level is again indeterminate if there is no nominally denominated government debt outstanding – if all government debt is index-linked or foreign-currency-denominated. Second, if there is a positive stock of nominal State bonds outstanding, the IBC of the State (holding with equality) determines the price level

[7] Cochrane (like most of the economic literature) treats central bank money as a true liability. The FTPL remains a logical fallacy.

(the reciprocal of the price of money) even if there is no money in the model either as a store of value or medium of exchange – money is a pure numeraire, like phlogiston. Third, if there is both nominal debt and index-linked debt (or foreign currency debt) outstanding, the price level determined by the IBC of the State can be negative[8]. Fourth, why restrict the debt valuation equation to the State? Households and firms have IBCs, and many could (and do) default on their debt. Why not have the Mrs Jones IBC Theory of the Price Level instead of the FTPL? Fifth, if the price level always assumes the value required for the IBC of the State to hold with equality, why are there sovereign defaults in the real world?

I am not arguing that it is inappropriate to treat the IBC of the State, holding with equality, as an equilibrium condition – a government debt pricing equation. It is inappropriate only if a suitable additional endogenous variable is not added as well. In *Buiter* (*2002*), I show that the additional endogenous variable is the "bond revaluation factor", the ratio of the market value of government bonds when there can be sovereign default, to their contractual value (what the market price would be if the IBC of the State were always satisfied). When the bond revaluation factor is introduced, the nominal indeterminacy reappears, even when the IBC of the State holds with equality.

That the FTPL is a logical fallacy matters for monetary and fiscal policy makers, because the FTPL may encourage reckless fiscal and financial behavior. No matter how large the stock of nominal public debt outstanding, and no matter how small the expectation of the PDV of current and future real primary surpluses and net seigniorage, there is never any risk of sovereign default. The general price level always takes on the value required to make the real value of the outstanding stock of nominal State bonds equal to what it must be for the IBC of the State to hold with equality. This could encourage fiscal profligacy and excessive public debt issuance.

6. Average inflation targeting is potentially costly economic nonsense

In August 2020, the Fed adopted a form of "average inflation targeting", called FAIT – flexible average inflation targeting (see *Clarida 2021* and *Buiter 2021b*). This followed an extended period (from late 2008 until early 2021), when inflation had been regularly below target (a 2-per cent annual rate for the core PCE index), and the Federal Funds Rate target zone was at or close to the ELB. FAIT implies that, to get the average inflation rate closer to the target, the Fed, following a period of below-target inflation, deliberately pursues a period of above-target inflation.

[8] Even if there is only a (positive) stock of domestic-currency-denominated public debt outstanding, the price level will be negative if the PDV of current and future real government primary surpluses plus current and future real net seigniorage revenue is negative.

Past inflation is a bygone and does not belong in the objective function of the central bank. Central bankers with a stable prices mandate should target current and anticipated future inflation. Of course, past inflation can influence current and future inflation and current expectations of future inflation. Price and wage contracts with lagged indexation clauses are one example. Past inflation can also impact expected future inflation, and thus actual future inflation. These indexation and expectation formation mechanisms should be modelled carefully and explicitly in the central bank's inflation models, even when the policy makers only target current and anticipated future inflation.

However, it was not plausible to argue in late 2020, that the only way to get inflation expectations on target following an extended period of below-target inflation, is by deliberately planning a period of above-target inflation. It surely matters why, in late 2020, inflation had been below-target for so long. The reason was a major weakening of the Fed's capacity to boost economic activity and inflation. This was caused by its inability to set the Federal Funds Rate (FFR) at a negative level potentially well below the ELB on nominal interest rates. The FFR instrument could only influence economic activity through forward guidance on additional FFR cuts in future periods when the ELB would no longer be a binding constraint. Only relatively ineffective instruments like Quantitative Easing remained available to stimulate economic activity and inflation. The Fed should be able to explain to most if not all economic actors, that the reason for the extended period of below-target inflation was that the ELB had been a binding constraint on the Fed's ability to boost economic activity and inflation. The Fed should also be able to explain that there is no Effective Upper Bound on the FFR. If inflation were to move above target (or threaten to do so), the FFR could always be raised to the level necessary to prevent serious and lasting overshooting of the inflation target. It makes no sense to compensate for an unavoidable past policy failure with an avoidable future policy failure. To argue that, following an extended period of ELB-driven undershooting of the inflation target, the only way to get inflation expectations on target is by deliberately overshooting the inflation target, makes sense only if either the relevant economic actors are not smart enough to understand the asymmetry in monetary policy effectiveness created by the ELB, or if the communication and explanatory skills of the Fed are seriously impaired. Fed Chairman Jerome Powell announced in his recent speech at Jackson Hall that as part of its 2025 wide-ranging 5-year Review of Monetary Policy Strategy, Tools, and Communications, the Fed will abandon FAIT (*Powell 2025*).

This issue would not have arisen, if there were no ELB. *Section 8* below explains why now is the time to abolish the ELB and how to do so.

7. The United States is on the road to fiscal dominance even with an operationally independent Fed

I consider it likely that before the end of President Trump's four-year term, inflation will be materially above the Fed's 2-per cent target. In this scenario, the Fed will knowingly set its policy rates below the level consistent with its price stability mandate. It will also knowingly engage in monetised purchases of US federal debt on a scale incompatible with its price stability mandate. This "fiscal dominance" will not be the result of a loss of Fed operational independence, or of a formal, legislated change in the monetary policy mandate of the Fed. Instead, fiscal dominance will be the result of the financial stability mandate of an operationally independent Fed taking precedence over its unchanged triple monetary policy mandate – maximum employment, stable prices and moderate long-term interest rates. The threat to financial stability would be material sovereign default risk triggered by increasingly unsustainable federal government debt and deficits.

There are three distinct drivers of fiscal dominance: brute force; a formal legal change in central bank objectives; and the central bank being able to meet its financial stability mandate only by knowingly engaging in a monetary policy that is more expansionary than is consistent with price stability.

7.1. Fiscal dominance through brute force

Fiscal dominance through brute force is unlikely in most advanced economies, including the United States. It occurs when the operational independence of the central bank is impaired or destroyed. The fiscal authority, backed by the president or prime minister, forces the supposedly operationally independent central bank decision-makers to keep policy rates lower and/or monetised public debt purchases higher than the central bank considers appropriate. One brute force mechanism is the fiscal authority replacing the central bank's operationally independent decision-maker(s) with appointees that will obey the fiscal authority even when this violates the mandate of the central bank.

Subject to one qualification involving foreign exchange market intervention, I consider the loss of operational independence by the Fed to be unlikely. It is, however, possible that the Treasury could force the Fed to set or target a path for the exchange rate that would be incompatible with the Fed's price stability mandate.

Foreign exchange rate targets (if there are any) are under the authority of the Treasury. The US Treasury states[9] that "The Secretary of the Treasury has the sole authority to establish the exchange rates for all foreign currencies ….".

[9] https://fiscaldata.treasury.gov/datasets/treasury-reporting-rates-exchange/treasury-reporting-rates-of-exchange

The Fed[10] confirms this: "The Department of the Treasury is the lead agency setting US international economic policy, including policies regarding the dollar." It then qualifies this by stating that "…neither the US Treasury nor the Federal Reserve targets a level for the exchange rate." This is correct today, but not during the Bretton Woods exchange rate regime (from the mid-1940s to the early 1970s), or earlier under the gold standard. It may not be true in the future.

For the US Treasury (on behalf of the President) to impair the operational independence of the Fed would require a majority of the 12 voting members of the Federal Open Market Committee (FOMC) to take orders from the White House. The voting members of the FOMC are the seven members of the Board of Governors of the Federal Reserve System and five of the presidents of the 12 regional Reserve Banks. Getting rid of the Chair of the Board of Governors would not give the President control over the Fed's monetary policy decisions.

Neither the President nor the Congress can fire (or appoint) any of the presidents of the regional Reserve Banks. The Board of Governors has the authority (never exercised) to terminate the appointment of a Reserve Bank president.

If departures from the Board of Governors are driven only by the legal term limits, two new members of the Board can be nominated by President Trump and confirmed by the US Senate.

The Federal Reserve Act[11] makes it clear that the President can remove any member of the Board of Governors of the Federal Reserve System "for cause".[12] "For cause" is a fuzzy legal concept meaning "because of inefficiency, neglect of duty, or malfeasance in office"[13]. Presumably, an independent third party (ultimately the Supreme Court) would have to decide whether the "for cause" clause has been met. There has never been a removal "for cause" of a Board member. If Trump fires Powell, the President can only appoint a successor (both as Board member and as Chair of the Board) with the consent of the Senate.

Firing Powell would still not give the President control over a majority of the 12 voting members of the FOMC. It could require firing (and replacing) a majority of the FOMC members (net of the two (soon to be three) current Board members that are significantly more dovish on inflation than Powell).

[10] https://www.federalreserve.gov/faqs/economy_12763.htm
[11] https://www.federalreserve.gov/aboutthefed/section10.htm
[12] Federal Reserve Act, Section 10, paragraph 2: https://www.federalreserve.gov/aboutthefed/section10.htm.
[13] https://columbialawreview.org/content/the-three-permissionspresidential-removal-and-the-statutory-limits-of-agency-independence/

7.2. Fiscal dominance through a formal change in the central bank's mandate

Fiscal dominance could also be achieved with an operationally independent central bank, if the targets or objectives of the central bank are not set by the central bank itself, that is, as long as there is no target independence. Qualitative objectives, such as full employment, price stability and financial stability, are generally set through legislation and can be changed only by a legislative majority. The FOMC did not explicitly set a numerical target for "stable prices" until January 2012. No numerical targets have been specified for maximum employment or moderate long-term interest rates. The ECB's Governing Council decides on the numerical interpretation of the Treaty-based price stability mandate. The Bank of Japan also sets its numerical inflation target. In the United Kingdom, the numerical target for the rate of inflation is set by the Chancellor of the Exchequer. Fiscal dominance through the legislature imposing a significantly more inflation-tolerant new mandate on the central bank is possible, but unlikely in most advanced economies, including the USA.

7.3. "Voluntary" fiscal dominance driven by fear of financial instability

Fiscal dominance when the central bank is operationally independent and has stable prices as one of its monetary policy objectives is possible when there is a threat of a systemic financial crisis. Financial stability is (and should be) the primary objective of the central bank. This is not always explicitly stated in the legislation that establishes the central bank and defines its objectives. The Bank of Japan Act[14] assigns the financial stability objective before the price stability objective — although it does not rank them. In the UK, the BoE is charged "to protect and enhance the stability of the financial system" (Bank of England Act 1998, Section 2a[15]). It also has several lexicographically ranked monetary policy objectives, with price stability ranked first (Bank of England Act 1998, Section 11[16]).

The Federal Reserve Act only mentions financial stability once, when it refers to the Financial Stability Act of 2010. The most recent statement of the financial stability responsibilities of the Fed can be found in the Financial Stability Act of 2010. It mentions the "Federal Reserve" 179 times.

The ECB's objectives, defined in Article 127(1) TFEU, are ordered lexicographically with price stability first. There are only two underwhelming references to financial stability in the Treaty. In its Financial Stability Review of November 2021, the ECB addressed the role of financial stability in the ECB's new monetary strategy.

[14] https://www.japaneselawtranslation.go.jp/en/laws/view/3788/en
[15] https://www.legislation.gov.uk/ukpga/1998/11/contents
[16] https://www.legislation.gov.uk/ukpga/1998/11/contents

A key statement[17] (missing from the Treaty) is "Financial stability is a precondition for price stability and vice versa."

A recent example of the primacy of the central bank's financial stability mandate was the (short-lived) malfunctioning of the UK's gilt market in the autumn of 2022. On 23 September 2022, Prime Minister Liz Truss and Chancellor of the Exchequer Kwasi Kwarteng proposed a "mini-budget" with wildly excessive government deficits. This triggered a sharp rise in long-term government bond yields which inflicted heavy losses on defined-benefit pension plans with liability-driven investment (LDI) strategies. On 28 September 2022, the BoE announced[18] it would engage in temporary purchases of long-dated UK government bonds to restore orderly market conditions. The key sentences in the announcement were: "The purpose of these purchases will be to restore orderly market conditions. The purchases will be carried out on whatever scale is necessary to effect this outcome." The willingness to intervene, if necessary, on any scale, made the BoE's intervention effective. The effectiveness, modest actual purchases and short duration of this financial-stability-driven intervention were no doubt boosted by the termination of the appointment of the Chancellor on 14 October 2022, after 38 days in office, and the resignation of the Prime Minister on 20 October 2022, after 45 days in office. The unprecedented early departure of the two most senior politicians responsible for the wildly unsustainable fiscal policies announced in the "mini budget" helped restore the credibility of more sustainable fiscal policies announced by their successors.

Unsustainable budgetary policies increase the likelihood of fiscal dominance as the independent central bank's least bad choice. I do not believe any central bank other than possibly the pre-euro era Bundesbank could credibly threaten not to engage in monetised purchases of sovereign debt on a scale that would cause materially above-target inflation, if not engaging in such monetised public debt purchases was likely to result in sovereign default.

The consolidated federal government and Fed non-monetary debt-to-GDP ratio at the end of 2024 was 87.3 per cent. The federal deficit in calendar year 2024 was around 6.8 per cent of GDP – a very high number, given that the economy was at full employment in peacetime. I expect a federal deficit for 2025 of well over seven per cent of GDP and rising in subsequent years. These public debt and deficits are unsustainable unless the neutral real rate of interest returns to its post-Great Financial Crisis (GFC) and pre-Covid levels of 0.5 per cent or less[19]. If fiscal unsustainability is not addressed promptly and effectively, monetised Fed purchases

[17] https://www.ecb.europa.eu/press/financial-stability-publications/fsr/focus/2021/html/ecb.fsrbox202111_08~d3131413c2.en.html
[18] https://www.bankofengland.co.uk/news/2022/september/bank-of-england-announces-gilt-market-operation#:~:text=On%2028%20September%2C%20the%20Bank,grounds%20at%20an%20urgent%20pace
[19] https://www.newyorkfed.org/research/policy/rstar

of US federal debt on whatever scale is necessary to restore orderly markets and prevent sovereign default could be huge and enduring, even though they are known by the FOMC to be inconsistent with the 2-per cent inflation target.

The fiscal unsustainability problems of the United States do not go away when instead of focusing mainly on government debt, we instead, as we should, focus on government net worth (see *Ball et al. 2024*). The balance sheet of the US federal government[20] as of 30 September 2024 shows total assets of USD 5.7 trillion. Total liabilities, however, are USD 45.5 trillion. The two largest liabilities are Federal debt and interest payable (USD 28.3 trillion), which is included in the conventional debt and cash-focused government accounts, and Federal employee and veteran benefits payable (USD 15.0 trillion), which is not included in the conventional government accounts. The total net position (net worth) of the federal government is −USD 39.9 trillion, −136.6 per cent of 2024 GDP.

If the real commercial assets of the federal government were managed well and valued properly (as the expected PDV of their current and future earnings), the net worth of the federal government would certainly be less disastrous. Despite DOGE, both more efficient management and better valuation of real commercial assets are unlikely in the foreseeable future.

Unless the dysfunctional political system of the US undergoes major reforms that result in some combination of material increases in tax revenues, reductions in public spending and more efficient management of public real assets, the likelihood of fiscal and financial turmoil will increase rapidly. There is also a small risk of a "technical" and short-lived sovereign default if the US Congress fails to raise, extend or revise the federal debt limit on time. Congress has acted 78 times since 1960[21] to prevent a violation of the debt limit and most likely will do so again when required. A US federal solvency crisis, if it occurs, will be driven by the fundamentals of fiscal unsustainability, even if the debt ceiling were abolished.

If a debt crisis occurs, and if there is no Truss-Kwarteng-style early resolution of the worst fiscal excesses, the Fed will have to choose between persistent large-scale monetised purchases of public debt that will cause above-target inflation and sovereign default followed by a domestic and global financial crisis. They will opt for above-target inflation.

[20] https://www.fiscal.treasury.gov/reports-statements/financial-report/balance-sheets.html
[21] https://home.treasury.gov/policy-issues/financial-markets-financial-institutions-and-fiscal-service/debt-limit

8. Time to become positive about (potentially deeply) negative interest rates

It is time to undertake the one financial reform required for the central bank to be able to set possibly deeply negative policy rates. This is necessary, because the drivers of appropriate future central bank policy rates are likely, at times, to point again to the desirability of significantly negative policy rates – rates that cannot be achieved as long as the ELB is in effect. The removal of the ELB may also eliminate one of two obstacles to operationalising the targeting of price stability by setting an inflation target of zero per cent rather than two per cent (in most advanced economies) or higher (in some emerging markets). When there is an ELB for the policy rate, a higher inflation target makes it less likely that this ELB will become a binding constraint on the central bank's ability to stimulate aggregate demand and boost inflation. The other argument for a target inflation rate higher than zero per cent is that real world price indices overstate the true increase in the cost of living. The CPI, for instance, considers the change in the average price of a fixed bundle of goods and services, thus omitting substitution effects. It is also unlikely that any price index fully captures quality improvements. The "inflation bias" argument for targeting a positive rate of inflation remains valid even if the ELB is eliminated. Whether the "inflation bias" is two per cent remains an open question.

The argument that negative interest rates are ineffective is wrong for three reasons. First, we have not seen deeply negative nominal interest rates. The Swiss National Bank and Danmarks Nationalbank had policy rates at –0.75 per cent. The Sveriges Riksbank's lowest policy rate was –0.50 per cent, although its lowest deposit rate was –1.25 per cent. The ECB set a Deposit Rate of –0.50 per cent. The Fed never cut the FFR target zone below 0.00 per cent to 0.25 per cent. The Bank of England's lowest Bank Rate was 0.10 per cent.

Second, the reason these de minimis negative central bank policy rates were not fully passed through to private borrowing and lending rates was the ELB, created by the existence of central bank paper currency – an alternative liquid asset with a zero nominal interest rate and modest carry costs of paper currency.

Third, the argument that negative nominal interest rates have a negative impact on private sector confidence has no robust empirical foundations. It would be irrational. There is nothing unnatural about negative nominal interest rates. Negative real interest rates have been a common phenomenon (see *Rogoff et al. 2022*). The near absence of negative nominal rates is an ELB-driven anomaly.

The argument that quantitative easing (QE) at the ELB can be as effective as more deeply negative interest rates in stimulating aggregate demand is unconvincing. QE was often accompanied by (changes in) forward guidance about the policy

rate. The identification of the impact of central bank asset purchases alone, is therefore difficult. It likely did contribute to significant bubbles in risk asset markets and encouraged excessive federal debt issuance. In small, open economies with a floating exchange rate, asset sales and purchases through foreign exchange market interventions can be viewed as another form of QE. When the monetary authorities wish to weaken the domestic currency and the domestic policy rate is at the ELB, the authorities can engage in purchases of foreign exchange and sales of the domestic currency of any desired magnitude. Whether such "international QE" is more effective than standard domestic QE is an open question.

Negative nominal policy rates can be desirable for a combination of four reasons: (1) a low neutral real rate; (2) weak economic activity (a negative output gap); (3) below-target inflation; and (4) an excessively strong exchange rate. The first three drivers of the appropriate policy rate are summarised neatly in the Taylor Rule (*Taylor 1993*): the nominal policy rate equals the neutral real rate plus the target rate of inflation, plus a constant (typically set at 0.5 or 1.0) times the proportional output gap, plus a constant (typically set at 1.5) times the difference between the actual and the target inflation rates.

The Taylor Rule omits the strength of the exchange rate as a driver of a lower policy rate. For the US, this may not be an issue. For a small and wide-open economy, such as Switzerland, Denmark or the Czech Republic, the exchange rate is a key driver of the central bank's policy rate. The Taylor Rule also does not allow for any impact of financial stability considerations on the policy rate.

How likely is it that the Taylor Rule will call for nominal policy rates below the deepest negative level that can be achieved when there is an ELB? *Rogoff et al.* (*2022*) establish a persistent downward trend (spanning over seven centuries) in long-maturity real interest rates for the advanced economies they study. Taylor's estimate of two per cent for the neutral real interest rate in 1992 is generally thought to be materially higher than its value in the decade following the GFC; 1.0 per cent (or even 0.5 per cent) would not be an unreasonable benchmark.

The US output gap[22] was deeply negative on several recent occasions (–5.3 per cent in 2009 Q1 and –9.1 per cent in 2020 Q2). The US annual PCE inflation rate[23] has been below the 2.0-per cent target for many quarters between 2008 and 2021, and even below 1.0 per cent and 0 per cent on some occasions.

Based on these data, our version of the Taylor Rule could easily generate a policy rate of –3.5 per cent or even –5.0 per cent.

[22] https://fred.stlouisfed.org/graph/?g=f1cZ

[23] https://apps.bea.gov/iTable/?reqid=19&step=3&isuri=1&1921=survey&1903=11#eyJhcHBpZCI6MTksInN0ZXBzIjpbMSwyLDMsM10sImRhdGEiOltbIk5JUEFfVGFibGVfTGlzdCIsIjQyNCJdLFsiQ2F0ZWdvcmllcyIsIlN1cnZleSJdLFsiRmlyc3RfWWVhciIsIjIwMDciXSxbIkxhc3RfWWVhciIsIjIwMjQiXSxbIlNjYWxlIiwiMCJdLFsiU2VyaWVzIiwiTSJdXX0=

I propose the elimination of the ELB through the abolition of fiat physical currency and its replacement by an interest-bearing retail central bank digital currency (CBDC) which allows for online and offline transactions and does not impose limits on the size of CBDC deposits or transactions. There are no valid economic arguments against this. It could well reduce private demand for commercial bank deposits (checking accounts). If this is deemed to be a problem (because it reduces potentially valuable financial intermediation by commercial banks), this can be addressed by the central bank depositing with commercial banks the receipts from CBDC issuance in excess of the pre-CBDC issuance of paper currency.

A political argument against getting rid of coins and paper currency is based on the privacy they offer. There is merit to this concern, although the privacy and anonymity of physical fiat currency encourage criminal and illegal activities (*Rogoff 2017*). It would be possible for a CBDC to provide the limited anonymity provided by Bitcoin and other cryptocurrencies. If the interest-bearing CDBC were put on a permissionless blockchain, the identity of the beneficial owners of the wallets on the blockchain would be private, although the transactions would not be.

Another argument in favour of retaining physical fiat currency is that some people are unbanked and rely on paper currency as their only means of payment. Cash cards and mobile wallets that support online and offline transactions can provide adequate means of payment for those who rely on physical currency.

It is incomprehensible that leading central banks, including the Fed and the ECB, have said that, if they introduce a retail CBDC, it will be non-interest-bearing, and that there will be a cap on the size CBDC accounts. They also promised that central bank paper currency would not be abolished. Could central banks be scared of imposing deeply negative interest rates on households and firms? This would indeed hurt savers. Fear of hurting borrowers, however, has not stopped central banks from setting steeply positive policy rates. I believe this position of the leading central banks is deeply misguided. They reject the opportunity to eliminate the ELB.

9. Conclusions

The paper develops seven propositions:

1. The central bank is a fiscal and financial agent of the government, its beneficial owner. Their accounts should be consolidated for fiscal sustainability analysis and policy design. There should be no private ownership of central bank equity because this can create confusion about whose interests are served by the central bank.

2. Central bank money is a liability in name only.

3. Central bank profits and losses should be treated symmetrically by the government. Central banks can be equitably solvent even when they have persistent negative conventional equity. Very deeply negative conventional equity may require recapitalisation by the government, if avoiding central bank equitable insolvency would require central bank money creation of a magnitude inconsistent with the price stability mandate.

4. The fiscal theory of the price level is a logical fallacy.

5. Average inflation targeting is potentially costly and questionable from an economic perspective.

6. Central banks may monetise public debt to prevent sovereign default and financial instability even when this is incompatible with price stability.

7. The effective lower bound must be eliminated by abolishing paper currency and creating an interest-bearing retail central bank digital currency.

Both the economics and the politics of central banking remain fascinating subjects.

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How Close Is China's Medium-Term Outlook to That of Japan? An Economic-Historical Perspective*

Alicia Garcia Herrero

After decades of strong growth, China's economy began a steady slowdown around 2012. Current GDP growth is less than half of previous levels, and the trend is expected to continue. Since its real estate bubble burst in mid-2021, deflationary pressures have raised concerns that China may follow Japan's trajectory from the early 1990s. Both countries show similar structural traits: low private consumption, high savings and significant economic imbalances – China's even more so. Their policy responses have also mirrored each other: slow monetary and fiscal easing, focus on manufacturing and reliance on trade surpluses, prompting US protectionist reactions. Like Japan, China is offshoring production to counteract trade barriers. However, China differs in key ways: it is still a developing economy with more room for growth and is a far stronger geopolitical force than Japan was. This power both motivates US technological restrictions and gives China broader global leverage, especially in the Global South. Whether China will repeat Japan's path remains a crucial, open question.

Journal of Economic Literature (JEL) codes: E20, E32, E44, F41

Keywords: China, Japan, economy, lost decade, savings, imbalances

1. How to evaluate China's medium-term outlook, in particular whether it is replicating Japan's lost decade?

Since peaking at a remarkable growth rate of 14 per cent in 2007, China's economy has experienced significant slowdown, gradually decelerating to 6 per cent in 2019 and dropping even faster during the COVID-19 pandemic and thereafter. Growth now is barely 5 per cent, at least according to official statistics, and is even less (4.2 per cent) in nominal terms because of the negative growth in the GDP deflator (i.e. when inflation is taken into account). Such a rapid economic slowdown and other

* The papers in this issue contain the views of the authors which are not necessarily the same as the official views of the Magyar Nemzeti Bank.

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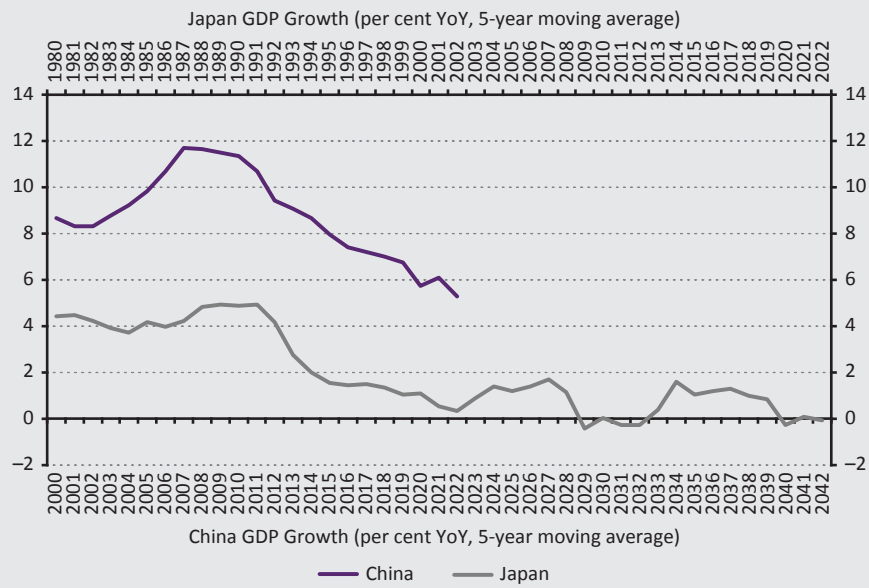
factors, such as the collapse of the real estate sector,[1] is behind the increasingly frequent comparison to Japan's experience in the 1990s, often referred to as 'the lost decade' (*Figure 1*).

Figure 1
Comparison of GDP growth rates of China and Japan



Note: Due to the temporal offset of the similar economic patterns observed in the two countries, I apply dual horizontal axes to align comparable trends. The upper time axis refers to Japan, while the lower axis corresponds to China.

Source: Natixis, CEIC

From this, the question arises: if Japan's experience then is comparable to China's today, does it offer a guide to understanding the future of the Chinese economy? Numerous studies have examined the explanations for Japan's lost decade, including fiscal inadequacy (*Kuttner and Posen 2002*), insufficient monetary policy and the liquidity trap (*Bernanke 1999*; *Leigh 2010*), the role of financial intermediation (*Kwon 1998*; *Ogawa and Suzuki 1998*), and the overinvestment that preceded Japan's lost decade and led to a low rate of return on capital (*Bayoumi 2001*).

[1] See for example Bloomberg News: '*China's Property Crisis Enters a Dangerous New Phase*', 11 February 2025. https://www.bloomberg.com/news/features/2025-02-11/china-s-real-estate-crisis-property-sector-debt-is-getting-worse.

In a seminal paper, *Hayashi and Prescot* (*2002*) took a long-term perspective on Japan's economic slowdown and argued that the fundamental driving force was the transition to a new, lower growth path, brought about by a decline in total factor productivity (TFP). *Griffin and Odaki* (*2009*) meanwhile showed that the lack of exits by the least-productive firms, and the lack of entries by small productive firms, reduced TFP growth during the 1990s, but there was no strong evidence of misallocation of resources across incumbent firms. The finding seemed to suggest the lack of a creative-destruction process during Japan's lost decade. An econometric analysis by *Imai et al.* (*2017*) further found that the decline in Japan's export competitiveness during the 1990s could be attributed to a decrease in innovation and growth in export industries.

Japan's economic success after the Second World War, which resulted in it challenging the US economy in the 1980s, has received attention in China and beyond as a potential comparison to China's economic success. This is even more the case recently as Japan went through the build-up of a real estate bubble and its bursting ten years later, which resonates with what has been happening in China in the last two decades. *The question then is whether China, like Japan, will also experience a prolonged slowdown following a period of rapid growth?*

China observers have compared the experiences of the two countries carefully. *Weede* (*2004*) reviewed Japan's and China's development models (see also *Nogimori 2023*), while *Wu* (*2023*) focused on the differences. *García Herrero and Iwahara* (*2024*) looked at the lessons from China from the real estate collapse in Japan.

In this paper, I take a broader perspective by focusing on the savings-investment patterns of China and Japan, showing how Japan's macroeconomic imbalances in the 1980s are comparable to those of China in the 2000s when its imbalance was built up. I also examine similarities in terms of real estate bubbles, demographics and deflationary pressures), and some significant differences – especially China's military and geopolitical power and leading position in the Global South.

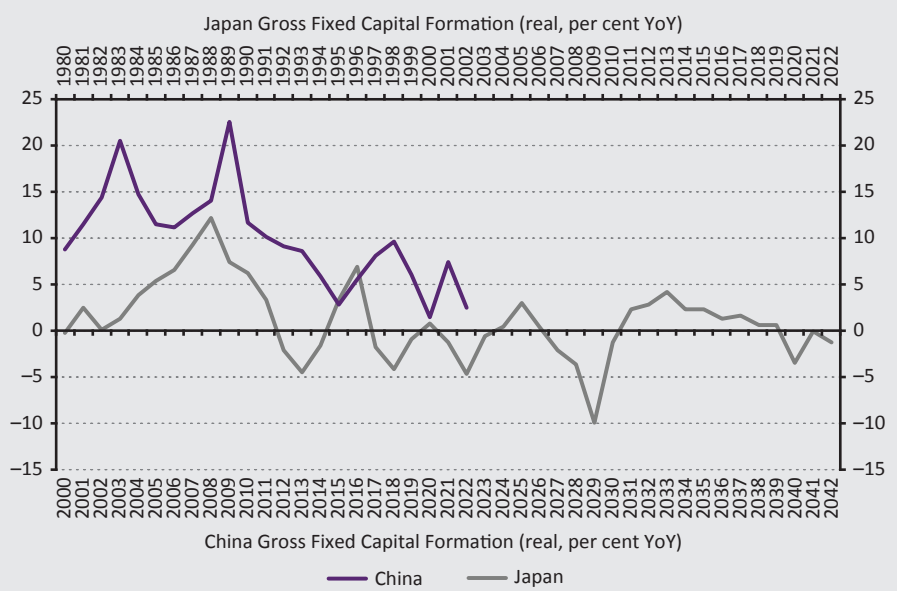
2. Savings-investment patterns

China and Japan have both had large macroeconomic imbalances with high savings and relatively low investment. That domestic savings could fully finance even high levels of investment and still leave excess savings made it easy for both countries to ride on an investment boom financed by artificially low interest rates. High investment was also accompanied by low private consumption in both countries.

Growth in Japan's fixed asset investment (FAI) rate declined sharply from an average of 4.7 per cent in the 1980s to only 0.34 per cent in the 1990s. In China, the growth in FAI reached 14.2 per cent after its accession to the World Trade Organisation (WTO) in 2001, fed not only by foreign direct investment in setting up manufacturing plants in China, but also by infrastructure investment (*Figure 2*). Subsequently, in the 2010s, China's growth rate slowed to 7.7 per cent following the slowdown of the real estate sector.

Japan's real estate sector experienced an increase in value added of 3.7 per cent in the 1980s, but this slowed considerably to 2.1 per cent in the 1990s. China's real estate value-added grew by 10.7 per cent in the 2000s, but this also slowed, reaching 5.11 per cent in the 2010s (*Figure 2*). The trend looks similar, but investment growth in China was always higher than in Japan, which explains why Chinese GDP growth always exceeded Japan's. It is also true that China's starting point, in terms of income per capita, was lower than Japan's, meaning China had more space for growth convergence, starting with a lower level of urbanisation.

Figure 2
Gross fixed capital formation

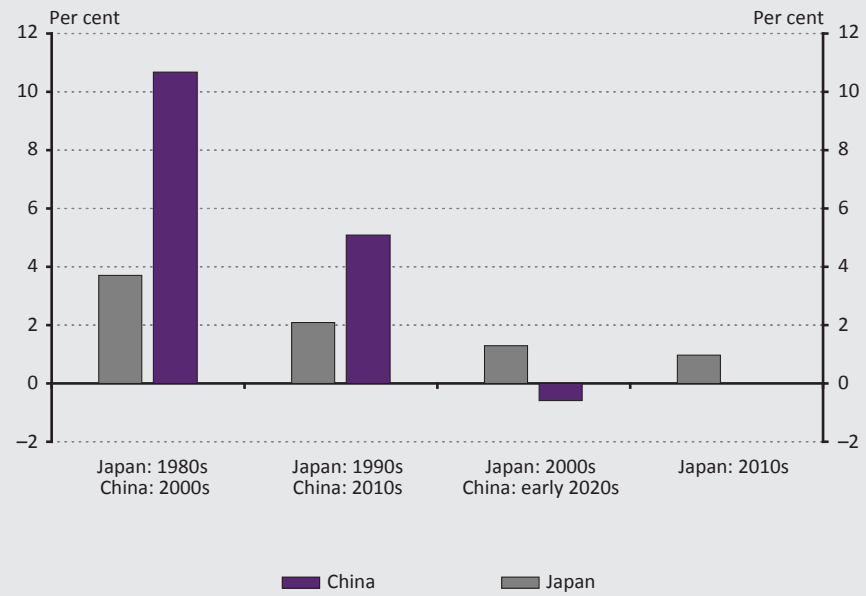


Note: Due to the temporal offset of the similar economic patterns observed in the two countries, I apply dual horizontal axes to align comparable trends. The upper time axis refers to Japan, while the lower axis corresponds to China.

Source: Natixis, CEIC

That said, China's real estate market adjustment has been more rapid than Japan's, raising concerns about a potential 'hard landing' in China's case[2] (*Figure 3*). The main risk appears to be associated with significant local government debt, in particular unofficial debt through local government financing vehicles (LGFVs) (*Tao 2015*). Although policymakers have taken steps to mitigate these risks, the lingering imbalances suggest that the financial system has not entirely stabilised. Japan's financial sector was mainly hit by the real estate crisis and the deleveraging of the corporate sector, less so by its local finances. Thus, the main sources of financial risk in Japan and China were and are somewhat different.

Figure 3
Real estate value added

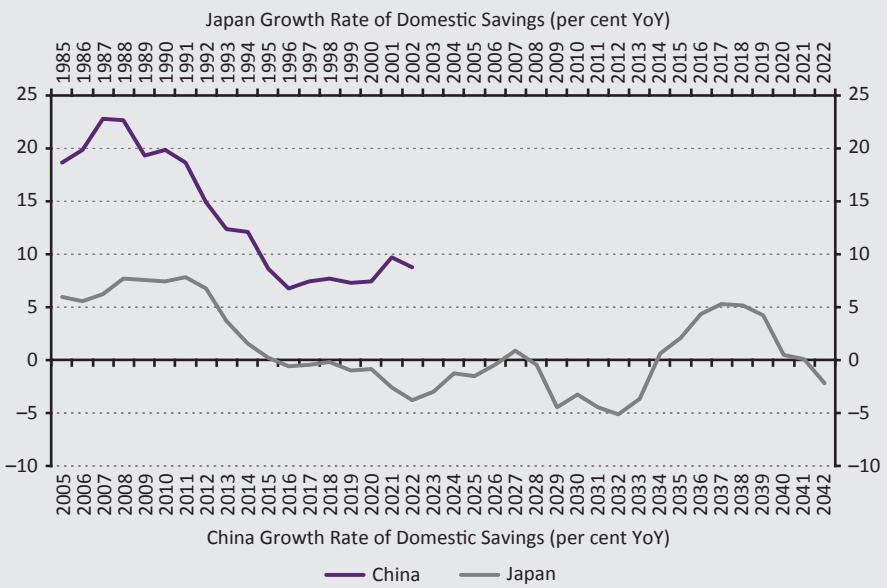


Source: Natixis, CEIC

[2] For example, *Ann Stevenson-Yang*: '*Soft or Hard? China's Property Sector Is Coming In For A Landing*', *Forbes*, 17 January 2022, https://www.forbes.com/sites/annestevenson-yang/2022/01/16/soft-or-hard-chinas-property-sector-is-coming-in-for-a-landing/.

Generally, a decline in investment typically leads an economy to rely more on consumption, reducing the incentive for saving. This was what happened in Japan in the 1990s. Japan's total savings growth rate dropped from nearly 8 per cent to negative levels during the economic deceleration of the 1990s (*Figure 4*). This was mainly caused by plunging fiscal revenues and deflationary pressures, which led to the deterioration of fiscal accounts well beyond the effects of corporate deleveraging during the so-called 'balance sheet recession'[3]. China has undergone a similar trajectory since 2008, but with a lesser decline in savings. Now, China continues to rank significantly above other major economies in terms of its savings-to-GDP ratio (*Figure 5*), even after the economic slowdown, which has already to some extent corrected the savings-investment imbalance.

Figure 4
Growth rate of domestic savings

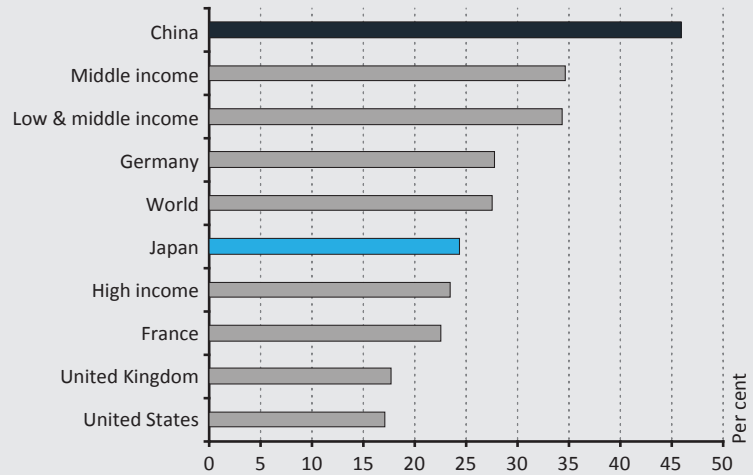


Note: Due to the temporal offset of the similar economic patterns observed in the two countries, I apply dual horizontal axes to align comparable trends. The upper time axis refers to Japan, while the lower axis corresponds to China.

Source: Natixis, CEIC

[3] The term 'balance sheet recession' refers to a prolonged period of economic stagnation in which private sector firms and households prioritise debt reduction (deleveraging) over investment and consumption, often following a financial crisis. This leads to subdued aggregate demand, deflationary pressures, and a weak economic recovery despite accommodative monetary policies. The concept was popularised by economist Richard Koo in the context of Japan's post-bubble economy in the 1990s (see *Koo 2023*).

Figure 5
Saving rate in major economies in the early 2020s



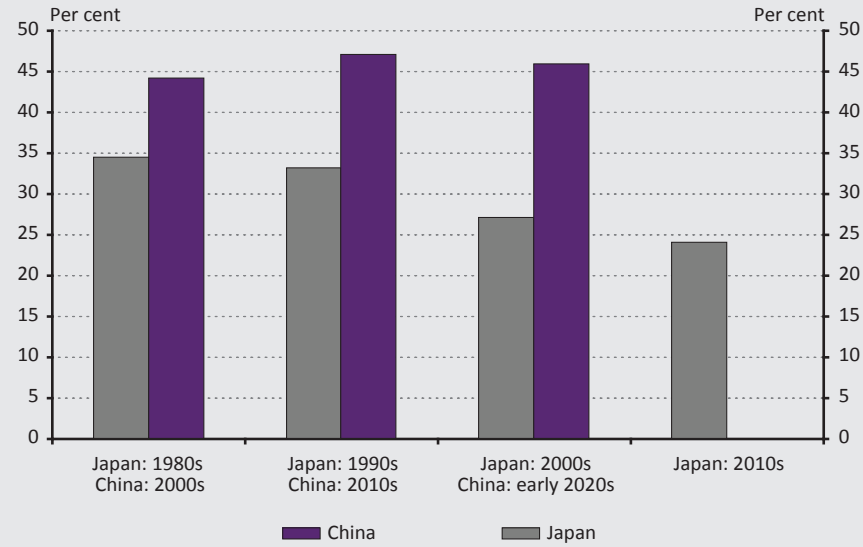
Source: Natixis, CEIC

The reasons for China's massively high savings, even surpassing Japan's, are partially related to the lack of a welfare state or, in other words, a public insurance mechanism (*Yang 2012*). Private insurance remains rather limited, even after the reform of China's financial sector which started in the 1990s under Premier Zhu Rongji. Beyond these factors, the high degree of uncertainty about the geopolitical environment, especially since President Donald Trump's first term and the ensuing US policies to contain China, as well as the COVID-19 pandemic, also explains why Chinese households take a precautionary perspective and still maintain higher levels of savings.

All in all, both China and Japan have experienced significant decreases in investment, but while Japan achieved a gradual shift from an investment-driven to a consumption-driven growth model, China has barely reduced its imbalances, characterised by high excess savings (*Figure 6*) and low private consumption.

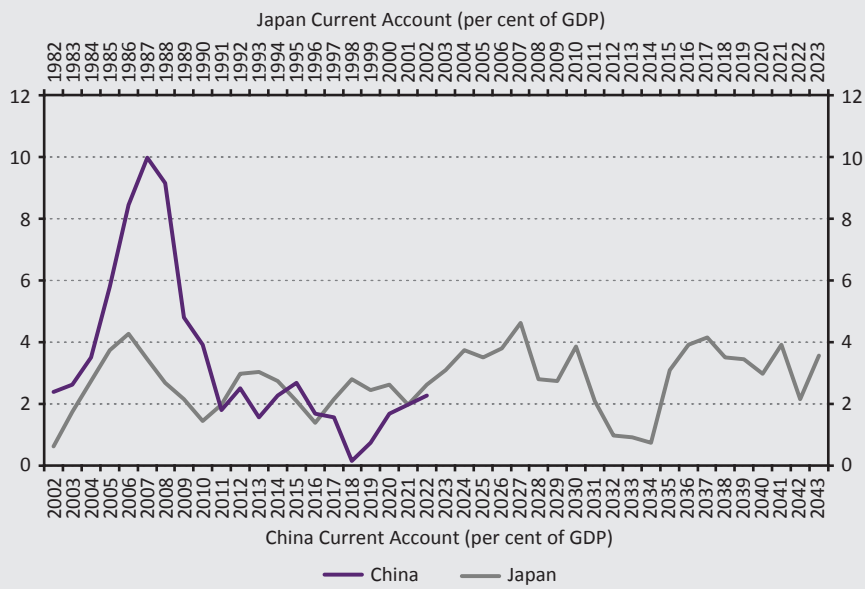
Consequently, China's savings rate continues to exceed its investment rate, leading to a persistent current account surplus. This outcome contrasts with earlier expectations that the surplus would decline as China's GDP per capita rose and imports increased, driven by a growing middle class seeking high-end consumer goods. China's current account ratio has plateaued at approximately 2 per cent, resembling Japan's situation in the early 2000s (*Figure 7*).

Figure 6
Savings rate in China and Japan



Source: Natixis, CEIC

Figure 7
China and Japan's current account



Note: Due to the temporal offset of the similar economic patterns observed in the two countries, I apply dual horizontal axes to align comparable trends. The upper time axis refers to Japan, while the lower axis corresponds to China.

Source: Natixis, CEIC

Finally, the containment strategy towards China adopted by both President Trump and President Biden mirrors Japan's experience in the late 1980s. In Japan's case, this containment was primarily economic, focusing more on trade than technology, as Japan had not re-established military capabilities following its defeat in the Second World War. The United States engaged in trade negotiations that heavily favoured American interests, capitalising on its significant bilateral deficit with Japan, particularly in the automobile and electronics sectors. The US also implemented tariffs and quotas on Japanese imports and pursued voluntary export restraints on specific products. In addition, the US targeted Japan's semiconductor industry, exemplified by the 1986 US–Japan Semiconductor Trade Agreement,[4] which aimed to boost the market share of American companies. The US also pushed Japan to appreciate the yen through the Plaza Accord[5].

The US containment strategy toward China has unfolded differently. Unlike Japan, China is perceived by the US as presenting not only an economic threat, but also military and security challenges. As a result, economic containment, such as the trade measures during President Trump's first term (*Dadush 2019*) and now being substantially reinforced during his second term, represents just one part of a broader strategy. US containment of China has also expanded rapidly to encompass technology, particularly dual-use technologies, with stringent export controls on critical sectors including advanced semiconductors. The overarching goal of the US regarding China is much more comprehensive than it was with Japan, as the US seeks to maintain its hegemonic position globally.

3. Some important lessons from Japan

3.1. The Bank of Japan's role in the bursting of Japan's bubble

With the benefit of hindsight, the BoJ's response to the equity and real estate bubbles in the 1980s was too little and too late, and possibly also a bit erratic. After lowering the policy rate from January 1986 to support growth, the Bank finally tightened from May 1989 to cool the overheating economy and stem off pressure from the bubbles (*Figure 8*). Although headline inflation was stable, bank loans accelerated by about +10 per cent annually and asset prices more than doubled during the same period. As macro-prudential policy was hardly developed at the time, the BoJ delayed responding to increasing macroeconomic imbalances.

[4] See *Statement on the Japan-United States Semiconductor Trade Agreement*, 31 July 1986, Ronald Reagan Presidential Library and Museum, https://www.reaganlibrary.gov/archives/speech/statement-japan-united-states-semiconductor-trade-agreement.

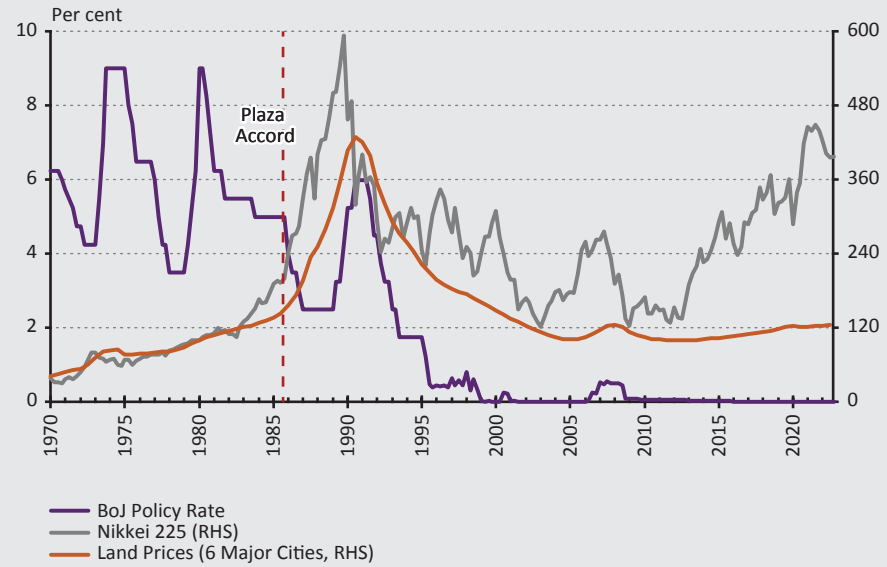
[5] See *Announcement the Ministers of Finance and Central Bank Governors of France, Germany, Japan, the United Kingdom, and the United States (Plaza Accord)*, 22 September 1985, https://g7.utoronto.ca/finance/fm850922.htm.

The BoJ was also slow to react to the sharp decline in equity prices. After the Nikkei stock index dropped by 38 per cent from the peak in December 1989, the Bank finally responded by lowering the policy rate by 50 bps in July 1991. The BoJ also took more than four years to lower the policy rate to 0.50 per cent in September 1995, because it was concerned that the monetary easing would reignite the real estate bubble. This gradual easing was not enough, as monetary conditions remained tight in the second half of 1990s. The "Japan premium" increased Japanese banks' financing cost in the international market and the Japanese yen steadily appreciated, when banks finally began to clean up their balance sheets.

After the policy rate reached 0.0 per cent in February 1999, the BoJ was confronted with the zero nominal lower bound, a belief that the policy rate cannot fall below 0.0 per cent. The monetary policy was still considered restrictive, as deflation lifted the real interest rate to about 1 per cent when the neutral rate was generally believed to have fallen below 0.0 per cent (*Figure 9*).

Finally, the BoJ introduced unconventional policy tools to address the zero nominal lower bound from 1999. At that time, the Bank declared it would keep the policy rate at 0.0 per cent until the prospect of ending deflation became clear, which is known today as forward guidance. Subsequently, the BoJ launched quantitative easing in 2001, by massively purchasing short-term government securities to expand banks' reserves on the BoJ's balance sheet. After introducing the Quantitative and Qualitative Monetary Easing (QQE) in April 2013 with the intention to lower the long-term bond yield and to reduce risk premiums in the equity and real estate markets, the BoJ expanded the framework by lowering the policy rate to –0.1 per cent (QQE with a Negative Interest Rate) in January 2016 to encourage banks to expand lending. In September 2016, the policy tool was re-framed by adding the Yield Curve Control (QQE with YCC) with a focus to maintain the 10-year Japanese Government Bond (JGB) yield at around 0 per cent, to lower the bond yield across the yield curve. While these policy responses ended up with a sharp increase in the size of the BoJ's balance sheet above 100 per cent of GDP, the highest among major central bank, the BoJ finally began to see the light at the end of the tunnel on deflation in early 2022.

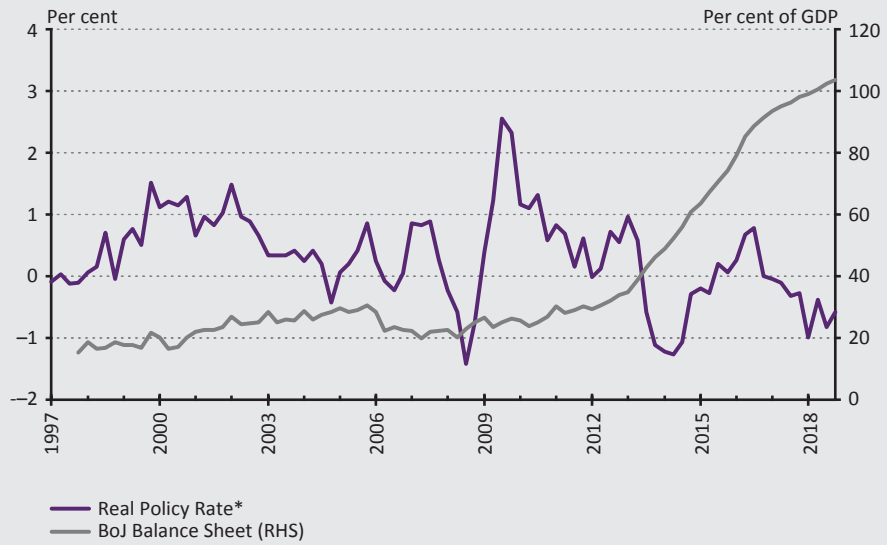
Figure 8
Japan: BoJ & asset prices



Note: On the right-hand scale: 1980Q1=100.

Sources: INDB, NATIXIS

Figure 9
Japan: BoJ policy rate & balance sheet



*Note: *Adjusted for VAT hike*

Sources: NATIXIS, INDB

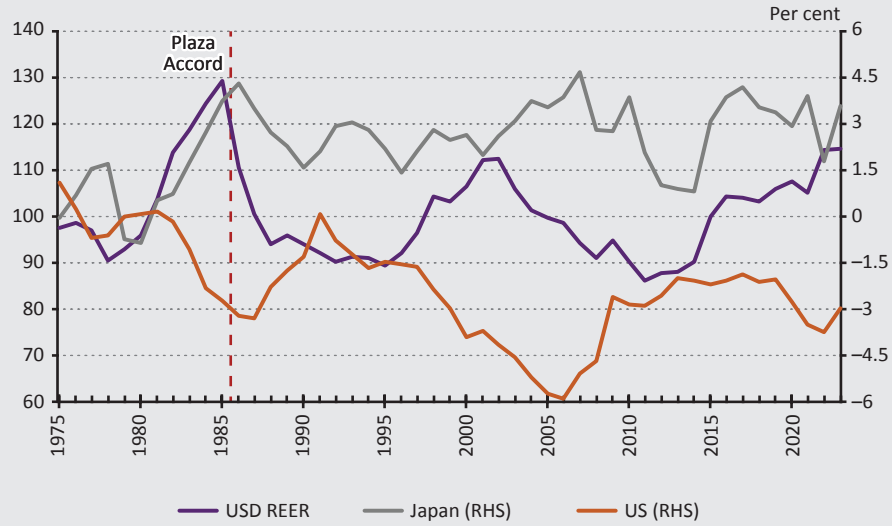
3.2. Yen appreciation: a structural factor behind Japan's lost two decades

The Plaza Accord in 1985 was arguably an important turning point for the Japanese economy. From the early 1980s, high interest rates and large fiscal deficits under the Reagan administration resulted in an appreciation of the US dollar. It was also widely argued that tight regulations in Japan prevented capital inflow, which undervalued the Japanese yen. As a consequence, the USD real effective exchange rate (REER) appreciated by about 25 per cent from 1981 to 1985, which in turn expanded Japan's current account surplus and the US's deficit (*Figure 10*). To alleviate the macroeconomic imbalances, in September 1985 Japan signed the Plaza Accord to devalue the US dollar along with the G5 nations. As the central banks coordinated interventions in the foreign exchange market, the yen rapidly appreciated from USD/JPY=237.1 in August 1985 to USD/JPY 139.7 in April 1987 (*Figure 11*). To counterbalance the severe headwinds for exports and to support growth, the Bank of Japan (BoJ) slashed the policy rate from 5.00 per cent in 1985 to 2.50 per cent in February 1987. The monetary stimulus ended up fuelling optimism on the Japanese economy, which ultimately resulted in twin bubbles in the real estate and equity markets.

After the bubble burst around 1990, the strong yen weighed on the economic recovery through different channels, characterising Japan's lost two decades. The appreciation of the yen not only reduced exports but also increased competition with cheaper import products from Asia. As domestic demand also stagnated during the post-bubble period, corporate profitability deteriorated further, reducing nominal wages, which in turn led to falling inflation. As deflation became embedded in expectations, manufacturing companies reduced investments due to the higher real interest rate, while expanding foreign direct investment in Asia, which resulted in the hollowing out of the Japanese economy. These developments complicated the BoJ's policy decisions after lowering the policy rate to 0.0 per cent in 1999.

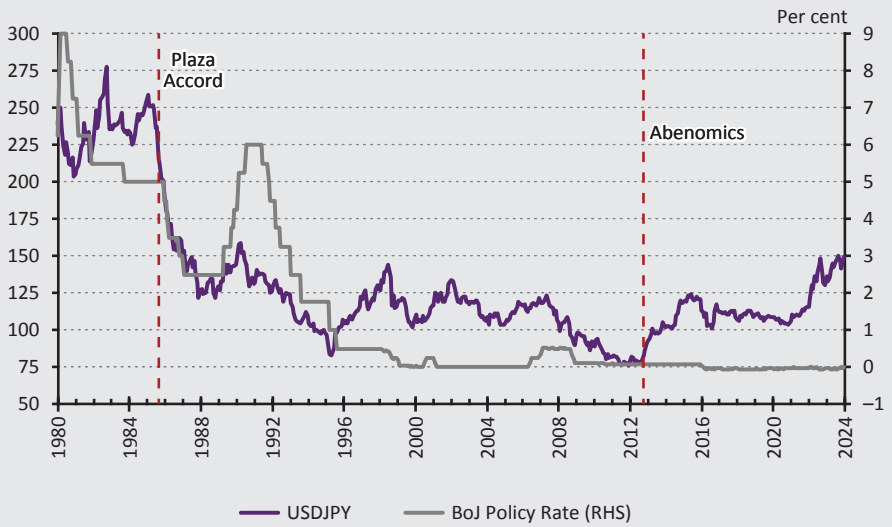
The trend in the yen finally reversed after the BoJ raised the inflation target to 2 per cent from 1 per cent in January 2013. While the monetary policy with the Quantitative and Qualitative Monetary Easing (QQE) under Abenomics depreciated the yen to around USD/JPY=115, the momentum accelerated from early 2022 on the back of a widening monetary policy differential between the US Federal Reserve (Fed) and the BoJ. While the Fed tightened to contain surging inflation, the BoJ kept its monetary policy accommodative to meet the 2-per cent inflation target in the medium term.

Figure 10
Japan: REER and current account (GDP ratio)



Sources: Datastream, NATIXIS

Figure 11
Japan: BoJ policy rate and exchange rate



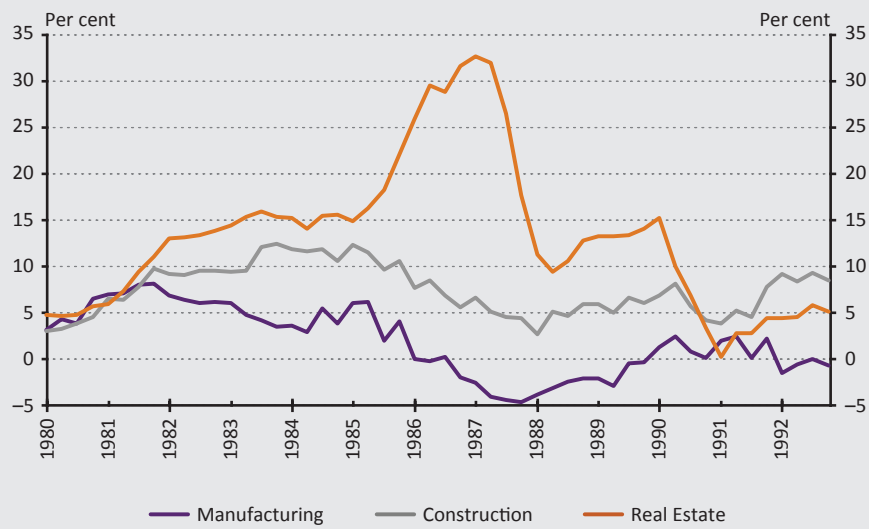
Sources: NATIXIS, INDB

3.3. Japanese banks: Decade-long trial and error to heal from the housing market crisis

In the 1980s, Japanese banking policies became increasingly misaligned, contributing to a significant asset bubble. Following financial deregulation, large companies began raising money from financial markets, reducing their dependency on banks. This pushed banks to find a new customer base, leading them to lend aggressively to the real estate sector. The Ministry of Finance's "convoy system," which ensured failing banks were merged rather than allowed to go bankrupt, further encouraged this reckless behaviour by increasing moral hazard.

The real estate sector was central to the bubble, underpinned by the "myth of land" – the belief that land values would never fall. After the Bank of Japan expanded monetary policy following the 1985 Plaza Accord, real estate prices tripled. In this frenzied environment, banks aggressively expanded loans to the real estate sector, often using the appreciating land as collateral (*Figure 12*).

Figure 12
Japan: bank loans by sectors (YoY)

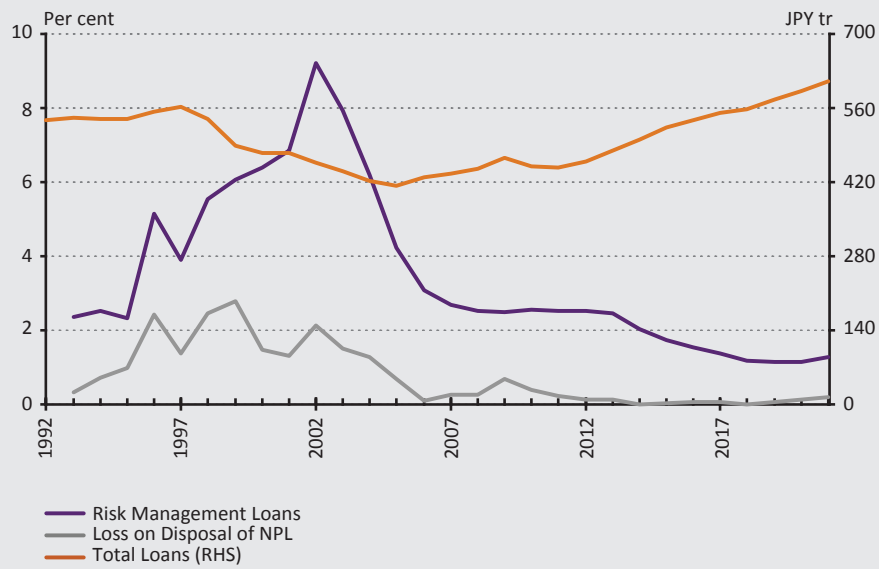


Sources: INDB, NATIXIS

When the bubble burst in the early 1990s, banks were slow to respond. Confident in the "myth of land," they expected a temporary price dip and refrained from writing off non-performing loans (NPLs), making inadequate provisions. This inaction was compounded by lax accounting rules and the belief in an eventual government bailout under the convoy system. As a result, banks continued to lend to "zombie" real estate and construction firms while restricting credit to new, productive sectors, which damaged Japan's economic productivity.

The 1997 financial crisis, which saw a major bank fail, was a crucial turning point. It became clear the government could not bail out all institutions. In response, Japan introduced legal frameworks like the 1998 Financial Revitalisation Law and the 2002 Financial Revitalisation Programme, shifting from discretionary policy to a law-based system and ending the convoy system. This forced banks to properly assess creditworthiness and write off NPLs. Consequently, bank loans finally bottomed out around the mid-2000s, a full decade after the bubble's collapse (*Figure 13*).

Figure 13
Japan: banks' non-performing loans (FY, ratio to total loans)



Sources: FSA, INDB, NATIXIS

4. Is China following Japan's trajectory?

Is the saving-investment pattern in China, similar to what happened previously in Japan, leading to a similar growth trajectory of a rapid deceleration after the bursting of a bubble?

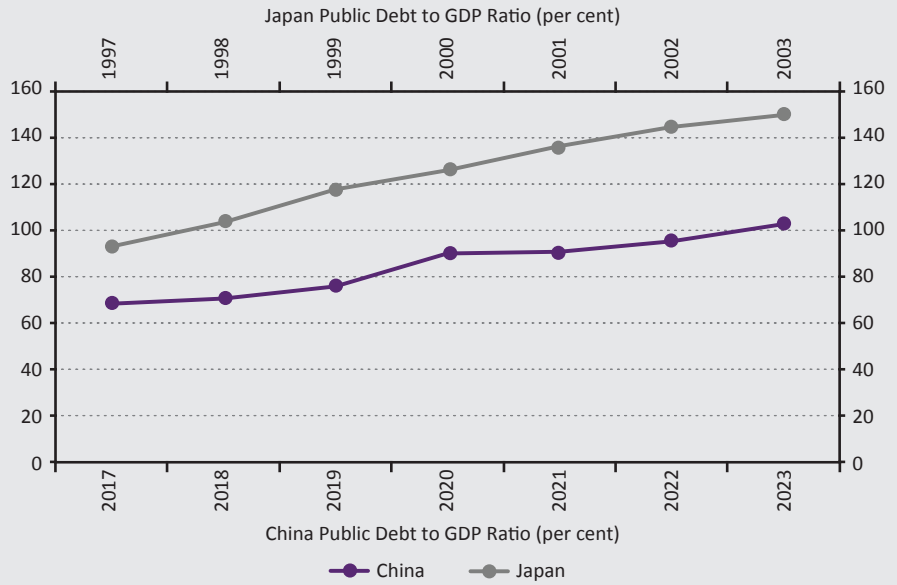
Kohsaka et al. (*2002*) argued that the Bank of Japan (BoJ) went too far in hiking rates between 1988 and 1989. This was done to dampen further growth in asset prices and contributed to the bursting of the bubble. In the same vein, one can argue that the monetary policy of the People's Bank of China (PBoC) in the run-up to and during the pandemic was also too tight, at least when compared to the rest of the world. This, together with additional regulatory tightening such as the so-called "three red lines" for real estate developers[6], rapidly cooled investment enthusiasm. More details were discussed in *Subsection 3.1.* on the behaviour of the Bank of Japan.

While the BoJ did cut interest rates after the bubble burst, it did so very gradually, reaching zero only in 1999, even though deflationary pressures were persistent, especially for producer prices. In other words, Japan's real interest rates remained stubbornly high after the bubble burst until Governor Haruhiko Kuroda moved to negative interest rates in late 2016 with a huge additional expansion of the BoJ's balance sheet[7] (*Figure 14*). A similar pattern can be found for China since the PBoC kept interest rates high after the real estate bubble burst in mid-2021. Even though the economy was running below potential with deflationary pressures, especially for producer prices, the change in the PBoC's policy stance has also been very gradual.

On the fiscal front, Japan has accumulated public debt very rapidly since the bursting of the bubble, reaching levels above 230 per cent of GDP today. China is following the same path of accumulation of fiscal deficits, piling up public debt (*Figure 15*). However, China has become very careful about the debt problem, especially at local government level, and has started to restrict fiscal spending. As such, China's fiscal stimulus has also been limited, even though the pile-up of debt has already become so noticeable that the government continues to implement measures to address it. In November 2024, it issued a stimulus package worth USD 1.4 trillion, including a debt swap of hidden local government debt (in the form of local government financial vehicles) into official local-government debt[8]. Such swaps, which have been happening for some time already, aim to reduce the financial risk embedded in the accumulation of excessive debt, especially non-official debt.

[6] The "three red lines" policy is a set of financial guidelines for real estate developers in China. The policy was introduced in August 2020 to help control the real estate sector's debt and improve its financial health (*Yang et al. 2023*).
[7] See Bank of Japan statement of 29 January 2016, *Introduction of "Quantitative and Qualitative Monetary Easing with a Negative Interest Rate"*, https://www.boj.or.jp/en/mopo/mpmdeci/mpr_2016/k160129a.pdf.
[8] https://www.reuters.com/markets/asia/what-you-need-know-about-chinas-14-trillion-debt-package-2024-11-10/

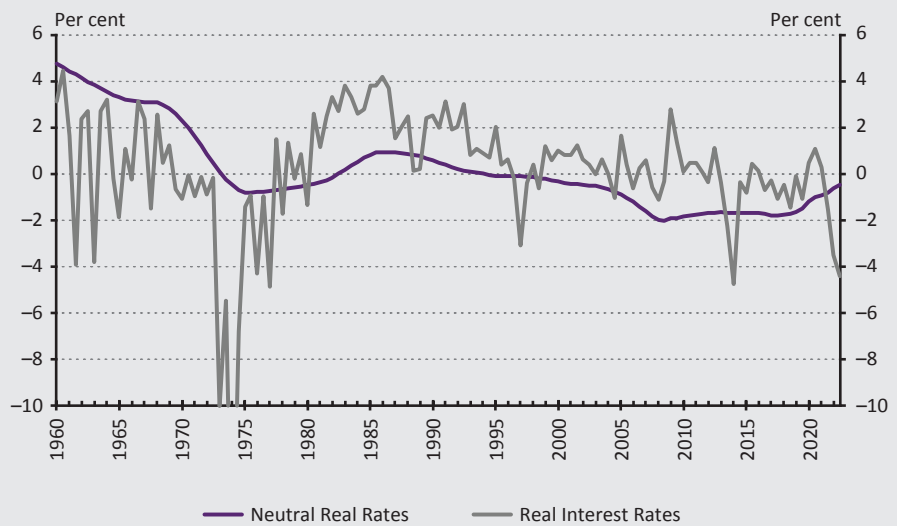
Figure 14
China and Japan's public debt-to-GDP ratio



Note: Due to the temporal offset of the similar economic patterns observed in the two countries, I apply dual horizontal axes to align comparable trends. The upper time axis refers to Japan, while the lower axis corresponds to China.

Source: Natixis, CEIC

Figure 15
Japan: neutral rate



Source: NATIXIS

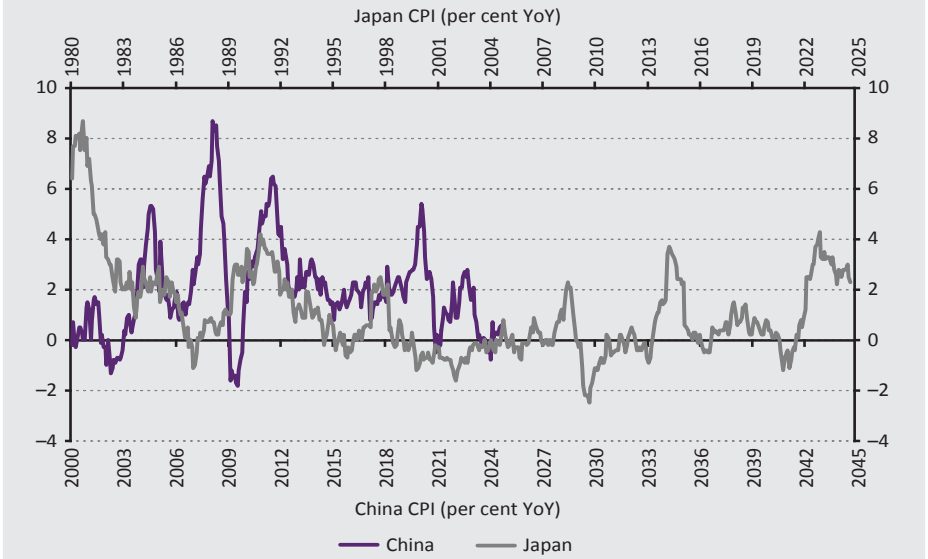
The other similarity is that both Japan and China doubled down on industrial policy as a response to the structural deceleration. In particular, the Japanese government set up a programme of financial assistance to banks (injecting over 18 per cent of GDP by 1998) (*Fujii and Kawai 2010*) and tax incentives for specific industries deemed strategically important, including information technology, biotechnology and environmental technologies (*Callen and Ostry 2023*). It also promoted financial support for research and development (R&D) and public-private partnerships. Japan's massive industrial policy did not stop the reduction in the share of manufacturing in the Japanese economy and, most importantly, Japan's declining innovation ranking (*Figure 16*) (*Fukao and Kwon 2005*). China is following the same route, increasing its R&D expenditure and carrying out special projects to support high-technology sectors.

Figure 16
Japan: global competitiveness ranking

Sources: IMD, NATIXIS

Stemming from the excessive focus on manufacturing and industry, both economies have suffered deflationary pressure, especially in producer prices. Japan endured prolonged deflationary pressure, whereas China has experienced two distinct periods of deflation: first in 2015 and again starting in 2022 (*Figure 17 and 18*). China managed to mitigate the deflationary pressures in 2015 through a stimulus, but has been more hesitant to follow the same route during the second episode.

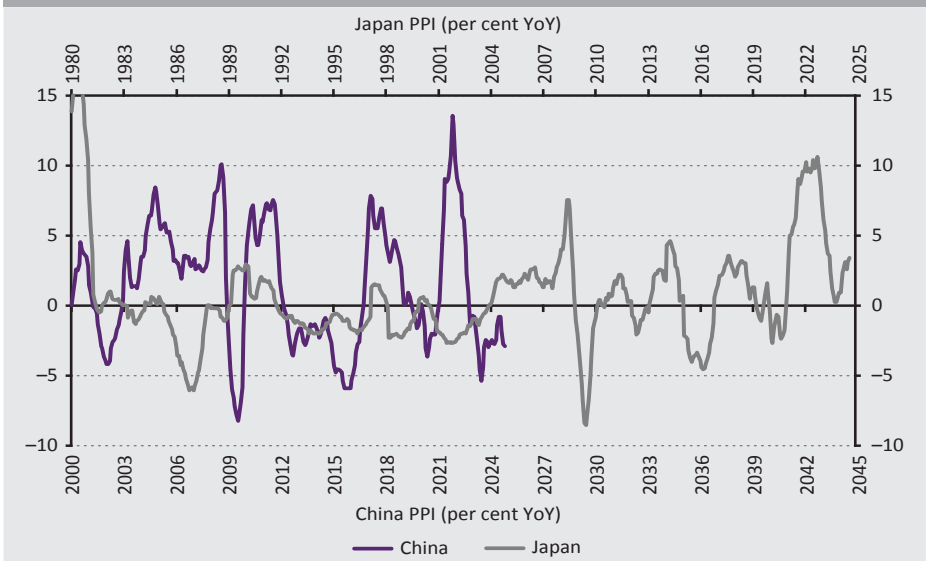
Figure 17
China and Japan's CPI comparison



Note: Data as of October 2024. Due to the temporal offset of the similar economic patterns observed in the two countries, I apply dual horizontal axes to align comparable trends. The upper time axis refers to Japan, while the lower axis corresponds to China.

Source: Natixis, CEIC

Figure 18
China and Japan's PPI comparison

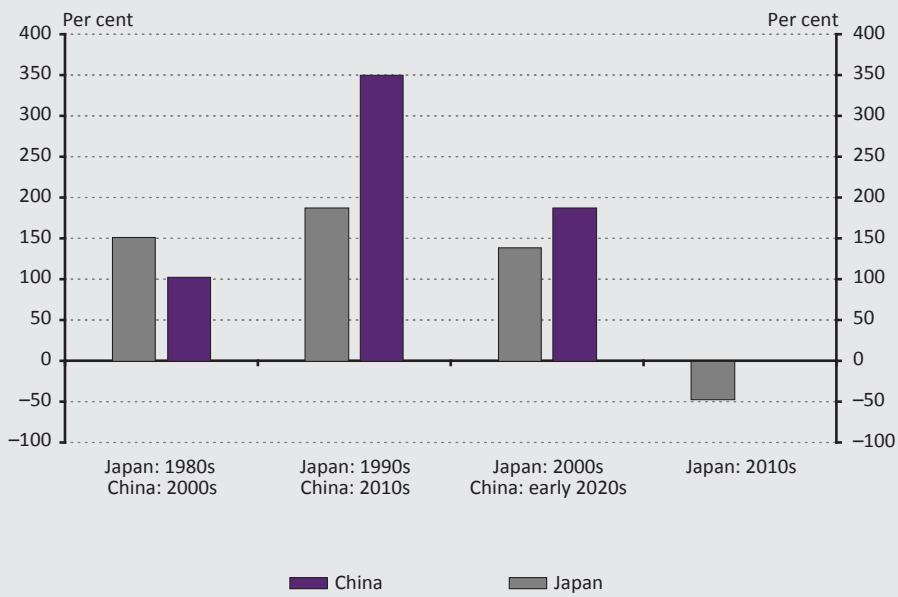


Note: Data as of October 2024. Due to the temporal offset of the similar economic patterns observed in the two countries, I apply dual horizontal axes to align comparable trends. The upper time axis refers to Japan, while the lower axis corresponds to China.

Source: Natixis, CEIC

Another relevant similarity is the use of export markets as an outlet for excessive manufacturing capacity. Japan tried to mitigate its structural slowdown by expanding overseas markets, leading to a current account surplus (*Figure 19*), but that effect faded away and had even disappeared after twenty years as Japan became more of a tourist destination than an exporter of manufactured goods. So far, in the wake of its slowdown, China still maintains a significant current account surplus, with particular improvement in higher-end technology exports.

Figure 19
Share of goods surplus as a proportion of current account surplus

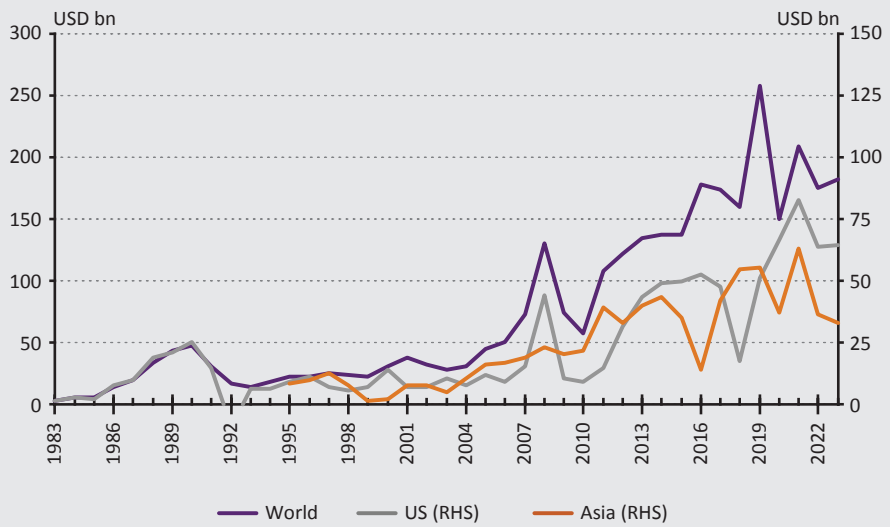


Source: Natixis, CEIC

Japan and China both decided to expand investment overseas through foreign direct investment (FDI) and lending. For Japan, FDI emerged as the primary channel for expansion, with Southeast Asia and China as key destinations under the "flying geese" strategy (*Kojima 2000*). In addition to greenfield investments in manufacturing, Japan also pursued mergers and acquisitions, which became particularly feasible, and not expensive, when the yen appreciated following the Plaza Accord. The bursting of Japan's economic bubble further accelerated its shift toward acquiring overseas assets, driven by a steep decline in domestic growth and persistently high labour costs within its manufacturing sector (*Figure 20*). Meanwhile, Japanese banks emerged as significant global overseas lenders, including in Latin America before its major sovereign crisis in the 1980s.

China has also significantly expanded its overseas presence, primarily through lending, with a particular emphasis on infrastructure financing. Its cross-border lending efforts have predominantly targeted emerging economies, especially those involved in China's flagship Belt and Road Initiative. Compared to Japan, China's greenfield investments in manufacturing are a relatively recent development, with the developed world selected as a key destination to expand markets and to acquire technology assets.

Figure 20
Japan: outward FDI (flow)



Sources: NATIXIS, JETRO

5. What might make China different from Japan?

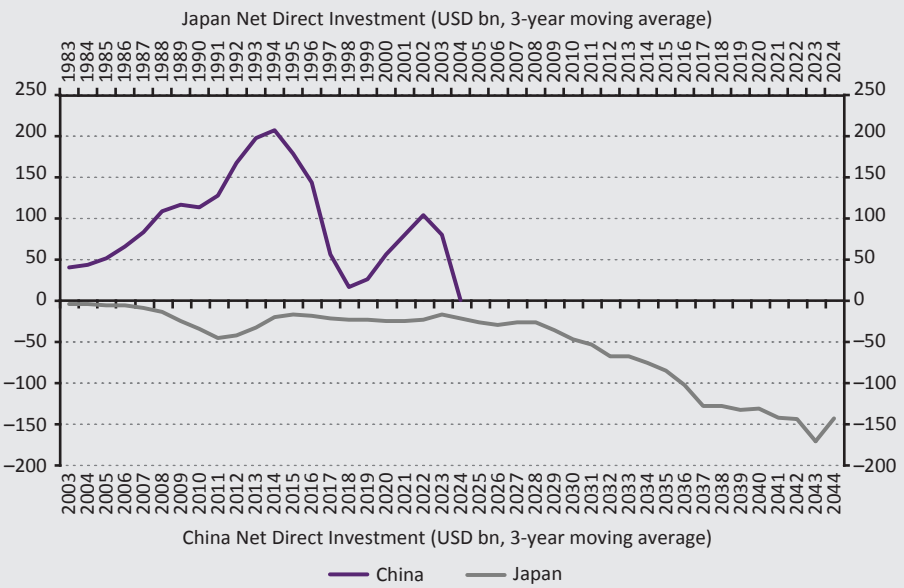
While there are many parallels between Japan in the 1980s and 1990s and China today, significant differences exist. Some of these favour China, while others suggest its situation could be even more challenging than Japan's was.

A key distinction is the level of outbound investment. Japan established itself as the world's largest net external creditor decades ago and maintains this status through substantial foreign direct investment (FDI) and portfolio flows. By contrast, China's surge in outbound FDI from 2013 to 2016 has since slowed considerably (*Figure 21*).

Furthermore, China has never fully liberalised capital outflows, leading to much more limited overseas portfolio investment (*Figure 22*).

This structural difference impacts their economic resilience. Japan's significant income from overseas investments has been vital in sustaining its current account surplus. China's surplus, however, is predominantly driven by trade, with minimal net income from foreign investments (*Figure 23*). This makes China more vulnerable to the rising tide of protectionism from the US and the European Union (*García Herrero – Vasselier 2024*). Additionally, with Chinese wages still lower than Japan's were at a similar stage, relocating production overseas is a less straightforward strategy, as the wage differentials are not as advantageous.

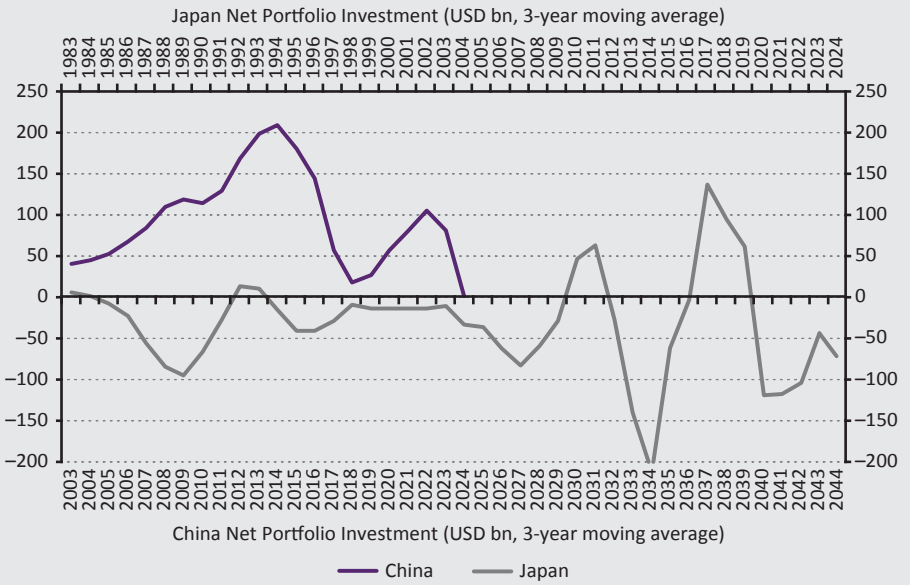
Figure 21
Net direct investment



Note: Data as of October 2024. Due to the temporal offset of the similar economic patterns observed in the two countries, I apply dual horizontal axes to align comparable trends. The upper time axis refers to Japan, while the lower axis corresponds to China.

Source: Natixis, CEIC

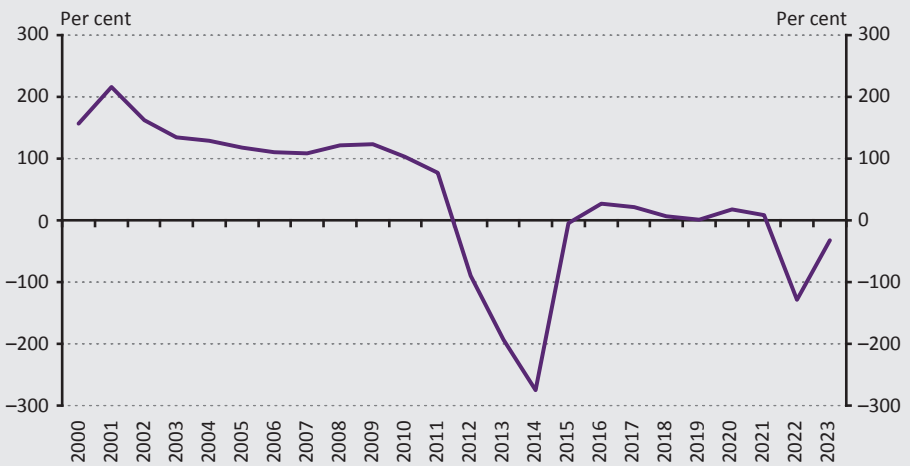
Figure 22
Net portfolio investment



Note: Data as of October 2024. Due to the temporal offset of the similar economic patterns observed in the two countries, I apply dual horizontal axes to align comparable trends. The upper time axis refers to Japan, while the lower axis corresponds to China.

Source: Natixis, CEIC

Figure 23
Japan's share of goods surplus as a proportion of current account surplus



Source: Natixis, CEIC

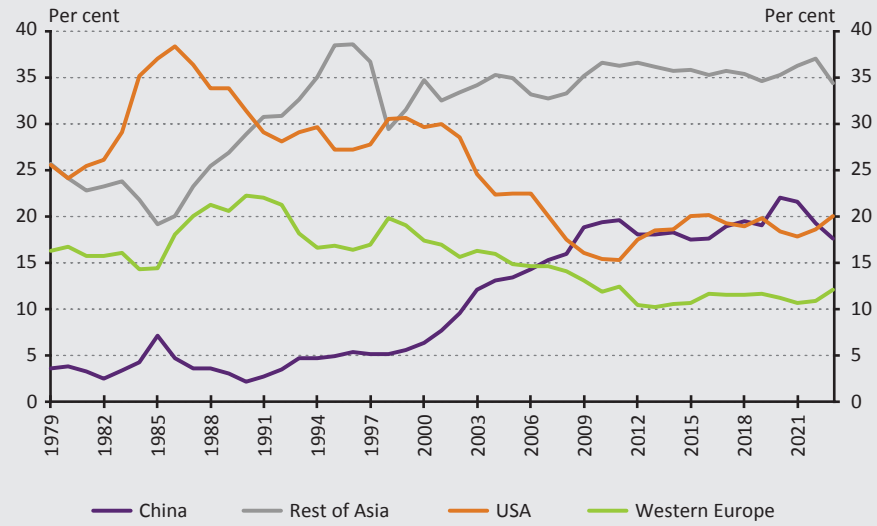
Japan's exchange rate policy was also different to that of China today, at least so far. Japan accepted a sudden, rapid appreciation of the yen after concerted intervention pushed by the US in the mid-1980s under the Plaza Accord. The consequences of the strong yen were analysed in *Subsection 3.2*. China has so far avoided any push from the US Treasury to appreciate its currency and has generally kept the renminbi relatively weak to foster external competitiveness. Capital controls are still important tools for China to achieve this goal, while Japan abandoned them a long time ago.

Another significant difference lies in the impact of the real estate crisis on the banking sectors of Japan and China. Japanese banks were significantly more exposed to real estate developers than their Chinese counterparts today (see *Subsection 3.3.*), as regulations in China have limited the ability of banks to finance real estate ventures. While Chinese banks have less direct exposure to developers, they are heavily exposed to local government financial vehicles (LGFVs), which have been instrumental in funding real estate and infrastructure projects, but are currently facing serious financial difficulties. Similarly to Japanese banks, Chinese banks are experiencing a shrinking interest rate margin, which is impacting their profitability (*Garcia Herrero – Ng* 2024).

In summary, while China has thus far managed to mitigate the effects on its banking sector of its economic deceleration and real estate market adjustments, it remains uncertain whether it will ultimately follow in Japan's footsteps. The ongoing decline in bank profitability and the emerging risks to asset quality could pose significant challenges in the future.

Internationally, their approaches diverge starkly. Japan, with its diminished post-WWII political status, has largely played a subdued role in global governance, historically aligning with US policies without forging its own path (*Figure 24*). China, conversely, has adopted an increasingly assertive posture. Through initiatives like the Belt and Road, it has actively expanded its economic, soft and even hard power globally, seeking to rally support from the Global South. This strategy could be beneficial, but also exposes China to direct US containment measures. Consequently, China's pursuit of self-reliance, particularly in critical sectors like semiconductors, is more proactive than Japan's ever was.

Figure 24
Japan: exports by country (share)



Sources: MoF, NATIXIS

Finally, China's technological trajectory may be different. It has achieved breakthroughs in critical fields, suggesting it is closer to the global frontier than Japan was at a comparable stage, reinforcing its push for technological independence amid US pressure. However, the crucial question is whether these advances can boost overall productivity. Current data indicates that China's TFP) has been declining during its economic slowdown (*Cerdeiro – Ruane 2022*), raising doubts about whether technological innovation can offset the country's ongoing structural deceleration.

5. Conclusions

The comparative analysis of China's current economic trajectory and Japan's experience in the 1990s reveals both striking parallels and critical divergences that will shape China's medium-term outlook. Both economies experienced rapid growth followed by a pronounced slowdown, underpinned by similar structural features: high savings rates, low private consumption and significant macroeconomic imbalances. In both cases, these imbalances were exacerbated by real estate bubbles and subsequent corrections, as well as by policy responses that were often slow or insufficiently forceful to address underlying vulnerabilities.

One key similarity lies in the savings-investment dynamic. Like Japan in the 1980s, China's high domestic savings have long financed outsized investment booms, particularly in infrastructure and real estate, while private consumption has remained subdued. As investment growth has slowed, both countries have faced the challenge of rebalancing toward consumption-driven growth. However, China's adjustment has been less pronounced: its savings rate remains exceptionally high, and the shift toward greater consumption has been limited, leaving persistent current account surpluses and continued reliance on external demand.

The real estate sector has played a pivotal role in both economies' slowdowns. Japan's bubble and its aftermath led to a protracted period of stagnation, while China's more recent real estate correction has been sharper and more rapid, raising concerns about a potential "hard landing." Yet, the sources of financial risk differ: Japan's crisis was rooted in corporate and banking sector deleveraging, whereas China's vulnerabilities are more closely tied to local government debt and opaque financing vehicles. Despite policy efforts to contain these risks, China's financial system remains exposed to lingering imbalances.

Demographic trends and deflationary pressures further reinforce the comparison. Both countries have faced aging populations and declining labour force growth, contributing to slower potential output and increased deflationary risks. In Japan, these factors contributed to the so-called "lost decade," while in China, they threaten to constrain future growth and complicate policy responses (*Garcia Herero 2024*).

However, the differences between China and Japan are equally consequential. China remains a developing economy with greater scope for catch-up growth, urbanisation and productivity gains. Its geopolitical position is far stronger than Japan's was in the 1990s, affording it more leverage in global affairs, particularly in the Global South. This geopolitical strength has also made China the target of a broader and more intense containment strategy by the United States, encompassing not only trade but also technology and security. Unlike Japan, which faced primarily economic containment, China must navigate a more complex and adversarial international environment.

Policy responses have also diverged. While both countries initially relied on gradual monetary and fiscal easing, China's policy toolkit is more extensive, and its leadership has shown a willingness to experiment with unconventional measures. Nevertheless, the effectiveness of these policies is constrained by structural factors, such as the lack of a comprehensive welfare state, which perpetuates high precautionary savings, and the slow pace of financial sector reform.

In summary, while China exhibits many of the symptoms that led to Japan's lost decade – slowing growth, real estate correction, high savings and deflationary pressures – it also possesses unique strengths and faces distinct challenges. Whether China can avoid a prolonged stagnation will depend on its ability to accelerate structural reforms, rebalance toward consumption, manage financial risks and adapt to an increasingly complex global environment. The lessons from Japan's experience are instructive, but China's path will ultimately be shaped by its own policy choices, institutional evolution and geopolitical strategy.

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Inflation and Uncertainty: Evidence from GARCH-MIDAS-in-Mean Modelling*

Chaoyi Chen – Tamas Barko – Olivér Nagy

We revisit the relationship between inflation and inflation uncertainty using a novel GARCH-MIDAS-in-Mean approach, which allows for the decomposition of inflation uncertainty into short-term and time-varying long-term components. We test our model on UK data. Our findings indicate that macroeconomic and financial variables significantly influence the long-term component of inflation uncertainty. By enabling long-term uncertainty to vary over time through MIDAS filtering, we show that the evidence for past inflation raising short-run uncertainty weakens compared to results that assume a constant long-term inflation uncertainty component. However, our results support the Cukierman–Meltzer hypothesis, indicating that the impact of inflation uncertainty on inflation becomes more robust and pronounced when longer samples are used, although this effect is sensitive to structural breaks, such as the VAT cut and the Covid-19 pandemic. Additionally, we find no evidence that changes in inflation feed back into short-run uncertainty.

Journal of Economic Literature (JEL) codes: E31, E52, C22

Keywords: Inflation, Inflation uncertainty, GARCH-MIDAS models

1. Introduction

Understanding the relationship between inflation and inflation uncertainty is one of the most critical issues for monetary authorities, with debates surrounding both the effects of inflation on its own uncertainty and the reverse effect of inflation uncertainty on inflation rates (see, for example, *Greenspan 2004*).

* The papers in this issue contain the views of the authors which are not necessarily the same as the official views of the Magyar Nemzeti Bank.

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The existing literature offers mixed evidence, highlighting the complexity of the inflation-uncertainty relationship. Notably, much of the literature relies on GARCH (-in-Mean) models, which inherently assume that long-term uncertainty remains constant over time, a restrictive and unintuitive assumption.[1] Our paper aims to relax this assumption. We contribute to the literature by applying a novel GARCH-MIDAS-in-Mean model, as formulated by *Engle et al.* (*2013*), to revisit the inflation-uncertainty nexus. Our modelling framework allows us to decompose inflation uncertainty into short-term and time-varying long-term components, assuming the long-term component driven by smoothed (longer-horizon) realised volatility or other macro-finance variables. This approach enables us to (1) assess the impact of inflation on short-run inflation uncertainty, which is often more critical given the smoother nature of long-term uncertainty, and (2) evaluate the influence of total inflation uncertainty – defined as the product of both time-varying short-run and long-run uncertainty components – on inflation itself.

We analyse an updated UK dataset extending through 2023 and compare our findings from the GARCH-MIDAS-in-Mean model with those obtained from the GARCH-in-Mean model used in *Kontonikas* (*2004*). Our results can be summarised as follows. First, by extending the sample period beyond 2002 (the endpoint used in *Kontonikas 2004*) to 2023, we find that the positive effect of inflation uncertainty on inflation becomes more pronounced in the GARCH-in-Mean model. However, this stronger effect diminishes when the sample excludes either the VAT cut episode or the Covid-19 period. Second, although the results vary across sample periods, we find that realised volatilities contribute meaningfully to long-run inflation uncertainty when the full sample is analysed. Moreover, our analysis shows that macroeconomic and financial variables exert a significant influence on the long-term component of inflation uncertainty. Third, by allowing long-run inflation uncertainty to be time-varying through MIDAS filtering, we observe that the effect of past inflation on current short-run inflation uncertainty becomes insignificant. This result offers a cautionary perspective: evidence suggesting that (short-run) inflation uncertainty rises in response to increases in inflation may partly stem from the restrictive assumption that long-run uncertainty remains constant over time. Nevertheless, we find that inflation uncertainty has a positive and significant effect on inflation in almost all GARCH-MIDAS-in-Mean specifications. Finally, we find no evidence that changes in inflation affect short-run uncertainty.

The rest of the paper is organised as follows: we survey the literature in *Section 2*, *Section 3* introduces the empirical methods, and then *Section 4* describes the data and presents the results. *Section 5* concludes with policy recommendations.

[1] Here, long-run uncertainty is defined as the inflation volatility over a longer horizon, rather than the long-run trend volatility.

2. Literature review

The theoretical underpinnings of the relationship between the level and uncertainty of inflation are strongly debated, with numerous arguments proposing that inflation affects inflation uncertainty, as well as the other way around.

Friedman (*1977*) argues that inflationary pressures often lead to inconsistent and unpredictable responses from monetary authorities, creating heightened uncertainty about future inflation and potentially slowing output growth.[2] *Pourgerami and Maskus* (*1987*), however, point out that a negative effect may exist because higher inflation can incentivise relevant economic agents to invest more in generating accurate predictions.[3]

There are also competing perspectives on how inflation uncertainty can affect inflation itself. *Cukierman and Meltzer* (*1986*) propose a model in which public uncertainty about money supply growth rates and policymakers' objectives can lead to expansionary monetary policies that are designed to surprise the public with inflation. In this framework, higher inflation uncertainty encourages policymakers to enact inflationary surprises to temporarily boost output. By contrast, *Holland* (*1995*) proposes a negative correlation, suggesting that inflation uncertainty can deter inflation. According to Holland, policymakers might avoid inflationary surprises during periods of uncertainty to manage the public's inflation expectations and prevent potential inflationary spirals.

The empirical literature has been steadily expanding, evaluating the latest developments in theoretical models on the link between inflation level and uncertainty.[4] Defining the de-facto standard for analysing the link between inflation and its uncertainty, the ARCH models in *Engle* (*1982*) show that UK inflation has a predictable, time-varying volatility.

Kontonikas (*2004*), for example, uses a GARCH-in-Mean model on UK monthly data to find a positive correlation between past inflation rates and present uncertainty levels. Similarly, *Fountas and Karanasos* (*2007*), studying G7 countries with a univariate GARCH model, observe that inflation tends to increase inflation uncertainty, though they report mixed evidence on whether inflation uncertainty reciprocally influences inflation. *Bredin and Fountas* (*2009*), using a bivariate

[2] *Ball* (*1992*) formalises Friedman's argument within the framework of an asymmetric information game between the public and the policymaker.
[3] This argument is formalised by *Ungar and Zilberfarb* (*1993*).
[4] In most of the empirical literature, inflation uncertainty is defined as the conditional variance of inflation innovations, which differs from monetary policy uncertainty that generally refers to unpredictability in policy decisions or the central bank's reaction function. We thank an anonymous referee for highlighting this important distinction.

GARCH-in-Mean model for EU countries, provide substantial evidence in support of the Cukierman–Meltzer hypothesis, indicating that in many European contexts, inflation uncertainty does indeed foster inflationary pressures as policymakers aim to spur economic growth through inflation surprises. *Fountas et al.* (*2004*) extend this analysis across six EU nations, where they find that inflation consistently increases inflation uncertainty in all countries except Germany, supporting Friedman's hypothesis. However, they obtain limited evidence for the reverse effect, with heterogeneous results regarding inflation uncertainty's influence on inflation across these countries. Moreover, *Daal et al.* (*2005*) examine inflation dynamics in Latin American economies, demonstrating that while inflation typically raises inflation uncertainty, the reverse causality varies, reinforcing the complexity of this relationship, particularly in emerging markets.

Using G7 data, *Balcilar and Ozdemir* (*2013*) employ rolling VAR and MS-VAR models to show that the link between inflation and its uncertainty is time-variant, frequently punctuated by structural breaks. They find strong support for Holland's hypothesis across Canada, France, Germany, Japan, the UK and the US, suggesting that inflation uncertainty can sometimes restrain inflation, while they also confirm Friedman's hypothesis for Canada and the US, where inflation heightens uncertainty. *Caporale and Kontonikas* (*2009*) examine the evolution of this relationship across the euro area, noting heterogeneity across countries and frequent structural breaks, particularly in the lead-up to the introduction of the euro. *Chang* (*2012*), using a modified regime-switching GARCH model, finds that in the US, inflation uncertainty does not significantly impact inflation across various inflationary regimes, underscoring that the inflation-uncertainty dynamic can be regime-dependent.

More recent studies, such as *Barnett et al.* (*2020*), employ semi-parametric approaches across five major developed and emerging economies, identifying a positive short-term to medium-term relationship during stable periods, aligning with Friedman's theory, and a negative relationship during crisis periods. *Apergis et al.* (*2021*), using econometric methods sensitive to structural breaks, identify a unidirectional causality from inflation to inflation uncertainty in Turkey, though this relationship holds only during certain sub-periods. *Bareith and Varga* (*2022*) find that Hungary's inflation-targeting regime significantly reduced core inflation, but had no robust effect on headline inflation or its volatility, with institutional factors such as central bank independence also influencing outcomes. *Sipiczki et al.* (*2024*) examine the exceptionally high inflation in Hungary by disentangling general global drivers from country-specific ("Hungaricum") factors, finding that domestic elements, such as price regulation policies, exchange rate pass-through and fiscal measures, play a significant role alongside international inflationary pressures. *Balatoni and Quittner* (*2024*) analyse the causes of Hungary's 2021–2023 inflation

wave, highlighting the combined impact of global supply shocks, energy price surges and domestic factors, such as fiscal stimulus, wage growth and exchange rate depreciation. *Martin and Nagy Mohácsi* (*2024*) evaluate Hungary's inflation-targeting regime and concludes that while it contributed to reducing inflation in the long run, its effectiveness was shaped by broader institutional credibility and the consistency of fiscal and monetary policy alignment.

Taken together, there is considerable literature covering the relationship between inflation and inflation uncertainty, with results varying across domiciles and time. However, the overarching assumption in the literature is that long-term inflation uncertainty is constant. Our contribution is that we relax this assumption and quantify its effect.

3. Econometric framework

Typically, inflation uncertainty is estimated using GARCH models. For instance, *Kontonikas* (2004) employs the following GARCH-in-Mean model to examine the relationship between monthly inflation and inflation uncertainty.

$$\pi_t = \gamma_0 + \gamma_1 \pi_{t-1} + \gamma_2 \pi_{t-3} + \gamma_3 \pi_{t-6} + \gamma_4 \pi_{t-12} + \delta \sqrt{\tau h_t} + \mu_t$$

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \, \mu_{t-i}^2 + \sum_{j=1}^{p} \beta_j \, h_{t-j} + \lambda^{\top} z_t \qquad (1)$$

$$\mu_t = \sqrt{\tau h_t} \varepsilon_t$$

where π_t is the monthly inflation rate at period t; τ is a constant measuring the long-run component of inflation uncertainty; h_t denotes the conditional variance of inflation following a GARCH(p,q) process and measuring the short-lived component of inflation uncertainty; z_t is a vector of other exogenous variance regressors; and ε_t is assumed to be *i.i.d.* normal. Note that δ measures the impact of inflation uncertainty on inflation. Furthermore, if we assume that z_t contains only a single variable in this study, namely π_{t-1}, then λ captures the effect of past inflation on current inflation uncertainty. Therefore, *Equation (1)* allows us to explore both directions: a significant λ supports the theory that the level of inflation influences its uncertainty (*Friedman 1977* or *Pourgerami and Maskus 1987*), while a significant δ aligns with the argument that inflation uncertainty affects the level of inflation (*Cukierman and Meltzer 1986* or *Holland 1995*).

However, the above model assumes a constant τ, failing to account for the possibility that short-run and long-run inflation uncertainty may be time-varying, significantly different and influence inflation (expectations) in distinct ways. Therefore, in the spirit of *Engle et al.* (*2013*), we modify *Equation (1)* by incorporating a MIDAS approach to obtain estimates of long-run uncertainty. The model takes the following form:

$$\pi_t = \gamma_0 + \gamma_1 \pi_{t-1} + \gamma_2 \pi_{t-3} + \gamma_3 \pi_{t-6} + \gamma_4 \pi_{t-12} + \delta \sqrt{\tau_t h_t} + \mu_t$$

$$h_t = \alpha_0 + \alpha_1 \mu_{t-1}^2 + \beta_1 h_{t-1} + \lambda^{\top} z_t$$

$$\tau_t = m + \theta \sum_{k=1}^{K} \phi_k (\omega_1, \omega_2) x_{t-k} \qquad (2)$$

$$\mu_t = \sqrt{\tau_t h_t} \varepsilon_t$$

where ε_t is assumed to be *i.i.d.* normal; for k=1,…,K, $\phi_k(.,.)$ is a weighting function and is known up to parameters (ω_1, ω_2); and x_{t-k} is a MIDAS explanatory regressor. *Equation (2)* offers several analytical and theoretical advantages. First, compared to *Equation (1)*, it allows long-run volatility to evolve over time by incorporating information from high-frequency macro-financial variables through the MIDAS filtering mechanism. Notably, *Equation (2)* nests the conventional GARCH-in-Mean specification as a special case when θ=0. Second, while the number of parameters governing the MIDAS weighting function is fixed, their values are estimated from the data rather than imposed, making the model more parsimonious than complex component volatility models, yet more flexible than approaches with pre-specified weights. As a result, the GARCH-MIDAS framework strikes a useful balance between empirical flexibility and model tractability.

Alternative methods for capturing time-varying long-run components – such as unobserved components models, Kalman filtering, Bayesian time-varying parameter (TVP) models, or smooth transition models – typically rely on latent variables subject to smoothness or trend restrictions. While effective in capturing persistence, these approaches often depend on strong parametric assumptions and utilise filtering techniques that may reduce transparency and hinder economic interpretation.

By contrast, the MIDAS approach links the long-run volatility component directly to observable macro-financial variables sampled at higher frequencies. This strategy provides several practical advantages: (i) it avoids arbitrary trend specifications; (ii) it enhances transparency by defining the long-run component as a function of measurable indicators; (iii) it flexibly accommodates time-varying contributions from different predictors through a parsimonious lag weighting structure; and

(iv) it is computationally efficient and compatible with quasi-maximum likelihood estimation. Anchoring long-run volatility in actual economic data rather than abstract latent constructs makes MIDAS a more interpretable and policy-relevant tool. It also aligns closely with the real-time forecasting practices employed by central banks and policy institutions. In this regard, the GARCH-MIDAS specification offers a robust, transparent alternative to more opaque, latent-variable models for modelling persistent volatility dynamics.

Following *Ghysels et al.* (*2004*) and *Engle et al.* (*2013*), we empirically employ a Beta function to specify the weighting scheme with the following form for our study:

$$\phi_k(\omega_1, \omega_2) = \frac{(k/K)^{\omega_1 - 1}(1 - k/K)^{\omega_2 - 1}}{\sum_{k=1}^{K}(k/K)^{\omega_1 - 1}(1 - k/K)^{\omega_2 - 1}}.$$

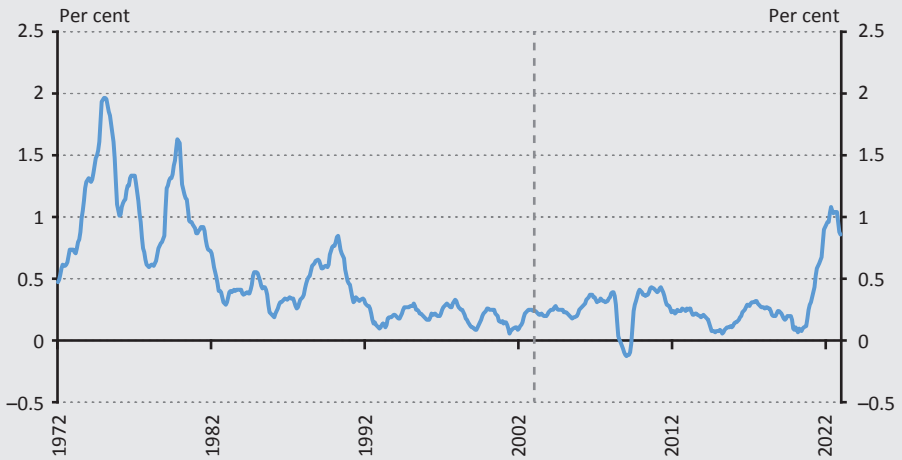
In practice, x_t may be in high-dimensional. In that case, an unsupervised machine learning method may be applied for dimensionality reduction. For instance, one can apply principal component analysis (PCA) to x_t as a first step. Then, one can use the first principal component (see, for instance, *Chen et al. 2023b*) as the latent MIDAS predictor.

4. Estimation results

This section presents the data and the estimation results. We obtain the monthly (seasonally-adjusted) UK inflation data used in our study from the Global Financial Database, covering the period 1972 to 2023, which is defined as $\pi_t = (CPI_t - CPI_{t-1})/CPI_{t-1} \times 100$. *Figure 1* shows month-on-month inflation in the UK between 1972 and 2023, where the dashed vertical line shows the end date of the sample used in *Kontonikas* (*2004*).

Consistent with *Kontonikas* (*2004*), between 1972 and 2003, we observe that periods of higher average inflation correspond to periods of more volatile inflation. Moreover, both inflation on short and long horizon are particularly volatile before the adoption of inflation targeting (1992). After 2003, however, we find that the inflation rate on long horizon remains low and tends to be much smoother than the rate on short horizon, except for the temporary shocks of the Global Financial Crisis and the recent turmoil (i.e. the Covid-19 pandemic and the Russo-Ukrainian War). Visual inspection of the plot indicates that the long-run volatility of the inflation rate is indeed time-varying.

Figure 1
Month-on-month inflation in the United Kingdom between 1972 and 2023



Note: The vertical dashed line shows the end date of the original sample.

An important question arises: Could macroeconomic and financial variables drive long-run inflation uncertainty, and if so, how might this influence the inflation-uncertainty nexus? To investigate this, we draw on previous research (e.g. *Baker et al. 2016*; *Grimme et al. 2014*; *Chen et al. 2023b*) and select the following macro-finance variables as potential contributors to long-run component uncertainty: UK economic policy uncertainty (EPU), the yield spread (defined as the difference between the three-month interbank rate and the three-month Treasury bill yield) and the CBOE[5] Volatility Index (VIX) as MIDAS explanatory variables.[6] To account for data availability, we collect the data from 2003 to 2023 for the above macro-finance variables. *Table 1* shows the descriptive statistics of the variables.

[5] Chicago Board Options Exchange
[6] The yield spread, defined as the difference between the three-month interbank rate and the three-month Treasury bill rate, is commonly interpreted as an indicator of short-term funding stress and risk premia. It tends to widen during episodes of financial market stress and uncertainty, thus providing a forward-looking signal of deteriorating financial conditions that often coincide with heightened macroeconomic and inflation uncertainty. For the empirical estimation, we rescale the values of EPU and VIX by applying the monotonic transformation log(EPU + 1) * 0.01 to the EPU variable and log(VIX) * 0.01 to the VIX. Without these transformations, the large magnitudes of the raw variables distort the estimation results. We thank an anonymous referee for bringing this issue to our attention.

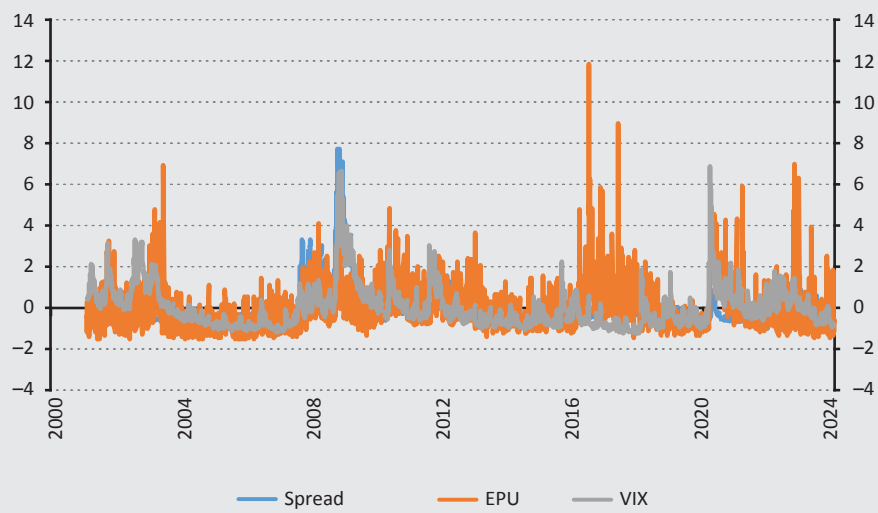
Table 1
Descriptive statistics

	Mean	Std.Dev	Min	Max	Variance	Skewness	Kurtosis
π	0.4666	0.4003	–0.1264	2.0041	0.1602	1.6157	2.2566
EPU	294.7170	194.7631	0.0000	2,610.0600	37,932.6448	2.1686	11.5161
Spread	0.2321	0.3391	–0.1213	2.8613	0.1150	3.8254	19.0868
VIX	20.2523	9.0781	9.1400	82.6900	82.4125	2.0400	6.3582

Note: The rows present descriptive statistics for various economic and financial indicators.

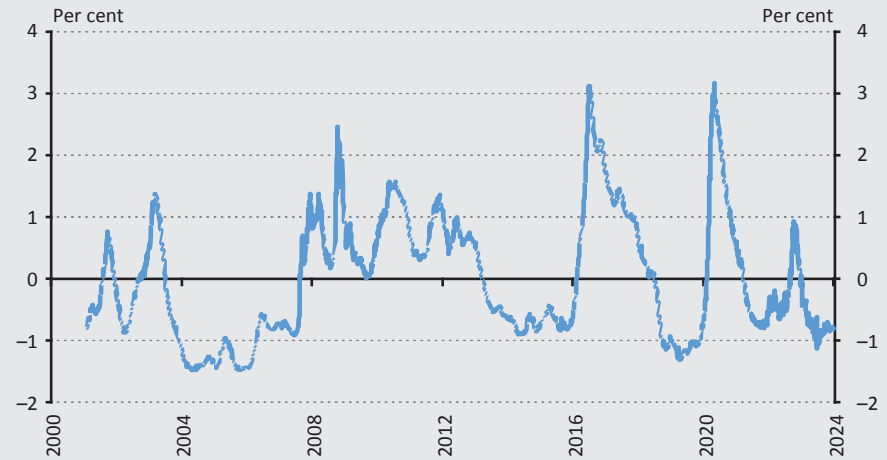
Figure 2 plots the standardised values of the EPU index, yield spread and VIX. *Figure 3* displays the first principal component extracted from these macro-financial variables, capturing their common factor. Over the period from 2003 to 2023, peaks in the individual series – particularly during episodes of global financial stress such as in 2008, 2012 and 2020 – tend to coincide with elevated month-on-month inflation. The first principal component reflects these synchronised spikes, indicating a strong co-movement between macro-financial uncertainty and inflationary pressures during turbulent periods.

Figure 2
Standardised values of high-frequency macro-financial indicators



Note: The series are standardised and cover the period from 2001 to 2023.

Figure 3
Common factor in high-frequency macro-financial indicators



Note: The series are standardised and cover the period from 2001 to 2023.

The literature has long documented mixed evidence on whether the UK inflation rate is stationary, depending on the sample period. *Joyce* (*1995*) found that augmented *Dickey–Fuller* (ADF) tests fail to reject the null hypothesis of a unit root over the period 1976–1994. *Grier and Perry* (*1998*) reported that CPI inflation is non-stationary over the post-WWII period, while *Kontonikas* (*2004*) found that both ADF and Phillips–Perron tests (PP) strongly reject the null over 1972–2002. Therefore, we conduct both full and period-based ADF unit root tests for π, and *Table 2* presents the results. Consistent with *Kontonikas* (*2004*), the ADF tests strongly reject the null of a unit root over the same period. The results also show that UK inflation was stationary before Covid-19. However, in the Covid-19 and post-Covid period (2019–2023), the test fails to reject nonstationarity.

Table 2
ADF unit root test, π across full and different subperiods

	Full	1972–2002	2002–2019	2019–2023
ADF statistic	–4.35***	–4.82***	–4.10***	–0.90
p-value	0.00	0.00	0.01	0.96
Lags	5	5	5	5
Observations	606	366	198	30
Crit. val. 1%	–3.97	–3.98	–4.01	–4.30
Crit. val. 5%	–3.42	–3.42	–3.43	–3.57
Crit. val. 10%	–3.13	–3.13	–3.14	–3.22

*Note: The ADF regressions include an intercept and a trend, with the optimal lag length selected based on the AIC criterion using up to five lags. The full period covers 1972–2023. *, **, and *** indicate rejection of the null hypothesis of a unit root at the 10%, 5%, and 1% levels of significance, respectively.*

We also employ the ADF test to assess the stationarity of the high-frequency macro-financial variables used in the MIDAS components. The results, reported in *Table 3*, indicate that the null hypothesis of a unit root is rejected for all variables (at least at the 10-per cent significance level), suggesting that all series are stationary.

Table 3
ADF unit root test, high-frequency variables

	Spread	EPU	VIX
ADF statistic	–3.25*	–12.05***	–5.84***
p-value	0.07	0.00	0.00
Lags	4	5	5
Observations	5,718	5,717	5,717
Crit. val. 1%	–3.98	–3.96	–3.96
Crit. val. 5%	–3.411	–3.411	–3.411
Crit. val. 10%	–3.128	–3.128	–3.128

*Note: The ADF regressions include an intercept and a trend, with the optimal lag length selected based on the AIC criterion using up to five lags. The period covers 1972–2023. *, **, *** and indicate rejection of the null hypothesis of a unit root at the 10%, 5%, and 1% levels of significance, respectively.*

We proceed with an extension of *Kontonikas* (*2004*), using a GARCH-in-Mean model with data up to 2023.[7] The results are summarised in *Table 4*. Specifically, we report the results for the original period, as defined in *Kontonikas* (*2004*), which spans from 1972 to 2002. Our extended period ("Full") expands this time frame to cover 1972 through 2023. The "Exclude Tax Cut" specification omits observations around the VAT cut implemented in the UK in 2009, while the "Exclude Covid" sample ends in December 2019 to avoid pandemic-related distortions.[8] Consistent with *Kontonikas* (*2004*), the estimated λ is positive and significant at the 1-per cent level, supporting the Friedman–Ball hypothesis. Notably, our findings also align with the Cukierman–Meltzer prediction, revealing that inflation uncertainty has a positive and significant effect on average inflation. To address concerns about potential structural breaks, such as the temporary VAT cut in 2009 and the Covid-19 pandemic, we conduct additional estimations that exclude these periods. The results, presented in *Table 4*, indicate that the estimates for λ and δ remain generally positive and statistically significant, reinforcing the main conclusions. In particular, the positive effect of δ becomes more pronounced when the sample period is extended from 2002 to 2023. However, this stronger effect diminishes once the observations associated with the VAT cut or the Covid-19 crisis are excluded.

[7] *Kontonikas* (*2004*) shows that, in most cases, when a GARCH(1,1) is used, the Ljung-Box statistics of the standardised and the squared standardised residuals are all insignificant, indicating proper model specification. Consistent with *Kontonikas* (*2004*), we choose the GARCH(1,1) specification of *Equation (1)*.
[8] We employ a Wald statistic to test the parameter restriction under the null hypothesis that $\alpha_1 + \beta_1 = 1$. In all cases, the null is rejected, supporting the stability of the GARCH(1,1) specification.

Table 4
GARCH-in-Mean model estimation results

z_t	π_{t-1}			
	Original Period	Extended Period		
		Exclude Tax Cut	Exclude Covid	Full
γ_0	–0.0022	0.0006	–0.0024	–0.0031
	(0.0040)	(0.0033)	(0.0037)	(0.0045)
γ_1	1.2686***	1.2612***	1.2555***	1.2407***
	(0.0346)	(0.0282)	(0.0380)	(0.0408)
γ_2	–0.2679***	–0.2535***	–0.2511***	–0.2299***
	(0.0470)	(0.0388)	(0.0485)	(0.0518)
γ_3	–0.0471**	–0.0496***	–0.0331*	–0.0464**
	(0.0261)	(0.0210)	(0.0208)	(0.0212)
γ_4	0.0238**	0.0176**	0.0097	0.0120*
	(0.0102)	(0.0084)	(0.0077)	(0.0087)
δ	0.3906**	0.3313**	0.3381**	0.4454**
	(0.2128)	(0.1979)	(0.1898)	(0.2153)
α_0	0.0001	0.0001**	0.0001***	0.0002***
	(0.0001)	(0.0000)	(0.0000)	(0.0000)
α_1	0.5438***	0.5663***	0.6542***	0.6288***
	(0.1290)	(0.1068)	(0.1191)	(0.1171)
β_1	0.0935	0.1184**	0.1011**	0.0980**
	(0.0828)	(0.0607)	(0.0530)	(0.0572)
λ	0.0008***	0.0008***	0.0005***	0.0005***
	(0.0002)	(0.0001)	(0.0001)	(0.0001)
Wald statistic	5.6002**	6.5881**	3.5224*	4.3986**
p-value	0.0180	0.0103	0.0605	0.0360

*Note: The standard errors are shown in parentheses. *, **, and *** indicate rejection of the null hypothesis of a unit root at the 10%, 5%, and 1% levels of significance, respectively. The original period, as covered in Kontonikas (2004), spans from 1972 to 2002. Our extended period (Full) expands this timeframe to cover 1972 through 2023. Exclude Tax Cut excludes the VAT cut in 2009 in the UK, and Exclude Covid spans until December 2019. Wald test for stationarity: Null hypothesis is $\alpha_1 + \beta_1 = 1$. Reported values are the Wald test statistics and p-values.*

Recognising the limitations of the GARCH model, which assumes constant long-term uncertainty, we employ a GARCH-MIDAS model to re-examine the inflation-inflation uncertainty relationship. *Table 5* provides the GARCH-MIDAS results using realised volatility as an explanatory factor for long-term inflation volatility.[9] Since monthly realised volatilities tend to be noisy, MIDAS filtering applies (MIDAS) weighted averages to create a smoothed volatility measure. Interestingly, we find that the estimate of the parameter θ is significant when using the full extended sample period, suggesting that the weighted average of realised volatilities contributes meaningfully to long-run inflation uncertainty over this horizon. However, this effect becomes insignificant when we restrict the estimation to the original sample period (1972–2002) or to the extended period excluding either the VAT tax cut or the Covid episode. Notably, the estimate of λ in the GARCH-MIDAS-in-Mean model also loses significance, implying that past inflation cannot predict short-run inflation uncertainty once long-run components are allowed to be time-varying. Importantly, this does not necessarily mean that the results from the GARCH-MIDAS-in-Mean specification contradict the Friedman–Ball hypothesis. Rather, they provide a cautionary perspective: the evidence that inflation raises expected short-run inflation uncertainty, as captured by the significant λ coefficient in the conventional GARCH-in-Mean model, may partly reflect the restriction of assuming a constant long-run inflation uncertainty component. Once this restriction is relaxed, the impact of inflation on expected short-run inflation uncertainty becomes less pronounced. This finding highlights the importance of carefully distinguishing between short-run and long-run components of uncertainty when evaluating the inflation-uncertainty relationship.

[9] The effective data spans from 1976 to 2023.

Table 5
GARCH-MIDAS-in-Mean model estimation results: RV as conditioning variable in MIDAS

z_t	π_{t-1}			
	Original Period	Extended Period		
		Exclude Tax Cut	Exclude Covid	Full
γ_0	–0.0047	0.0046	0.0041*	0.2924***
	(0.0066)	(0.0039)	(0.0030)	(0.0090)
γ_1	1.2150***	1.2128***	1.2298***	–0.0038
	(0.0404)	(0.0385)	(0.0332)	(0.0084)
γ_2	–0.2086***	–0.1961***	–0.2301***	0.2452
	(0.0569)	(0.0505)	(0.0449)	(0.1938)
γ_3	–0.0697**	–0.0612***	–0.0391*	–0.2667*
	(0.0347)	(0.0249)	(0.0249)	(0.1885)
γ_4	0.0133	0.0047	0.0029	–0.1298
	(0.0151)	(0.0107)	(0.0113)	(0.1057)
δ	0.8522**	0.3227*	0.2621*	0.3306***
	(0.3832)	(0.2018)	(0.1774)	(0.0553)
α_0	–0.0006	0.0350	0.1442	0.3308***
	(0.0013)	(0.1554)	(0.9289)	(0.0266)
α_1	0.3756***	0.5039***	0.4221***	0.2133***
	(0.1280)	(0.1256)	(0.1049)	(0.0352)
β_1	0.0436	0.0901	0.0000	0.0000
	(0.1299)	(0.1054)	(0.1635)	(0.1262)
λ	–0.0010	0.1773	0.1767	0.0591
	(0.0024)	(0.7820)	(1.1563)	(0.1877)
m	–0.2283	0.0030	0.0009	0.0030***
	(0.5234)	(0.0133)	(0.0060)	(0.0000)
θ	–0.3357	0.0008	0.0021	0.3492***
	(0.9653)	(0.0037)	(0.0134)	(0.0589)
ω_1	4.5093**	4.5016	4.5175	4.5190
	(2.4549)	(6.1963)	(6.2885)	(3.6012)
ω_2	2.7584	2.7864	2.7623	2.7630
	(6.3777)	(10.6942)	(5.4596)	(2.2411)

*Note: The standard errors are shown in parentheses. *, **, and *** indicate rejection of the null hypothesis of a unit root at the 10%, 5%, and 1% levels of significance, respectively. This table shows the GARCH–MIDAS-in-Mean estimation results, using realised volatility as the explanatory variable in the MIDAS component. The original period, as covered in Kontonikas (2004), spans from 1972 to 2002. Our extended period (Full) expands this timeframe to cover 1976 through 2023. Exclude Tax Cut excludes the VAT cut in 2009 in the UK, and Exclude Covid spans until December 2019.*

A key question we need to address is whether macroeconomic and financial variables can impact long-run inflation uncertainty, and if they do, how this might shape the relationship between inflation and uncertainty. To explore this, we consider using macro-finance variables (as discussed above) as explanatory variables.[10] *Table 6* presents the GARCH-MIDAS results, showing that the weighted average of both the EPU and the yield spread significantly affects the volatility of long-term inflation. This finding suggests that long-run volatility indeed varies with macroeconomic and financial conditions.[11] Consistent with the findings using realised volatility as the explanatory variable, we find that λ is insignificant across all specifications. This suggests that once the model flexibly allows for time-varying long-run uncertainty, the evidence that short-run uncertainty drives higher inflation becomes substantially weaker. Regarding reverse causality, we observe that inflation uncertainty exerts a positive impact on inflation when the long-term component of uncertainty is modelled as a function of the EPU or the yield spread, consistent with the hypothesis of *Cukierman and Meltzer* (*1986*). However, this effect disappears when the VIX is used as the conditioning variable.

While persistent inflation is generally linked to the formation of long-run inflation uncertainty, changes in inflation are more intuitively connected to short-run inflation uncertainty. Therefore, we also assess the relationship between changes in inflation and short-run inflation uncertainty and reported the results in *Table 7*.[12] Similar to the previous analyses, we utilise three macroeconomic and financial variables. As *Table 7* illustrates, the λ estimates across all specifications are insignificant, indicating that inflation changes do not affect future short-run inflation uncertainty. Meanwhile, the Cukierman–Meltzer prediction holds across all models except the VIX.

[10] Although τ_t is introduced and interpreted as long-run inflation uncertainty within our framework, it is important to note that it is estimated using macrofinancial variables – namely EPU, VIX and the yield spread. Therefore, τ_t may also be viewed more broadly as a measure of persistent macrofinancial uncertainty, or its trend, which often overlaps with inflation uncertainty but is not limited to it. This broader interpretation is justified by the strong co-movement observed between these variables and inflation dynamics during periods of financial stress. Accordingly, τ_t should be interpreted as a latent factor capturing both long-run inflation uncertainty and more general macro-financial risk conditions that influence expectations and volatility in the inflation process. We thank an anonymous referee for pointing this out.

[11] While τ_t is constructed to represent long-run inflation uncertainty, it is derived from macrofinancial variables that themselves may reflect broader economic and financial conditions. Therefore, τ_t may simultaneously capture co-movements arising from shared underlying shocks. As such, the results should be interpreted as conditional correlations rather than structural causal effects.

[12] The only difference between the specifications in *Table 6* and *Table 7* lies in the definition of the variable z_t: while *Table 6* uses lagged inflation π_{t-1}, *Table 7* replaces it with the absolute change in inflation, $|\Delta\pi_{t-1}|$.

Table 6

GARCH-MIDAS-in-Mean model estimation results: Recent period (2001–2023) with different conditioning variables in MIDAS

z_t	π_{t-1}			
	GARCH-in-Mean	GARCH-MIDAS-in-Mean		
		EPU	Spread	VIX
γ_0	0.0072	0.0199***	0.0880**	0.0082**
	(0.0343)	(0.0052)	(0.0509)	(0.0045)
γ_1	1.1619***	0.5028***	–0.0420	1.2009***
	(0.2038)	(0.1217)	(0.4031)	(0.0661)
γ_2	–0.1360	0.5634***	0.2075	–0.1884**
	(0.1848)	(0.1492)	(0.5869)	(0.0920)
γ_3	–0.0547***	–0.0792*	–0.3043	–0.0365
	(0.0113)	(0.0580)	(0.4530)	(0.0379)
γ_4	–0.0170*	–0.1180***	–0.1657	–0.0197
	(0.0104)	(0.0438)	(0.3382)	(0.0176)
δ	0.2479**	0.3064***	0.3716***	0.1860
	(0.1140)	(0.0336)	(0.0807)	(0.3536)
α_0	0.0002***	0.0762*	0.4197***	0.1219
	(0.0000)	(0.0473)	(0.1178)	(0.2580)
α_1	0.8146**	1.0000***	0.2019***	0.5364***
	(0.4843)	(0.1687)	(0.0281)	(0.2019)
β_1	0.0000	0.0911***	0.2004	0.0731
	(0.4654)	(0.0373)	(0.1643)	(0.1188)
λ	0.0004**	0.0167	0.0875	0.2443
	(0.0002)	(0.1740)	(0.1943)	(0.5205)
m		–0.0172***	0.0141**	–0.0044*
		(0.0000)	(0.0055)	(0.0094)
θ		0.3638***	0.4171***	0.2185
		(0.0012)	(0.1564)	(0.4622)
ω_1		4.5184***	4.5190	4.5199
		(1.3027)	(4.3355)	(10.7931)
ω_2		2.7636***	2.7630	2.7582
		(0.7527)	(3.0131)	(4.7358)

*Note: The standard errors are shown in parentheses. *, **, and *** indicate rejection of the null hypothesis of a unit root at the 10%, 5%, and 1% levels of significance, respectively. This table shows the GARCH-in-mean and GARCH-MIDAS-in-Mean estimation results. For the GARCH-MIDAS-in-Mean, the Economic Policy Uncertainty Index (EPU), the Ted Spread (Spread) and the CBOE Volatility Index (VIX) served as the explanatory variable in the MIDAS component, respectively. The period spans from 2001 to 2023.*

Table 7

GARCH-MIDAS-in-Mean model estimation results: Recent period (2001–2023) with different conditioning variables in MIDAS, $z_t=|\Delta\pi_{t-1}|$

z_t	$\Delta\pi_{t-1}$			
	GARCH-in-Mean	GARCH-MIDAS-in-Mean		
		EPU	Spread	VIX
γ_0	0.0120***	0.0175***	0.0989***	0.0076***
	(0.0038)	(0.0021)	(0.0353)	(0.0021)
γ_1	1.2062***	0.5273***	–0.0342	1.1821***
	(0.0520)	(0.0713)	(0.3337)	(0.0499)
γ_2	–0.2139***	0.5368***	0.2149	–0.1696***
	(0.0740)	(0.1844)	(0.5003)	(0.0686)
γ_3	–0.0222	–0.0866	–0.2978	–0.0352
	(0.0348)	(0.2129)	(0.4105)	(0.0333)
γ_4	–0.0142	–0.1186	–0.1617	–0.0200
	(0.0142)	(0.1072)	(0.3198)	(0.0178)
δ	–0.0286	0.3506***	0.3717***	0.1902
	(0.1524)	(0.0579)	(0.1299)	(0.1865)
α_0	0.0002***	0.1105***	0.4063**	0.0914
	(0.0001)	(0.0341)	(0.2134)	(0.3320)
α_1	0.6951***	1.0000***	0.2054***	0.5709***
	(0.2251)	(0.0779)	(0.0266)	(0.1943)
β_1	0.0000	0.0398***	0.1982	0.0114
	(0.0175)	(0.0061)	(0.3589)	(0.0476)
λ	0.0062	0.1282	0.1293	0.2039
	(0.0050)	(0.1512)	(3.8907)	(1.2992)
m		–0.0145***	0.0058	–0.0096
		(0.0000)	(0.0215)	(0.0315)
θ		0.3055***	0.4147**	0.4776
		(0.0000)	(0.2292)	(1.5969)
ω_1		4.5213***	4.5190	4.5181
		(0.9698)	(7.4625)	(11.7613)
ω_2		2.7589***	2.7631	2.7637
		(0.2886)	(2.5563)	(6.5527)

*Note: The standard errors are shown in parentheses. *, **, and *** indicate rejection of the null hypothesis of a unit root at the 10%, 5%, and 1% levels of significance, respectively. This table shows the GARCH-in-Mean and GARCH-MIDAS-in-Mean estimation results. $z_t=|\Delta\pi_{t-1}|$. For the GARCH-MIDAS-in-Mean, the Economic Policy Uncertainty Index (EPU), the Ted Spread (Spread) and the CBOE Volatility Index (VIX) served as the explanatory variable in the MIDAS component, respectively. The period spans from 2001 to 2023.*

5. Conclusion

This paper revisits the relationship between inflation and inflation uncertainty using a GARCH-MIDAS-in-Mean approach with UK data, allowing us to decompose inflation uncertainty into short-term and time-varying long-term components. We find that macroeconomic and financial variables significantly impact long-term inflation uncertainty. Furthermore, the empirical analysis shows that the standard GARCH-in-Mean model finds a positive and significant effect of inflation on inflation uncertainty, consistent with the Friedman–Ball hypothesis. However, when short-run inflation uncertainty is separated from time-varying long-run uncertainty, the evidence that past inflation increases short-term uncertainty becomes much weaker. This suggests that the Friedman–Ball hypothesis may apply mainly to long-run inflation uncertainty rather than short-term fluctuations. Additionally, we find strong evidence of a positive impact of inflation uncertainty on inflation, providing support for the Cukierman–Meltzer hypothesis.

Our evidence shows that long-run inflation uncertainty is time-varying and that uncertainty feeds back into inflation. This suggests that policy should target the determinants of the long-run component. First, stabilise and clearly communicate the reaction function (i.e. rules-based decisions and state-contingent forward guidance) to anchor expectations and lower policy uncertainty. Second, coordinate monetary and fiscal measures (e.g. VAT changes) and pre-announce time paths to avoid surprise regime shifts that create structural breaks. Third, embed a real-time MIDAS-style dashboard (EPU, yield spread, market volatility) into the policy process and publish it so that reducing long-run uncertainty becomes an explicit intermediate objective. Fourth, when shocks hit, favour automatic stabilisers and targeted measures with sunset clauses over discretionary packages that are hard to forecast. Finally, since short-run inflation does not reliably raise short-run uncertainty once long-run variation is modelled, avoid overreacting to transitory price spikes and focus on anchoring the longer-horizon component.

This analysis can be extended in several directions. First, while we allow nonlinearity within the MIDAS weighting function, the long-run volatility is essentially assumed to be linear given the weighting scheme. Extending the MIDAS to a nonlinear framework through a regime-switching model as in *Pan et al.* (*2017*), a threshold model as in *Chen et al.* (*2023a*) or a kink model as in *Zhang et al.* (*2024*) would be an interesting avenue for future research. Second, while this paper focuses on the UK, it would be worthwhile to extend the model to a panel setup and use global data to re-examine this nexus. Third, in this paper, we focus exclusively on the impact of inflation on short-run uncertainty, without examining the long-run uncertainty. It would be intriguing to investigate how past inflation affects both the short-run and long-run components of uncertainty by introducing lagged inflation as an additional regressor into the MIDAS model. We leave these possibilities for future research.

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The Relationship between Competitiveness, Resilience and Risk Structure*

László Csorba

This study presents the relationships between enterprises' competitiveness, resilience and risk structure. The use of normal distribution and related theories is fundamental in enterprise quality management, but this is not typical in the areas of competitiveness and resilience. According to the central limit theorem, whether or not the frequencies of a company's performance characteristics follow a normal distribution depends on the risk structure. However, the normal distribution of these characteristics can be an important indicator of a company's competitiveness and resilience. The central limit theorem imposes very strict conditions on the risk structure of a company. These were modelled using dice with different numbers of sides. According to the results, well-diversified risks can form the basis for competitiveness and resilience. At the same time, the setting of business objectives and the creation of reserves remain important.

Journal of Economic Literature (JEL) codes: D81, G11, L21, P34

Keywords: competition, competitiveness, resilience, risk, risk structure, normal distribution

1. Introduction

One of the fundamental characteristics of economic competition is that competitors respond differently to the demands placed on them and thus achieve their goals with varying degrees of success. Competitors can be companies, but also industries, regions and countries. This study discusses the relationships between competition, competitiveness, resilience and risk structure at the corporate level. The significance of this micro level of analysis is that, in this case, it is the company alone that needs to survive, develop and meet the requirements of competition, while at higher, meso and macro levels, smaller or larger groups of companies must do so. In the latter case, greater compliance with competitive requirements can often

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be achieved if some companies are forced to retreat or even cease to exist, while others can develop, as was the case during the Covid-19 pandemic (*Canton et al. 2021*).

The concept of corporate competitiveness has been a well-researched area of economics for a relatively long time, as Megginson pointed out to US companies as early as 1963 that businesses in Western European countries, which had been devastated by the war, had not only recovered but in many respects had gained better market positions than their American competitors. "It is not the most intelligent species that survive, nor the strongest, but those that are most responsive to the changing environment in which they live" (*Megginson 1963:4*).

At the same time, the 1973 oil crisis drew attention to the fact that it is possible to manage effectively in other "peacetime" situations and in other crisis situations and their aftermath. While the oil crisis also had a strong impact on market economies, albeit to varying degrees, the development of socialist countries was clearly disrupted (*Sanchez-Sibony 2016*). The 2008–2009 financial crisis had a similarly powerful impact on economic actors, countries and regions (*Doran – Fingleton 2015*), as did the consequences of the Russian-Ukrainian war (*Kimhi et al. 2023*).

Whether in terms of competitiveness or resilience, risks are clearly unavoidable. A competitive company must be able to perceive the demands placed on it as well as changes in those demands, and must also be able to adapt to them, while consistently outperforming its competitors (*Chikán 2011*). The capabilities, characteristics and strategy of a competitive economic actor are more in line with the requirements of competition, so that overall it faces smaller and/or more manageable risks (*Rutkauskas 2008*). The ability to cope adequately in extremely unfavourable situations – i.e. resilience – also assumes that what constitutes a critical situation varies among different actors, meaning that such situations pose smaller and/or more manageable problems for resilient actors than for non-resilient actors (*van der Vegt et al. 2015*).

In biology, observations, experiments and theoretical models have also proven that from an evolutionary perspective the individual that will be more successful is the one whose numerous, relevant risks do not, on their own, have such undesirable consequences that, if realised, would decisively influence the individual's development and survival (*Cohen 1966*). Biological relationships are often applied in economics. In general, the risk structure of economic actors is rarely extremely favourable or unfavourable; for the vast majority – those with average or near-average performance – it is relatively balanced (*Stearns 2000*). According to economic life cycle models, actors in the maturity phase have the most balanced

risk structure, while the most problematic phase – where extremely high risks must be faced – is typically the birth and growth phase (*Boussabaine – Kirkham 2004*).

This study seeks to answer the question of whether a company can be competitive and resilient without having a balanced, i.e. sufficiently diversified, risk structure. So, if one or a few of a company's risks are significantly greater than its other risks, can it achieve an adequate level of competitiveness and resilience? On the other hand, is a balanced risk structure only a necessary condition or a necessary and sufficient condition for corporate competitiveness and resilience? In general, can the competitiveness and resilience of a business be measured by its risk structure alone?

The first part of the study briefly introduces the concepts of competition, corporate competitiveness and resilience in relation to risks. Subsequently, based on the central limit theorem, the significance of the risk structure in terms of corporate competitiveness and resilience is modelled. The study ends with a set of conclusions.

2. Competition, competitiveness, resilience and risks

Defining the essence of economic competition is obviously important if we want to talk about competitiveness. Two main, essentially complementary approaches to the concept of competition have gained ground in recent decades. According to one (*Stigler 1972*), competition is the parallel, mutually influential activity of economic actors, where the strength of competition basically depends on how many are competing and the relative size of the competitors to each other and to the market. According to the other approach, competition is for certain scarce goods, such as buyers, raw materials and labour (*Hueting 1980*). Since there are many different types of competition, economic competition generally means that economic actors have a certain degree of freedom to determine their goals and the planned means of achieving them, at least in part autonomously, while also having certain obligations towards their stakeholders. In this way, through the autonomy that has been granted, economic competition is able to regulate itself to a certain extent (*Tardos 2014*). Economic actors therefore have a certain degree of freedom to set their own unique goals, as well as the freedom to decide for themselves how to achieve those goals by exploring and exploiting new opportunities. At the same time, it is not certain that economic actors will be able to use this theoretical room for manoeuvre, as their knowledge and skills, and the extent to which they have access to relevant resources may be decisive in this regard. On the other hand, it is also not certain that economic actors will want to use this room for manoeuvre, as their cultural and institutional characteristics and their expectations regarding future competitive requirements may also be decisive in this regard. The possibility

of using this room for manoeuvre is essentially a right to "decentralised initiative" (*Kornai 2010:10*), which is obviously accompanied by certain obligations, whether towards the government, the state, customers, suppliers or other stakeholders. However, the scope of rights and obligations only defines the framework, and the actual process of competition is then determined by a great many factors. Thus, among other things, the constantly changing requirements imposed on competing companies, the expectations placed on them (*Beckert 2013*) and their prior or subsequent adaptation to these expectations (*Haasnoot et al. 2020*) are important, as well as the influence of competitors' simultaneous activities. In terms of how successfully competitors are able to achieve their goals in course of competition, their competitiveness is of paramount importance.

Competitiveness is an important concept in economics, which is linked to surviving in appropriate shape and the ability to hold one's own in future competition. We can distinguish between the competitiveness of organisations, industries, regions and countries, and each level has several concepts and definitions related to competitiveness (*Zuñiga-Collazos et al. 2019*). This study focuses on the competitiveness of economic organisations and businesses. For the sake of comparability, it is necessary to assume that all parties involved are participating in the same competition. In other words, their goals and methods are nearly identical, and the competition imposes the same requirements on them (*Porter et al. 2008*). With regard to the goals and methods of achieving them, it is usually stipulated that they must be legal in the given competitive environment (*Moorthy 1985*). If existing legal or social and cultural institutions actually require sustainability or social responsibility, then compliance in these areas will indeed be closely linked to competitiveness (*Czakó – Chikán 2007*). There is no single type of competition at any given time. Even within a single country, for example within different industries, there may be several types of competition, which grant rights and impose obligations in different ways, i.e. they define the scope of action of the players in different ways. This is why it is difficult to compare competitiveness across industries and countries from different perspectives, such as social responsibility (*Reisinger 2023*). Even under normal, non-extreme conditions, it is not uncommon for some economic organisations to fail to survive in the face of competition (*Trout – Rivkin 2008*). Competitiveness is essentially about the quality of the economic actor itself in relation to the competition in each market (*Chiles – Choi 2000*). In general, the competitiveness of an economic actor is determined by its ability to adapt to constantly changing competitive conditions with sufficient speed and to the appropriate extent, while at the same time achieving its objectives to a sufficient degree (*Megginson 1963*). In terms of competitiveness – and thus the adaptation that underpins it – human resources are of decisive importance, since without sufficient innovation performance, competitiveness cannot even be discussed (*Csath*

2022). Adaptation reduces the risks taken, while innovations increase such risks due to their novelty.

The concept of resilience came to economics from the field of psychology. In the latter, it refers to how people are able to adapt to serious situations and risks, and to what extent they are able to preserve a good level of mental and physical health in such circumstances and maintain this in the future (*Masten et al. 2002*). Resilience is therefore a characteristic possessed by those who can continue living in a reasonably good state, despite experiencing extreme difficulties. Similarly to competitiveness, the economic concept can be interpreted at the level of economic actors, or at the industry, regional or national levels. At the level of enterprises, the concept places greater emphasis on how economic actors can minimise their losses in extremely negative circumstances, in order to continue to achieve their current goals in the future (*Hallegatte 2014*). One key difference between the biological and economic concepts of resilience is that the human body and brain are much more constrained in terms of adaptation and renewal than a business. A resilient economic actor therefore has the knowledge, skills, resources and strategies that enable it to adapt very quickly and restore the normal functioning of that which has been disrupted by an external shock or the unexpected and prolonged persistence of extreme economic conditions. Restoring the operating order often means establishing a new order or renewal, which enables the actor to once again achieve their goals sufficiently effectively (*Halmai 2021*). Resilience – much like competitiveness – is a dynamic concept that also makes predictions about the future, while both past and present facts and forecasts remain partially relevant (*Kovács 2024*). The three basic dimensions of resilience are vulnerability, shock absorption and recovery capabilities. Economic actors need resilience when a risk with serious consequences or a combination of risks with such cumulative consequences materialises. In such cases, it is advantageous for the actor to prepare contingency plans, provided that they were aware of their risk exposure in advance (*Nemeslaki 1996*). In terms of resilience, it is by no means a disadvantage for an economic actor to be part of a cooperative group (*Magas 2018*). Well-chosen insurance policies, including liability insurance, can also contribute significantly to the actor's resilience in the event of serious damage (*Markó – Pandurics 2015*).

Resilience is often measured retrospectively, based on the extent to which an economic actor has regained its economic strength and viability, and the extent to which it has managed to return to its previous growth trajectory (*Volkov et al. 2021*). At the same time, similar to competitiveness, it is useful and advisable to measure resilience before potential periods of crisis, as this provides an indication of whether the business will be sufficiently resilient in the future (*Rose – Krausmann 2013*). The main determinants and measurable factors of resilience are financial, resource and technological reserves, operational flexibility, the duration of

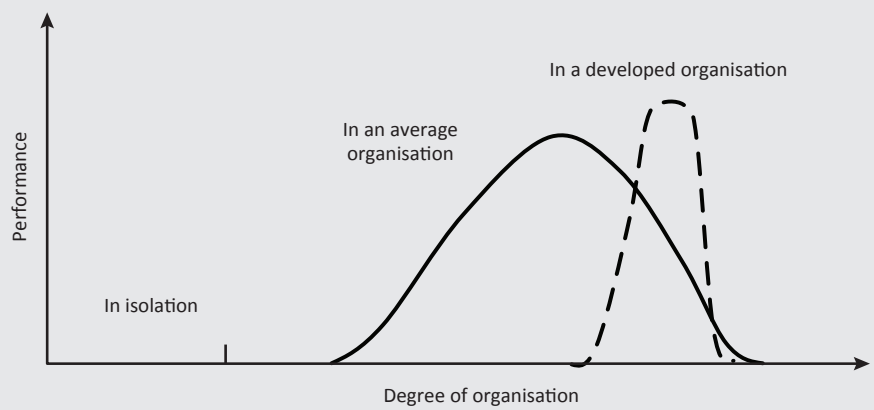
cooperation with partners and innovation activity (*Rose – Krausmann 2013*). The degree and strictness of government regulation (*Wang – Li 2022*) may be important in relation to flexibility and innovation activity, but so may the method and extent of government support (*Liang – Li 2023*). State and government regulation and involvement affect the shock-absorbing capacity and thus the resilience of all businesses via market and labour market prices and the functioning of financial markets (*Halmai 2021*). A higher level of resilience can be achieved if the enterprise develops its risk structure with great awareness, taking into account the relationship between return and risk, and making good use of the risk reduction opportunities offered by diversification (*Wang – Li 2022*). At the same time, however, stockpiling and diversification also mean foregoing some of potential economic growth, at least in the short term (*Wang – Li 2022*).

Risk is understood as the possible materialisation of some negative consequence in relation to the achievement of the actor's goals (*Aven 2016*). The success of a business in the short term may not necessarily reflect the extent of the risks taken to achieve that success. This is because risks do not necessarily have a negative impact, and thus even with high risk it is not certain that the associated undesirable negative consequences will actually materialise (*Jorion 2000*). The example of the financial company Long-Term Capital Management also shows that high risks do not necessarily materialise in the short term, thus creating the illusion of low risks, while in the longer term they inevitably have an impact (*Jorion 2000*).

The question is how the level of risk taken relates to the competitiveness of the economic actor. If we consider the product life cycle theory, there are two life cycle stages where the risk level can be favourably low (*Boussabaine – Kirkham 2004*). On the one hand, there is the growth phase, when the risks hindering growth have already been eliminated or significantly reduced, while the new risks arising from growth itself have not yet become too pronounced. On the other hand – and this is more typical – this may be the case in the maturity phase, when the associated risks have already been substantially reduced, and stable, balanced conditions have been established. From a competitiveness perspective, the maturity stage is clearly the most favourable, when product quality reaches its peak, risks are minimised and financial success is relatively strongest (*Porter 1990*). The life cycle is also applicable to companies, where the level of risk taken is also lowest in the maturity phase, while their profitability is highest (*Shahzad et al. 2019*). The level of risk taken by companies is lowest in the maturity phase because managers want to or are forced to take the least risk at this stage (*Habib – Hasan 2017*). Economic actors often compete with each other through the risks they take, which in turn can have a negative impact on their competitiveness (*Király – Nagy 2008*).

From the perspective of corporate theory, companies can remain on a growth path as long as the risks increase less than the value created (*Cummins 1976*). The basis of a company's existence is that it not only reduces the direct costs of production, but also transaction costs and, in connection with both, risk-related costs. In general, it can be said that companies that place greater emphasis on risk management have a higher value (*Krause – Tse 2016*). This is also the view of evolutionary economics, which argues that what essentially takes place in the economy is group selection. In this process, members of a community do not participate in selection primarily and decisively in isolation from others, but as part of a smaller or larger community as a selection unit. In this way, it is not individual characteristics that must meet the selection requirements, but relevant group characteristics. The group may exist because the individual derives or may derive some selection advantage from the more or less coordinated activity and "proximity" of its members: risks are reduced, chances of survival increase and survival conditions may improve (*van den Bergh – Stagl 2003*). *Deming* (*2000*) emphasised the importance of the group – primarily the company or organisation from an economic perspective – as a supportive environment. Some average organisations can offer little more than this to individuals, but most are able to significantly increase individual performance (*Figure 1*). Organisations that have been further developed through considerable effort are better able to fulfil their supportive function and ensure coordination and the conditions for continuous learning.

Figure 1
Organisations' excess performance potential



Source: Based on Deming (2000:127)

In quality management methodology – see, for example, statistical process control – normal distribution receives special attention. In well-controlled processes – where various risks have already been eliminated or minimised – the basis is that the measurement results of the various variables follow a normal distribution, and then the main goal is to further reduce the probability of extremely small and large values (*Allen 2006*). All of these quality efforts are made with the aim of strengthening the competitiveness of the manufactured product or service, and thus of the business. At the same time, the almost total avoidance of extreme situations also strengthens the resilience of the business (*Sabatino 2016*).

Risk reduction and management is one of the central categories of survival and development. Risk can be reduced with more favourable conditions, as the chances of the actor being able to control the given activity increase, thereby avoiding unfavourable outcomes. With greater knowledge, more resources and more meaningful decision-making alternatives, the actor typically faces less risk. Ultimately, culture is also a determining factor in terms of the risk taken (*Vasvári 2015*). With the widespread application of portfolio theory (*Markowitz 1952*), it is now generally accepted that diversification can significantly reduce the level of risk. *McCloskey and Nash* (*1984*) also confirmed *McCloskey's* earlier (*1976*) hypothesis that farmers in medieval England primarily established producer communities in order to stabilise the farming activities of community members by spreading potential individual losses among the members, thereby minimising potential individual losses as well as individual savings needs. The issue of portfolio diversification and reducing risk thereby often arises in conjunction with the issue of sharing risks with partners (*Csóka 2003*).

Traditional risk management approaches focus on identifying risks and reducing vulnerability to external disruptions. The resilience approach to extreme negative situations has a different meaning: it means that the focus of attention is on other abilities and capacities, on resources that are flexible enough, can be stored, transformed and further adapted so that systems can successfully cope with extremely negative, unexpected events and learn from them (*Sutcliffe – Vogus 2003*). In the case of so-called black swan events, the primary goal should not be to predict them, but rather to prepare economic actors for the possibility that their operations and activities could be seriously and extremely disrupted by something that could not have been anticipated as a real risk based on previous experience (*Grandori 2020*). A resilient economic actor is therefore prepared for the emergence of extremely negative situations and for coping with such situations, which presupposes that it has been able to achieve its goals successfully in near-average situations. Only economic actors which have been sufficiently successful and effective in their usual competitive environment are able to accumulate the necessary knowledge, skills and resources (*van der Vegt et al. 2015*).

When competition between economic actors becomes excessive in terms of risk-taking, it also has a strong impact on their resilience (*Bethlendi 2015*). At the same time, economic actors can only become and remain competitive if they are sufficiently resilient, i.e. if they are able to return to a path of growth and development after a crisis at a similar speed as their leading competitors (*Halmai 2019*).

3. Modelling the risks underlying normal distribution

Next to Lake Titicaca, Indians in the Andes traditionally grew potatoes – and often still do today – with each family cultivating an average of 17 plots measuring 225 square meters each, which are so far apart that the Indians spend three-quarters of their working day walking from one plot to another (*Diamond 2013*). This does not seem to be a very time- or cost-effective method, as, for example, by combining the plots through exchanges, each family could produce several times more than with this fragmented method. However, since this fragmented, scattered method of production is also traditional and accepted in other parts of the world, experts have examined the reasons for this. Why do these families, who live in very poor conditions, forego the possibility of much larger crop yields? The expert analysis concluded that this is essentially a very effective form of portfolio diversification, as the individual plots differ from each other in many ways, enabling them to almost completely compensate for each other's yield fluctuations, regardless of the annual weather conditions (*Diamond 2013*). Admittedly, the price of this is that even in good years, they are unable to produce exceptional yields. However, this is less important to their owners than ensuring that they have enough potatoes to meet their basic needs. If production took place on a single, consolidated plot, the Indians could harvest significantly more potatoes in an average year, but every 10 years there would be a bad year in which they would starve to death due to insufficient harvests (*Diamond 2013*).

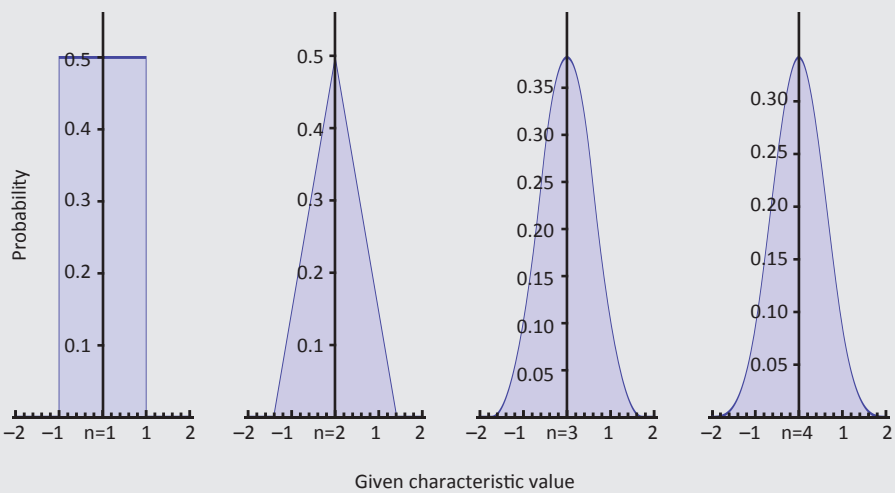
The yields of traditional Andean potato cultivation followed a normal distribution per family, where the annual harvest was almost always average or close to average, and it was very rare for them to harvest an extremely poor or good crop. This enabled the Indians to survive in the region for thousands of years. Interestingly, these Andean Indians applied the central limit theorem without being aware of it. Today, we are familiar with this theorem, but its use in everyday or strategic decisions is perhaps less widespread. What does the central limit theorem say? According to the theorem, the value of a variable will follow a normal distribution (*Dudley 2014*), which is the standardised mean of certain probability variables, provided that these probability variables:

- are independent of each other;
- are sufficiently numerous;

- have very similar ranges of influence on the sum of the probability variables; and that
- the number of measurements taking all probability variables into account at the same time is sufficiently large.

Interestingly, it does not matter whether the distribution of individual probability variables is normal or not (*Dudley 2014*). Thus, when the distribution of a variable follows for example a power law – i.e. the smaller the value that can be taken by the variable, the smaller its frequency – this does not preclude the conditions of the central limit theorem from being satisfied for all probability variables together (*Dudley 2014*). Normal distribution can therefore be achieved by ensuring that the above four conditions are met, for example by repeatedly throwing a set of six-sided dice (*Kwak – Kim 2017*). In this case, the probability variables are the dice themselves and the results of throwing them individually, die by die. The aggregate result is the one that should follow a normal distribution if we roll a sufficient number of dice and perform a sufficiently large number of rolls (*Figure 2*). The condition of independence is also fulfilled, while the possible contribution of each die (1–6) to the aggregate result is sufficiently similar, in our case identical. It is obvious that the more dice we throw, the greater the aggregate result we can expect, compared to which the contribution of each die roll becomes smaller and smaller. At the same time, it is very important to have a sufficiently high number of throws, as in the case of small series (samples), the law of large numbers cannot yet prevail, and they are more prone to producing more extreme results, i.e. non-normal distributions (*Lyon 2014*).

Figure 2
Validity of the central limit theorem according to the number of variables included



Source: Based on Lyon (2014:625)

We can see that the Andean Indians correctly applied the central limit theorem in developing their production strategy, since an average of 17 plots of nearly identical size is large enough to produce a near-normal distribution of their total annual potato yield, even when considering a shorter period of time. The reason why only a near-normal distribution is achieved in this case is that the edges of the distributions are unlikely to be properly defined in such a small number of experiments. What is the reason for this? Staying with the example of throwing six-sided dice but now applying it to the Andean potato-growing Indians, the sides of the dice can represent the annual yield per plot on a scale of 1 to 6, measured in quintals (100kg). Thus, in the worst year, when each plot yields only the lowest amount of 1 quintal, the total harvest will be 17 quintals, as there are 17 plots under cultivation. Similarly, the maximum possible yield, when each plot yields 6 quintals, will be a total of 102 quintals. If the yields of the 17 different plots are determined independently of each other, then the probability of an annual yield of 17 quintals or 102 quintals will be the same, almost 0 per cent, i.e. 1:16,926,659,444,736. The probability of any other yield between the minimum of 17 quintals and the maximum of 102 quintals is higher than that of the extremes, especially the two values close to the average of 59.5, namely 59 and 60 quintals. The probability of the latter is 5.5989 per cent, separately. If, for example, 45 quintals of potatoes is the family's annual minimum subsistence level, then the probability of a higher yield is 98.3937 per cent, which seems reassuring.

In the case of normal distribution, the probability of quantities closest to the average is so high compared to the extremes because, in the case of extremes, the conditions for production must be either the best possible (102 quintals) or the worst possible (17 quintals) for all 17 plots, which is only 1 combination (respectively), out of the possible 16.9 trillion. In the case of 59 and 60 quintals, which are closest to the average (59.5 quintals), approximately 5.6 per cent of all possible combinations are suitable (respectively) for these crop yields to be realised.

We can test the validity of the central limit theorem if we want to produce the same sum with fewer dice but with more sides. In our case, this was originally 102 for the 17 six-sided dice, and will be 100 in the other modelled cases, but the results still adequately illustrate that the originally perfectly normal distribution changes significantly with fewer dice. In the case of fewer dice, roll totals up to 16 were not taken into account, as these could not be produced with the original 17 dice. According to the results, although the average remains almost the same, the distribution becomes much flatter and its edges – or tails, to use the technical term – become much fatter. By reducing the number of dice from 17 to 5, the probability of the minimum required roll of 45 drops dramatically, by about 26 percentage points, while the fatness of the tails – still remaining below half a per cent probability – increases by about 240,000 times (*Table 1*). Thus, if the number of probability variables decreases significantly while remaining at the same risk level,

the amount of risk taken increases significantly. All of this supports *Markowitz*'s (*1952*) portfolio theory.

Table 1
Probabilities of the sums of rolls of dice with different numbers of sides and numbers of dice

Dice	Probability of a minimum roll of 45 (1–16 not counted)	Probability of a minimum sum of 17 and a maximum sum of 25 (negative extreme)	Probability of negative extremes compared to the case of 17 six-sided dice (ratio)
17 x 6-sided dice	98.39	1:15,692,186	1
10 x 10-sided dice	87.42	1:3,095	5,070
5 x 20-sided dice	72.70	1:66	239,248
10 x 8-sided dice and 1 x 20-sided die	84.23	1:57,983	271
8 x 10-sided dice and 1 x 20-sided die	79.95	1:7,984	1,965

Source: Based on data from Georgiev, G.Z.: "Dice Probability Calculator" (https://www.gigacalculator.com/calculators/dice-probability-calculator.php)

If we want to examine the case where one of the probability variables has a much larger effect range than the others, i.e. they no longer influence the final result in a nearly identical manner, we find that the probability of the minimum required roll amount decreases significantly, while the fatness of the tails increases less. The larger the deviation of the selected probability variable's effect range from the others – from the base level – the greater the flattening of the normal distribution, the decrease in the frequency average and the increase in the fatness of the tails (see *Table 1*).

The independence of probability variables is also an important issue in terms of the creation and maintenance of normal distribution. In the case of dice, the effects of possible positive correlation are well illustrated by the influence on the results when the values of all other variables depend entirely on the value of one probability variable (correlation value 1). The normal distribution flattens dramatically and falls apart, while the fatness of the tails increases enormously (*Table 2*). Essentially, they can no longer be interpreted as tails at this point, as it is as if we were throwing only one six-sided die instead of 17 six-sided dice and multiplying the results by 17. Of course, such a strong correlation between probability variables is very rare, but it shows the tendency of what happens when the independence condition between probability variables is violated. In this case, the thickening of the tails is greatest. Then the negative extremes, which should occur only exceptionally rarely, become significantly more frequent.

Table 2
Effect of correlation on the probabilities of the sum of rolls in the base model

Dice	Probability of a minimum roll of 45 (1–16 not counted)	Probability of a minimum sum of 17 and a maximum sum of 25 (negative extreme)	Probability of negative extremes compared to independent case (ratio)
No correlation	98.39	1:15,692,186	1
Correlation: 1	66.66	1:6	2,615,364

Source: Based on data from Georgiev, G.Z.: "Dice Probability Calculator" (https://www.gigacalculator.com/calculators/dice-probability-calculator.php)

Another important question – beyond the conditions of the central limit theorem – is what goals the actors set and what returns they expect and demand in connection with their activities. If they wish to achieve their goals with a high degree of certainty (i.e. with a high probability), it is reasonable to specify a value that is approximately one standard deviation below the mean of the normal distribution. Specifying higher target values initially reduces the probability of realisation and further increasing the target values drastically reduces it. In our case – see the original model – 17 six-sided dice can produce a maximum roll of 102, where the average is 59.5 (since the smallest roll is 17). Even with an expectation slightly below the average – 55 – there is a 24-per cent chance that the set goals will not be achieved. With a value slightly above the average – 65 – there is a 76-per cent probability that the goals will not be achieved. The probability of achieving a target value of 85, which is 17 per cent lower than the maximum possible value, is only 0.01 per cent (*Table 3*). In addition to the existence of a normal distribution, it is therefore very important to determine what target values are set in relation to the average and the standard deviation. Setting overly ambitious targets generates additional risk in itself. However, actors which are able to set their management frameworks and targets in such a way that the probability of achieving their targets is very high will be able to create and maintain a state of knowledge, skills and resources that will enable them to respond flexibly, efficiently and effectively to any usual competitive challenge. This does not mean that low goals should be set, but rather that high goals should be aligned with the normal distribution and should be below average. We have previously referred to such players as competitive.

Table 3
Probabilities of certain roll totals in the basic model

Probability of a minimum roll of 45	Probability of a minimum roll of 55	Probability of a minimum roll of 65	Probability of a minimum roll of 85
98.39	75.96	24.04	0.01

Source: Based on data from Georgiev, G.Z.: "Dice Probability Calculator" (https://www.gigacalculator.com/calculators/dice-probability-calculator.php)

It is also extremely important that if the objectives are not achieved, the economic actor must be able to cope with the consequences of strongly or extremely negative outcomes, i.e. the losses suffered in this way. Are they able to manage such losses by using the financial and non-financial reserves accumulated during their previous, more successful management in such a way that they do not exhaust their future opportunities? Sustainability is thus inevitably linked to resilience. Sustainable management is essentially resilient, but the reverse is not true, i.e. an economic actor can be resilient without managing in a completely sustainable manner (*Espiner et al. 2017*).

Competitiveness does not necessarily mean resilience. It is possible to be competitive in the short term – under normal, everyday, average and near-average conditions – but if extraordinary situations put economic actors to the test and they are found to be vulnerable, it is not possible to speak meaningfully of competitiveness in the longer term. Resilience can be maintained in the short term even without competitiveness, but in the longer term it is essential that competitive activity strengthens, develops and maintains reserves of knowledge, skills and resources, while in the absence of competitiveness, existing stocks and reserves will be depleted.

In theory, a company with a risk structure that satisfies the conditions of the central limit theorem is competitive and is not threatened by any serious negative events that could affect its resilience, as the probability of such events is negligible. In reality, however, crises and other shock events do affect even the most competitive companies, and such situations arise much more frequently than the negligible probability would suggest. This apparent contradiction may be due to the following reasons:

- Due to goals that are excessive compared to the given normal distribution and significantly exceed the average, outcomes that are not extremely disadvantageous in theory – only slightly below average – but have a significant probability are already considered relatively serious negative outcomes.
- There is no significant correlation between certain probability variables in everyday, average or near-average periods – thus, there is essentially a lack of measurement data – but under certain circumstances, the correlation becomes visible, "activated," and this greatly increases the probability that would otherwise have been considered negligible.
- When individual risks are linked to decision-makers – such as stock exchanges – there is always a danger that, instead of diverse decisions, significant uniformity will develop, which excessively reduces probability variables and distorts the normal distribution.

Extreme values, particularly in terms of competitiveness but particularly in terms of resilience, are of great importance, especially because these values and their probabilities of occurrence are often underestimated. Extreme values and their probabilities can be estimated using a separate methodology – see extreme value theory – because it is not really possible to apply the central limit theorem, as it is often impossible to fully determine the probability variables involved, and even if it were possible, the relationships between them and dependencies between them would be underestimated (*Kratz 2019*).

Between 1845 and 1852, Ireland experienced the Great Famine, during which 1 million of its 8 million inhabitants starved to death due to potato blight, and another 1 million emigrated to the United States (*Kinealy 1994*). At that time, for many decades Ireland had been growing potatoes in huge quantities as a monoculture without crop rotation, which enabled it to meet the rapidly growing calorie needs of its population. The potato blight appeared to come out of nowhere and caused extreme damage for seven years. It has now been proven that the pathogen arrived via North America from the Andes, where it had always been present but had not been able to cause significant damage due to diversified cultivation (*Saffer et al. 2024*). There was never a famine in the Andes, and due to the sufficiently moderate risk structure, negative extremes only occurred once every few hundred years, in a single season. Thus, the true impact spectrum of the pathogen causing potato blight could not be known, especially in Ireland, under different production conditions. All of this demonstrates the validity of the central limit theorem, but also its limitations, as well as the applicability of extreme value theory. In certain industries, such as credit institutions, this perspective – namely, that the risk structure also indicates the quality of the actor's management – can be considered commonplace (*Kovács 2015*), while in other industries it is much less common or not common at all.

4. Summary and conclusions

Hope for the best, but prepare for the worst, as the English proverb says. While the concept of competitiveness focuses on the usual, average and near-average, assumed future conditions, resilience focuses on exceptional events with serious negative consequences. Here, dangers and risks obviously receive more attention, but the emphasis is on survival techniques and accumulated reserves of knowledge, skills and resources. Yet risks are one of the generally very important indicators of the state and functioning of economic actors. This study essentially sought to approach the concepts of both competitiveness and resilience from the perspective of risks. In order to make this approach more precise, the concept of normal distribution and, in connection with this, the central limit theorem were included.

According to the results, in order for an actor to be highly competitive – i.e. for there to be a small gap between the relevant competitive requirements and the actor's capabilities related to them – its risk structure must be well moderated in accordance with the conditions of the central limit theorem. This is not simply a matter of diversification, as the participant must apply extensive risk management to create a sufficiently large number of independent risks, each with a small potential impact. This risk management includes, among other things, strategic, business model-related financial and technological decisions, efforts and developments, not just the participant's efforts to diversify its activities or other portfolio.

The four conditions of the central limit distribution – especially the similar weight and independence of the probability variables – may seem overly sterile and "alien to life". However, it should not be forgotten that the risk structure should satisfy this set of conditions not before risk management, but after it. In addition, in the course of risk management, priority is always given to those risk factors that have a large effect range in themselves and/or on which other risk factors are partly dependent. Within the framework of advanced quality management systems, continuous improvement will eventually result in a sufficiently moderate risk structure, which on the one hand ensures sufficient competitiveness for the future, and on the other hand creates a suitable basis for dealing with and overcoming unexpected, serious situations.

Competitiveness is fundamentally necessary in terms of resilience, but it is not a sufficient condition. Only sustained competitiveness, only consistent performance in competition during "peacetime" can create the knowledge, skills and accumulation of financial resources that enable a player to survive in appropriate shape and overcome extremely negative situations. In such cases, it is necessary to map out the risks as thoroughly as possible, as this is when the most resources, time and measurement opportunities are available. At the same time, this also requires the intention to manage potential losses appropriately, i.e. sufficient awareness, which allows for the accumulation and preparation of the appropriate knowledge, skills and resources.

Most businesses link success to the risks they take, believing that without taking a certain amount of extra risk, it is not possible to achieve sufficient success. In the case of credit institutions, for example with regard to credit risks, it is clear that a certain healthy appetite for risk is necessary in order to achieve profit targets. At the same time, in order to achieve and maintain competitiveness and resilience, it is necessary that there be no significant differences between the impact ranges of the risks taken and that there be no significant correlation between the risk factors. Credit institutions pay particular attention to this on both the deposit and credit sides, avoiding concentration risk that could be considered excessive and

balancing and proportioning the risks posed by different customers. The Coca-Cola Company, with its extremely complex, multifaceted product portfolio and its underlying procurement and manufacturing practices, is a good example of how to operate a highly competitive and resilient business with a large number of risk factors that have a similar impact spectrum and are only slightly interdependent. Due to the obvious differences in size, it seems difficult for anyone to follow the example of the Coca-Cola Company, but it was precisely the Andean potato farmers described earlier who showed how this can work on a small scale – in the given competitive environment.

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An Alternative for Future Lending: Income-Linked Repayments*

Zsombor Incze

The study presents the most typical domestic and international trends in mortgage lending models and product development through a literature review of their historical evolution. It concludes that innovations concerning the basic structure of mortgage loan products have not spread in the Hungarian market, although recent academic literature has proposed such developments. Building on one of these academic innovations, a mortgage product based on income variation over the career cycle is developed. This product is examined through the Hungarian medical wage scale and the Magyar Nemzeti Bank's housing affordability methodology. The findings suggest that, with timely and forward-looking financial planning, a household consisting of early-career physicians could potentially afford to purchase a home, suitable for raising children, as their first property.

Journal of Economic Literature (JEL) codes: G20, G21, G50, G51

Keywords: mortgage loan, career cycle, instalment, house purchase, housing affordability

1. Introduction

Housing affordability is a serious social problem worldwide, and Hungary is no exception. According to data from the Magyar Nemzeti Bank (the central bank of Hungary, MNB), in Budapest, purchasing a *first home* for a childless household is typically only possible with considerable financial tightness, and the same is true for rural economic centres (*MNB 2024a*).

Therefore, this study draws on international examples and results from Hungarian literature to construct a loan scheme that takes into account the borrower's *initial* status not only in terms of dwelling size, but also in terms of career: the fact that their income is expected to increase in real terms over the years.

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* The papers in this issue contain the views of the authors which are not necessarily the same as the official views of the Magyar Nemzeti Bank.

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The impact of the scheme on the affordability of house prices is examined using the medical wage scale and the MNB HAI (Housing Affordability Index) methodology, after which the results are summarised and further research opportunities are suggested.

One limitation of the analysis is that how such a scheme would fit into the current Hungarian legal environment is not analysed. The aim of the study is to highlight how powerful it is in itself to go beyond the narrow limits of annuity mortgages – as many other countries do – and to assess the social relevance of the scheme.

2. Overview of mortgage lending and mortgage loan products

Presenting a brief historical overview of mortgage lending, this section summarises the operational models of mortgage-based financing and the product schemes built on them. A broader analysis of the size and dynamics of the mortgage loan market is beyond the scope of this study.

2.1. A brief historical overview of mortgage lending

2.1.1. International developments

Before the emergence of institutionalised housing financing systems, direct forms of financing (within families or ethnic groups) were the most common. More advanced forms of these were, for example, networks organised by notaries in France or Germany in which the notary's presence and access to databases recording property relations provided a kind of basic guarantee for the lender. However, one fundamental feature was that they financed local housing needs from local capital (*Blackwell – Kohl 2017*). In the Anglo-Saxon countries, deposit-based financing solutions were the first to spread, either in a bank-like or more targeted institutional framework (e.g. building societies). The common feature here was that, due to their decentralised operation and local capital raising, they did not compete for the same capital market resources as mortgage bonds and were therefore better able to support the growth of individual home ownership (*Blackwell – Kohl 2017*).

The foundations of institutional mortgage lending which remain typical in continental Europe to this very day date back to the German *Pfandbrief* (mortgage bond) system in 1769. The German system provided a very stable basis for the development of property-based lending. Modern German mortgage financing was established by the Mortgage Bank Act (Hypothekenbankgesetz, HBG), which came into force on 1 January 1900 (*Quirk 2010*). The foundations were so stable that there has not been a single Pfandbrief default in Germany to date (*VDP 2025*), and many other countries have based their mortgage lending structures on the German one, including Hungary.

The Danish mortgage lending system has a similarly strong history, with the foundations laid in 1797 to finance the need for property investment following the fire in Copenhagen in 1795. The Danish system is based on the "balance principle" (*balanceprincippet*), which means that the credit institution disbursing the mortgage loan must issue a mortgage bond that is precisely tailored to the parameters of the mortgage loan in order to finance the loan. The Danish Mortgage Act was adopted in 1850, regulating the institutional structure established in 1797. Today, Denmark is one of the most developed and complex mortgage markets in the world (*Chong 2010*).

In examining mortgage lending, we cannot ignore securitisation structures in the US (and in some European countries). In contrast to the covered bond solution used in Europe, securitisation means that the mortgage loan does not remain on the balance sheet of the issuing bank, but is transferred as a transferable security to capital market investors seeking to invest their long-term funds. Therefore, from a credit risk point of view, the two asset classes are different: the issuing bank is liable for the mortgage bond even if the mortgage loans default, while in the case of a securitised mortgage loan the investor bears the credit loss (*Bozsik 2002*). The resulting anomalies of interest-based systems (the bank assessing creditworthiness is not interested in the long-term soundness of the loan if it outsources it from its balance sheet) were discussed in more detail by *Marsi* (*2008*), while a comprehensive assessment of the perfected model of securitised mortgage lending ("originate to distribute") was published by *Király – Nagy* (*2008*).

Somewhere between the two systems is the Swiss structure, which is also based on mortgage bonds. The Swiss solution is governed by the 1930 Mortgage Bond Act;[1] therefore, this is also a model with proven stability over a long period. Switzerland uses a so-called *pooling model* to secure long-term funding for mortgage loans. In this model, customers are financed by commercial banks, which refinance customer loans (or a part of them) with long-term collateralised refinancing loans received from mortgage banks (these refinancing loans are collateralised by the individual mortgage loans themselves). Mortgage banks are responsible for raising long-term funds on the capital markets. This model has effectively created *specialised* credit institutions with exceptional operational efficiency: a separate institution responsible for serving borrowers and a separate specialised institution responsible for providing the necessary long-term funding (*Nagy et al. 2020*).

The Swiss pooling model presented by *Nagy et al.* (*2020*) thus represents a real transition between *classical* mortgage banking model in Europe and securitisation, which is mainly overseas:

[1] PfG (1930): *Pfandbriefgesetz*. https://www.fedlex.admin.ch/eli/cc/47/109_113_57/de. Downloaded: 20 March 2025.

- The lender provides the commercial bank with the secure, long-term funds necessary for lending;
- This occurs with appropriate economies of scale (as a smaller bank would not be able to securitise on its own);
- It also incentivises commercial banks to exercise restraint, because although they receive capital market funding, they still essentially bear the credit risk.

2.1.2. Hungarian developments

A comprehensive historical overview of mortgage lending in Hungary is provided by *Kovács* (*2004*). In Hungary, the keeping of a land register, which was absolutely necessary for mortgage lending, became compulsory from 1855 (extended to Transylvania from 1870), and from 1856, the mortgage department of the Austrian National Bank also started to provide mortgage lending. This activity was basically able to meet the credit needs of the aristocracy; therefore, in 1863, the Hungarian Land Credit Institute was established to lend to the broader public, lending its funds acquired through the issuance of mortgage bonds. After the Compromise, the market boomed, with more and more players getting involved in mortgage lending. A correct picture of the prudence of the period is basically provided by the fact that while by 1909, 98 per cent of mortgage loans in Budapest credit institutions were backed by mortgage bonds, the national figure was only around 30 per cent (*Kovács 2004*).

Before the First World War, mortgage-based lending was mainly intended to meet the financing needs of agricultural investments, but in the 1920s the financing of mass housing demand also started. However, one problem in the sale of mortgage bonds was the lack of capital for post-war reconstruction in Hungary and the post-war devaluation of the koruna abroad, which led to mistrust in Hungarian mortgage bonds. To reduce their transaction costs, Hungarian banks therefore raised capital to finance Hungarian lending through cooperatives (somewhat similar to the Swiss pooling model) in previously unused markets (e.g. London), but after the onset of the global economic crisis, foreign fund raising became completely impossible (*Kovács 2004*).

Mortgage lending in Hungary was reinvigorated after the change of regime with the 1997 Mortgage Loan Companies Act[2] and the establishment of mortgage banks.

The early 2000s were defined by interest-subsidised loans. Initially, the state provided interest rate subsidies on the liability side (linked to mortgage bonds) and then on the asset side (directly linked to loans), which was a very generous

[2] Act XXX of 1997 Mortgage Loan Companies and on Mortgage Bonds (Mortgage Loan Companies Act) https://net.jogtar.hu/jogszabaly?docid=99700030.tv. Downloaded: 19 March 2025

scheme; in other words, a substantial transfer to the debtors and banks (see *Papp 2005; Hegedüs – Somogyi 2004*).

Following the reduction in interest subsidies, the industry turned to foreign currency lending. This study does not aim to discuss FX lending in view of the already detailed coverage of the topic. The reasons for the emergence of FX lending were analysed, for example, by *Nyeste – Árokszállási* (*2012*), *Dancsik et al.* (*2019*) and more recently by *Schepp – Pitz* (*2022*). *Kovács* (*2013*) summarised the differences between public beliefs and banking reality, while *Bozsik* (*2009*) and *Király – Nagy* (*2008*), for example, drew attention to the looser management of the associated risks. *Bethlendi* (*2015*) published a summary of the systemic failure resulting from faulty product development, *Dancsik et al.* (*2015*) conducted a comprehensive analysis of non-performing loans and *Bodzási* (*2015*) presented a summary of the changes in the legal framework based on experience.

The 2010s were more about the post-crisis business and regulatory adjustment of the banking sector and less about product innovation. Therefore, the most influential changes in recent years have been the introduction of borrower-based measures in 2015 (*Fáykiss et al. 2018*), the introduction of the Mortgage Funding Adequacy Ratio (MFAR) and the EU mortgage bond regulation (*Nagy et al. 2020*). The latter was primarily intended to address the *mismatch* problem, which is discussed below. These were followed by the digitalisation trends that are still on the agenda (*Becsei et al. 2023*), which are primarily aimed at simplifying the mortgage lending process and thus improving the level of service and customer satisfaction.

2.2. A brief historical overview of the development of mortgage loan products

The history of mortgage loan product development goes back a long way. *Fabozzi – Modigliani* (*1992*) summarised the main development trends and product structures in Chapters 5, 6 and 7 of their book. Although a 33-year-old summary may seem outdated at first glance, we soon realise that in fact the product structures available on the market have not changed much in recent times.

Mortgage loans were not always amortising products: before the Great Depression, balloon schemes were common in the United States, which also meant that the debtor faced a refinancing constraint at maturity. In addition, in some cases, banks could demand payment of the entire outstanding debt before maturity. During the Great Depression, this product scheme proved to be unstable: banks often liquidated their disbursed mortgage loans to cover depositors' withdrawals, which meant that debtors had to find refinancing in the middle of an economic crisis, with no small challenge (*Fabozzi – Modigliani 1992*). The social importance of the problem is reflected by the fact that, in the HOLC (Home Owners' Loan Corporation) scheme, introduced as part of the New Deal in 1933, over 1 million (non-performing

or poorly performing) mortgage loans were purchased from lenders in three years. Borrowers typically received new, more modern, amortising loans in their place, while lenders found themselves in a significantly better position as a result of the programme by cleaning up their balance sheets (*Rose 2011*).

In the 1930s, the annuity housing loan was therefore developed. It was a huge success and contributed greatly to meeting post-war housing and borrowing needs. Later, however, in the 1970s, it reached its structural limits in connection with two problems: *mismatch* and *tilt* (*Fabozzi – Modigliani 1992*).

The *mismatch* problem is basically caused by the fact that institutions providing long-term loans finance these loans with short-term funds. This can result in higher interest rates paid on deposits than interest rates earned on loans in a period of high inflation, when interest rates are also high to manage inflation. As a result, Adjustable-Rate Mortgages (ARMs) were developed in the 1980s and quickly became popular (*Fabozzi – Modigliani 1992*).

Later, adjustable-rate mortgages became more complex products: for example, convertible ARMs (which included an interest rate fixation option) or balloon/reset ARMs, where the financing was provided by the lender for a longer period of time but the interest rate was reset at specific future dates. In a way, these products can be seen as the predecessors of the "interest rate period" and helped both parties to manage interest rate risk (*Fabozzi – Modigliani 1992*).

The *tilt* problem basically means that the real value of the instalments essentially "tilts" towards the beginning of the repayment period (*Alm – Follain 1984*), or, to put it another way, it is the problem caused by the high inflation of the 1970s, i.e. the depreciation of the repayment instalments at the end of the term. For example, assuming 10-per cent inflation, by the end of the twentieth repayment year, the real value of an instalment for a given period is only 15 per cent of its original value. This problem is not solved by variable-rate loans alone, as inflation does not necessarily go "hand in hand" with market interest rates (*Fabozzi – Modigliani 1992*).

This is essentially the basis for the finding of *Kovács – Pásztor* (*2018*) that the amortisation schedule of a mortgage loan is at odds with the life cycle of the borrowing population. To address this, the authors prescribe a mortgage loan scheme constant at present value, which means a lower initial repayment burden for borrowers. *Kovács – Nagy* (*2020*) built on this when they extended the original *Kovács – Pásztor* (*2018*) mathematical model, based on further income-side studies, to create a mortgage loan scheme based on real income growth back-tested by statistical methods over the life cycle.

In the following, we present some specific mortgage loan product schemes [partly based on *Fabozzi – Modigliani* (*1992*) and partly based on own collection], which

are in some way able to address either the mismatch or the tilt problem (and the related life-cycle problem).

- A *Graduated Payment Mortgage* (GPM) offers a gradually increasing instalment model, primarily for young first-time homebuyers where there is a strong expectation by the parties that the borrower's income will improve (*FHA 2025b*). The rate of increase is fixed and, in most cases, spread over five or ten years (after which the instalment remains fixed). The limitation of the product, however, is that only a choice of predetermined repayment plans is available, and no repayment schedule tailored to the needs and individual situation of the borrower is available (*Winkler – Jud 1998*; *Fabozzi – Modigliani 1992*). However, with the high interest rates at the time of its development (1980s–1990s), negative amortisation was a virtual certainty, which did not improve the product's competitiveness. According to *Winkler – Jud* (*1998*), the product's widespread adoption was also hampered by its complexity, which is why they developed a generalised equation for calculating the initial instalment. A notable difference compared to *Kovács – Pásztor* (*2018*) and *Kovács – Nagy* (*2020*) is that while the repayment plans available in a GPM calculate a maximum instalment increase of ten years, in the latter case, the instalment increases over the entire term. In the case of GPMs, the increase is also not linked to any external circumstance (e.g. inflation or changes in life-cycle income), but is based on the pre-contracted repayment schedule.

- A *Growing Equity Mortgage* (GEM) offers a fixed interest rate and continuously increasing instalments, thus allowing a faster amortisation (*Fabozzi – Modigliani 1992*). This product is similar in nature to *Kovács – Nagy* (*2020*)'s model based on life-cycle income change, in that debtors pay increasing instalments according to a predetermined schedule, with the aim of repaying the mortgage loan earlier than the original 30 years. The main difference is that while *Kovács – Nagy* (*2020*) defined a generalised increase in instalments derived from a long-term statistical data analysis, in a typical US FHA (Federal Housing Administration) Section 245(a) GEM (*FHA 2025a*), the debtor can choose between predetermined repayment increase rates at the time of taking out the loan, and the increase does not last until the end of the term but only for a specific initial period. *Lessambo* (*2013*) also points out that one of the main differences between GEMs and GPMs is that while in the case of GPMs debt service starts with reduced instalments, in the case of GEMs, it starts with full instalments, which will then increase in a predetermined manner.

- A *Shared Appreciation Mortgage* (SAM) combines a traditional annuity mortgage loan with the transfer of a portion of the yield from the appreciation of the property to the lender. The actual payment can be made when the property used as collateral is sold or when the mortgage loan matures (typically 30 years after the loan was taken out). *Iezman* (*1981*) gave a detailed overview of the product,

while *Dougherty et al.* (*1982*) presented the challenges of product pricing in detail. *Fabozzi – Modigliani* (*1992*) argue that it has not been widely adopted because of its overly complex product design. One of its advantages was that it could have provided financing to a wider range of lower-income debtors in an extremely high interest rate environment, as the product could have had a lower interest rate, even zero (*Sanders – Slawson 2005*). It was very popular in the United Kingdom in the second half of the 1990s, and for a short period, there was even a version of the product (with a maximum loan-to-value ratio (LTV) of 25 per cent) that had no payment obligation until the sale of the property used as collateral or the death of the borrower (*Sanders – Slawson 2005*). This product was an interesting innovation, from a mortality point of view, on the borderline of banking and insurance operation. SAMs have subsequently been reinterpreted; for example, *Greenwald et al.* (*2021*) redefined them as housing loans with instalments linked to a house price index.

- The product design of the *Price-Level-Adjusted Mortgage* (PLAM) is essentially designed to ensure the real value of the loan, with monthly instalments fixed in real terms rather than in nominal terms (*Leeds 1993; Fabozzi – Modigliani 1992*). However, the problem was that the principal amount was also indexed, which, although it dealt with the tilt problem, in practice increased the principal balance for a very long time because of negative amortisation: In the example of *Fabozzi – Modigliani* (*1992*), for a 30-year mortgage loan with an initial interest rate of 4 per cent, the instalments rose to over 500 per cent in nominal terms and the negative amortisation at the beginning doubled the principal balance by year 15. *Kovács – Pásztor* (*2018*) makes the instalments constant only in real terms; therefore, it differs substantially from the above model.

- *Swedish mortgage loans*, where once a certain LTV level has been reached, it is up to the debtor to decide whether or not to reduce the principal balance. An overview of the presentation of the Swedish model and an assessment of the regulatory steps taken to reduce the challenges is provided in *Hull* (*2017*). In such a model, the principal repayment instalments are paid entirely according to the borrower's ability to repay, taking into account their willingness to take risks; thus, the life-cycle problem raised by *Kovács – Pásztor* (*2018*) can be freely addressed.

- *Swiss indirect repayment* and *interest-only mortgage loans*: The idea is that instead of amortising the debt, the borrower pays the principal repayment of the loan into a special pension savings account, which the bank can use to recover the debt in the event of default. In essence, the loan becomes an interest-only loan until the debtor retires, at which point the pension savings can be used to amortise the loan in a lump sum, if necessary. The product is described in more detail, for example, by *Bélanger* (*2012*) and *Bourassa – Hoesli* (*2010*). In the Swiss mortgage loan market, interest-only loans are not uncommon, and since the

timing of any principal repayment instalments is left to the debtor, they also have the related advantages of Swedish mortgage loans. However, through the possibility of indirect repayment, the benefits are complemented by the fact that borrowers are also given a tax-efficient savings option to invest the amounts not paid on instalments. Indirect repayment (combined with investment) combination loans were also popular in Hungary before the 2008 crisis, but given the inherent flaws in the Hungarian version of the product (*Bethlendi 2015*), they have since fallen out of the focus of stakeholders' interest.

In the Hungarian market, considerably simpler loan schemes than the above are only available to the mass of household customers: either variable or fixed interest rate, but otherwise *traditional* annuity mortgage loans with full amortisation. The history of Hungarian household mortgage lending over the past 20–25 years has therefore been dominated by product developments within a simple annuity framework, such as:

- *Foreign currency (based) mortgage loans*. These loans are not presented at the product level, as a brief literature review is provided in the previous section.
- *Innovations for consumer protection*, notably the Certified Consumer-friendly Housing Loans (CCHL) framework developed by the Magyar Nemzeti Bank. CCHL loans were presented by *Parragh – Végh* (*2018*) as an initiative to reduce information asymmetry in cooperation between the state and the market. Studies on the speed of interest rate transmission measured through CCHL loans were carried out by *Hajnal – Lados* (*2022*).
- A notable exception to the above is the *equalisation loan* product scheme, where the amount of deposits held with the bank reduces the amount of the underlying loan debt and, in this sense, deviates the product from the normal annuity path through a shortening of the maturity (*MBH 2025*). The product, which is unique on the market, was developed by Budapest Bank and was added to MBH's product range through the merger of Bankholding.

At the product level, the current direction of development is green loans, for which the preferential capital requirement programme provided by the MNB, is one of the drivers (*Kim et al. 2024*), while on the financing (liability) side of products, green mortgage bonds are leading the way (*Nagy et al. 2021*). The MNB has also eased the LTV and DTI rules for the green loan purpose from January 2025 (LTV: max. 90 per cent; DTI (debt-to-income ratio): max. 60 per cent).

Overall, it can be seen that the products available on the Hungarian market rarely offer innovations in product scheme that affect basic repayment parameters. Meanwhile, however, as *Kovács – Pásztor* (*2018*) and *Kovács – Nagy* (*2020*) point out, the "life-cycle-ignoring" nature of mortgage loans remains and burdens

borrowers. A typical housing loan has fixed instalments, which means that over the 15–30-year term of a mortgage loan, instalments fall significantly in real terms. However, in many typical home purchase situations (e.g. moving out of the parents' home/rented accommodation, starting a family), loans are taken out by young people who are at the beginning of their life or career path and therefore do not have sufficient income to finance the purchase of a property that can realistically serve as their long-term home. In practice, this (may) result in multiple moves, which entail considerable financial and human costs (social/family relations, children's integration into new communities, etc.).

In the current study, the *Kovács – Nagy* (*2020*) life-cycle-income-based mortgage loan model is used as a basis and built upon to describe the career-cycle-income-based mortgage loan model. Although this model does not address the need to move due to a lack of own funds, it can help in cases where own funds are available, but the ability to repay is not yet due to the specificities of the career cycle.

3. Career-cycle mortgage loan instalment

Within the framework of the career-cycle approach, employees' earnings trajectories are characterised by real wage increases that predominantly occur at discrete transition points between successive career stages, while in the intervening periods real wages remain essentially constant. Consequently, the 1-per cent lifetime real wage growth documented by *Kovács – Nagy* (*2020*) is not a steady 1 per cent, but can be higher than 1 per cent in some years and 0 per cent in most years. In this section, this is illustrated by further developing the model elaborated by *Kovács – Nagy* (*2020*).

3.1. Career path matrix

In order to differentiate borrowers on the basis of career-cycle characteristics, it is essential to identify the set of possible career trajectories. Once these trajectories are known or can be reasonably estimated, it becomes feasible to calibrate loan repayment schedules so that they are consistently aligned with borrowers' career-cycle income patterns. The starting point is as follows: each career trajectory can be represented as a vector (a one-dimensional data array), where the *t*-th element denotes the income adjustment realised at time *t*. From this representation, we derive equation (1), in which the elements of vector *K* correspond to the income changes indexed by *j* at time *t*.

$$\overline{K} = (j_1; j_2; \dots j_t) \tag{1}$$

The vector *K* can be written for each career path (of number *i*). This gives us the matrix *K* of career paths.

$$K = \begin{pmatrix} j_{1,1} & \cdots & j_{1,t} \\ \vdots & \ddots & \vdots \\ j_{i,1} & \cdots & j_{i,t} \end{pmatrix} \tag{2}$$

Row *i* of the matrix *K* contains the income changes associated with the i^{th} career path, while each column *t* contains the income changes associated with time *t*.

Thinking further in this framework, a borrower can be given a *personalised* instalment, which depends on their profession, the years they have already spent in it (since not everyone starts at *t*=1, i.e. at the beginning of their career, when taking out a loan) and the chosen maturity (i.e. how many years to take into account the values for their profession).

(1) To implement this, two tasks must be accomplished: the matrix *K* must be populated with the appropriate values for each profession *i* and each career period *t*;

(2) Using the elements of the *K* matrix, repayment schedules must be derived for individual borrowers, thereby determining the complete amortisation profile of the mortgage loan.

Therefore, computation of the mortgage amortisation schedule requires extracting the relevant element from the career-path matrix for each year and using it to adjust the repayment amount. This mechanism results either in accelerated repayment or, alternatively, in a higher effective loan principal for a given maturity.

The study assumes the latter, since the social objective mentioned in the introduction – fewer moves and lower related transaction costs in the broad sense – is best achieved by enabling the disbursement of larger loan amounts. One limitation of the model is that it does not in itself account for the career-path income of different professions, which can be estimated in the different ways. As a simple parameter, for a given profession *i*, it expects the rate of income growth expected after *t* years in the profession. While this approach permits the incorporation of sector-specific or geographically differentiated earnings trajectories (since any number of professions *i* can be defined, thereby allowing workers with identical occupations in different industries or locations to be modelled separately), it remains silent on the estimation uncertainty surrounding these parameters.

3.2. Sample calculation based on the medical wage scale

In the example calculation, the aim is to show how much more borrowing would be possible for profession *i* if borrowers increased their instalments by $j_{i,t}$ at time *t* in line with the expected increase in their income. It is important to note that the medical wage scale does not mention the automatic indexation of medical wages by inflation, which is why in this example calculation the inflation parameter of the model (by which we increase the instalment to be constant in real terms) is taken to be 0.

The wage scale defined in the Medical Wages Act[3] provides a simple example calculation to demonstrate the power of the model. The simplicity of the example is that the rate of increase in the medical wage scale depends primarily on the number of years in the profession; therefore, it provides an excellent illustrative basis. The medical wage scale is presented in *Table 1*.

Table 1
Medical wage scale from 1 January 2023

	A)	B)
	Time in practice (years)	**Amount (HUF)**
1	0–2	687,837
2	3–5	875,906
3	6–10	1,231,212
4	11–15	1,399,247
5	16–20	1,491,679
6	21–25	1,655,653
7	26–30	1,794,715
8	31–35	1,868,567
9	36–40	2,025,667
10	41–	2,380,057

Source: Annex 1 of Act C of 2020

The *i*=medical profession row of the matrix *K* can be defined based on the medical wage scale and is called the K_M vector for the sake of simplicity. Loading the vector K_M for a 20-year maturity for the example calculation, the change in a junior doctor's income according to the wage scale is given in equation (3).

$$\overline{K_O} = (0\%; 0\%; 0\%; 27\%; 0\%; 0\%; 41\%; 0\%; 0\%; 0\%; 0\%; 14\%; 0\%; 0\%; 0\%; 0\%; 7\%; 0\%; 0\%; 0\%) \quad (3)$$

[3] Act C of 2020

Using the K_M vector, *Table 2* shows the evolution of instalments for a HUF 1 million mortgage loan with a 20-year maturity and a 5-per cent interest rate taken out by a junior doctor. For the sake of simplicity, the unit of time was taken to be 1 year (the example would still be applicable if broken down into months, but then in the case of the vector K_M, t would not refer to an annual but a monthly breakdown). How much loan can be taken out in the case of a traditional annuity mortgage loan is also presented.

The example calculation was performed as follows:

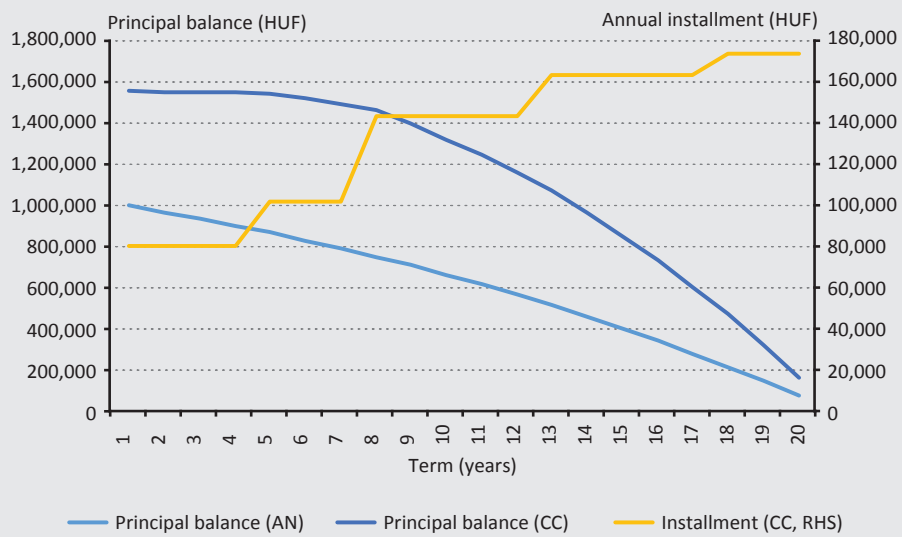
(1) the instalment of a conventional fixed interest rate annuity loan is calculated;

(2) the loan instalment in each period is increased by the amount of the increase allowed by the K_M vector (also transposed the K_M row vector to the K_M column vector);

(3) the instalments for the relevant period are discounted at the nominal interest rate;

(4) and by summing up the discounted instalments, the amount of the loan that could be taken out in the career-cycle mortgage loan scheme is obtained.

Figure 1
Principal maturity of career-cycle and annuity loans with identical initial instalments and the size of the CC loan instalments (annual data)



Note: career cycle: CC, annuity: AN

In *Figure 1*, it can be observed that the specific mortgage loan modelled has a slower start compared to the annuity loan and then a much steeper decline in principal maturity due to the increase in instalments, starting from around year 7–8.

The adjective "*specific"* should be highlighted: As each borrower is at a different point in their career, the expected timing of their income growth is different. Thus, however illustrative the study's example calculated based on the medical wage scale is, in reality, each career-cycle loan will have different principal maturity characteristics, as will its variation from a standard annuity loan, depending on the expected changes in income over the borrower's career.

Table 2
Maturity tables for annuity and career-cycle loan products

Year	Annuity			Career cycle			
	Repayment (HUF)	Principal amount (HUF)	Interest (HUF)	Increase (per cent)	Repayment (HUF)	Principal amount (HUF)	Interest (HUF)
1	80,243	30,243	50,000	0	80,243	2,458	77,785
2	80,243	31,755	48,488	0	80,243	2,581	77,662
3	80,243	33,342	46,900	0	80,243	2,710	77,533
4	80,243	35,010	45,233	27	80,243	2,845	77,397
5	80,243	36,760	43,483	0	102,183	24,927	77,255
6	80,243	38,598	41,645	0	102,183	26,174	76,009
7	80,243	40,528	39,715	41	102,183	27,483	74,700
8	80,243	42,554	37,688	0	143,632	70,306	73,326
9	80,243	44,682	35,561	0	143,632	73,822	69,811
10	80,243	46,916	33,326	0	143,632	77,513	66,120
11	80,243	49,262	30,981	0	143,632	81,388	62,244
12	80,243	51,725	28,518	14	143,632	85,458	58,174
13	80,243	54,311	25,931	0	163,235	109,334	53,902
14	80,243	57,027	23,216	0	163,235	114,800	48,435
15	80,243	59,878	20,364	0	163,235	120,540	42,695
16	80,243	62,872	17,370	0	163,235	126,567	36,668
17	80,243	66,016	14,227	7	163,235	132,896	30,340
18	80,243	69,317	10,926	0	174,018	150,323	23,695
19	80,243	72,782	7,460	0	174,018	157,840	16,179
20	80,243	76,422	3,821	0	174,018	165,732	8,287
	Total	**1,000,000**			**Total**	**1,555,696**	

Note: t=20 years, k=5 per cent, i=0 per cent

Several lessons can be drawn from *Table 2.* On the one hand, the career-cycle-based amortisation schedule is a very powerful instrument, as it allows for an initial contract size more than 50 per cent higher when aligned to the starting point of the medical wage scale, while leaving all other conditions unchanged.

On the other hand, it is also sensitive to changes in income, since in the initial period, only about 3 per cent of instalments are made in principal repayment instalments (the rest in interest), and only in year 9, after two significant increases in income, do principal repayment instalments become larger than interest repayment instalments. Meanwhile, the total amount of the instalment (interest + principal) increases by 117 per cent compared to the initial value.

3.3. Sensitivity testing of the model

Several sensitivity tests were conducted in the model, using the vector *K* on the medical wage scale and a 20-year maturity as an example and a loan of HUF 1 million for a normal annuity scheme as a basis. *Figures 2* and *3* show the evolution of the initial annual amortisation and the available loan amount for the career-cycle scheme on the vector *K* in different interest rate scenarios.

Figure 2
Effect of interest rate on the initial annual amortisation

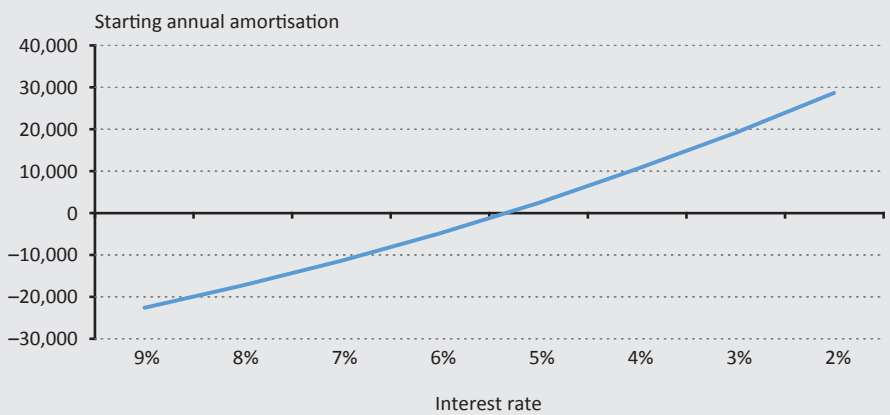
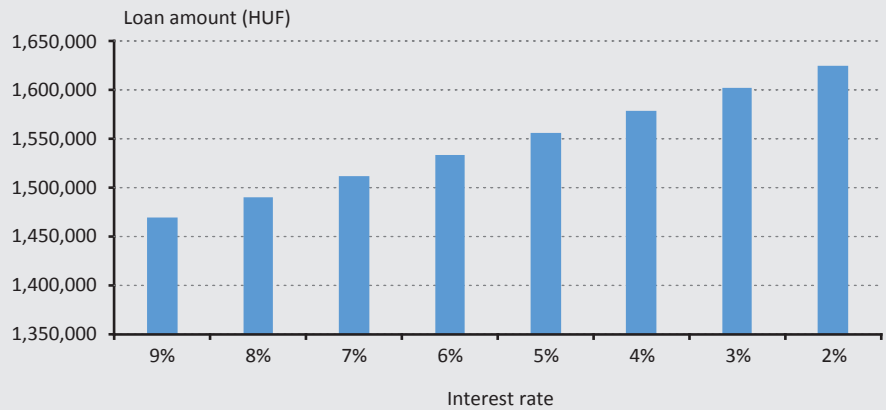


Figure 3
Effect of interest rate on the available loan amount



It is easy to see that the scheme is highly sensitive to the rate of interest. At an interest rate higher than about 5.3 per cent, negative amortisation appears in the initial years and the debt service paid is not even sufficient for interest.

It can also be seen that the interest rate has a significant impact on the size of the loan available. The reason for this perhaps non-trivial relationship is that the debt service rate (annual amount of principal and interest payments) is fixed in the model, adjusted to the borrower's income path (vector *K*). This is why the maximum value of the loan amount has to adapt: if the interest rate is higher, the amortisation is negative and will need to be compensated for later – but this is only possible with a lower loan amount, due to the fixed debt service. The difference (between the largest and the smallest loan amount) is not small, in the range of 2 to 9 per cent, and is in the order of 10 per cent.

However, it is also important to underline the limitations of the sensitivity analysis: this particular example can only be applied to the specific case for which it was calculated. Each borrower's calculated income path is different, resulting in different interest rate sensitivities.

3.4. The impact of career-cycle mortgage loans on housing affordability

Housing affordability is fundamentally a social, sociological issue rather than a narrow banking or financial one. In Hungary, the housing system, its affordability, what kind of housing we live in and how much we pay for it have been and are being investigated by numerous researchers, including, for example, *Nagy* (*2023*)*, Hegedüs – Székely* (*2022*)*, Hegedüs* (*2021*)*, Dóra et al.* (*2018*) and many others. The MNB has also been calculating the Housing Affordability Index (HAI) since the first publication of the Housing Market Reports (*MNB 2020*). According to the MNB's definition, the HAI shows how many times the income needed for a specific dwelling size is available to a two-earner household, where both earners have average earnings, if they borrow in accordance with specific parameters. According to the MNB's definition, the parameters are as follows: LTV=70 per cent, DTI=30 per cent and maturity = 15 years.

According to the MNB's latest Housing Market Report (*MNB 2024a*), housing affordability has been on an improving trend recently, especially among those eligible for state-subsidised (family subsidies) loans. The MNB calculates two indicators (national and Budapest HAI) and several sub-indices of these according to the number of children, the size of the dwelling required in relation to the number of children and the different conditions of family subsidies. It is interesting to note that although Budapest has the highest house prices, the affordability of housing in Budapest is basically significantly better than what the national HAIs show. A HAI indicator below 1 indicates financial tightness, while a value above 1 indicates buying a home with a loan without financial tightness. The MNB assumes a dwelling size of 45 m^2 for a two-earner household without children and 65 m^2 for a two-earner family with two children (*MNB 2024a*).

In Hungary, it is often argued that measures to support housing market demand primarily stimulate the demand side, while only affecting the supply side to a lesser extent (*Bereczki et al. 2025; Banai et al. 2021*), and accordingly, even a career-cycle loan product would not substantially improve affordability through the adjustment of house prices. Meanwhile, the question arises whether there is a justification and timeliness for a new demand-enhancing measure in parallel with the launch of the Home Start Programme, which offers new home buyers a fixed interest rate housing loan of 3 per cent.

However, a number of important features of a career-cycle mortgage loan add nuance to the picture. First, it provides demand-side assistance without budget support, so that budget resources can be used to address supply-side challenges. Second, it is less transparent from a communication point of view and is in all respects individualised (based on individual career paths); therefore, supply would find it harder to adapt as not all potential buyers would have the same ability to pay. Third, as there is no non-repayable subsidy element, borrowers would also be

more responsible about it, as they would have to repay the full amount – which could also keep prices under pressure.

3.5. Examining housing affordability using the HCSO's Real Estate Data Warehouse

An analysis of housing affordability for Budapest and five rural cities (Debrecen, Szeged, Miskolc, Pécs, Győr) is presented below.

As a starting point, the latest publicly available house price data for 2023 from the HCSO's Real Estate Data Warehouse (*HCSO 2024*)[4] ("Total dwellings"; thus, no distinction was made by type) were used, along with the basic parameters used by the MNB (DTI=30 per cent, LTV=70 per cent, maturity=15 years). However, a (simplifying) assumption is made that the net wage is 2/3 of the gross wage (according to the wage scale). The interest rate chosen for the example calculation is the average interest rate on market-based housing loans at the end of 2023, i.e. 7.3 per cent (*MNB 2023*).

Table 3
Level of house prices, amount of instalments with annuity loans and corresponding HAI values by dwelling size, calculated on the basis of the starting wage according to the medical wage scale

House prices		Annuity loan			
		45-m² flat		65-m² flat	
Settlement	Average m² price (thousand HUF)*	Repayment instalment (thousand HUF/year)	HAI	Repayment instalment (thousand HUF/year)	HAI
Budapest	894	3,151	1.05	4,551	0.73
Debrecen	684	2,411	1.37	3,482	0.95
Szeged	583	2,055	1.61	2,968	1.11
Miskolc	375	1,322	2.50	1,909	1.73
Pécs	521	1,836	1.80	2,652	1.24
Győr	650	2,291	1.44	3,309	1.00

*Note: * HCSO Real Estate Data Warehouse*

Table 3 shows that affordability for a 45-m² small home for a two-earner household in the example is consistently above 1, with the exception of Budapest, where it is not much above 1, which represents financial tightness. However, in the case of families with two children (65-m² dwelling size), affordability is already below level 1 in Budapest and Debrecen (making it financially difficult to buy), while in Győr, it is just below 1, and in Szeged, it is close to 1; therefore, it was considered to be significantly burdensome there as well by the end of 2023.

[4] https://www.ksh.hu/s/ingatlanadattar/adattar?year=2023. Downloaded: 16 March 2025.

Table 4
House prices and the contract size available with a career-cycle loan, the size of the dwelling and the value of the associated initial repayment instalment

Settlement	Average m² price (thousand HUF)*	House price (thousand HUF)	Dwelling size (m²)	Contract size (thousand HUF)	Initial repayment instalment (thousand HUF/year)	HAI
Budapest	894	56,702	63.4	39,691	3,151	1.05
Debrecen	684	43,383	63.4	30,368	2,411	1.37
Szeged	583	36,977	63.4	25,884	2,055	1.61
Miskolc	375	23,784	63.4	16,649	1,322	2.50
Pécs	521	33,044	63.4	23,131	1,836	1.80
Győr	650	41,226	63.4	28,858	2,291	1.44

*Note: * HCSO Real Estate Data Warehouse*

Table 4 shows the strength of the career-cycle mortgage loan. It can clearly be seen that with the same HAI as the one associated with a 45-m² dwelling in a normal annuity loan, the household in the example could have purchased a 63-m² dwelling in 2023 year-end market conditions (assuming that the necessary own funds were available, as the LTV remained the same), which is approximately equivalent to the dwelling size used by the MNB as the basis for the HAI calculation for a family of four (65 m²).

This is an extremely strong claim because, in fact, *Kovács – Nagy* (*2020*) argues that with conscious long-term planning and a larger contract size, it is possible to avoid significant moving costs when taking out a first loan. The figures in *Table 4* provide practical evidence for this claim, for a household with the parameters of the example household, in 2023 year-end market conditions.

4. Challenges and considerations for career-cycle mortgage loans

4.1. Key challenges

Career-cycle mortgage loans face a number of challenges that are critical to the success of the product type.

One basic risk is that most professions are not on a wage scale. Therefore, there may be uncertainty about the increase in income and hence the increase of the instalment. In the case of certain professions or groups, technological upgrades or other reasons may lead to situations where the actual income of the borrower differs from the income level calculated at the time of taking out the loan, even if the profession itself or the market position of the industry changes over the term of the mortgage loan.

It also poses a risk if a borrower's income growth is exceeded by inflation (whether due to industry-specific characteristics or the cyclical nature of the economy as a whole), and it significantly increases the borrower's risk if management career paths are also taken into account in the career matrix, as it often takes longer to find a replacement of a similar level if such a job is lost.

Additionally, rising instalments in line with wage increases impose a natural limit on consumption for borrowers. In the case of families, for example, this can be an obstacle to increased consumption associated with the arrival of children.

The viability of the model and the benefit to borrowers may be affected by the fact that the interest paid over the entire term of the loan is also higher relative to the principal amount for a career-cycle mortgage loan than for a traditional annuity scheme – and depending on the contract size, the difference may even exceed the financial burden of a move in the strict sense.

4.2. Considerations related to the challenges

The career matrix underlying career-cycle mortgage loans allows income changes at each point in time to be estimated with sufficient conservatism. Although the baseline model (*Kovács – Nagy 2020*) assumes a constant repayment instalment in real terms, the career matrix approach provides sufficient flexibility to ensure that constancy in real terms is not a necessary condition.

The main purpose of creating this model was to allow well-planned career paths, such as when a junior administrator becomes an experienced senior administrator (or a junior doctor becomes an experienced doctor), and this experience is generally reflected in their income, to be taken into account in bank credit assessments. It is therefore not the intention to include either managerial career paths or career paths across job families; estimating these is a further research task.

In the case of GPMs and GEMs, which are available in the US and most similar to the scheme, as presented in *Section 2.2*, the FHA – as a public mortgage insurer – provides credit insurance, the premium for which is paid by the borrowers. This is an important distinction from a typical government loan programme in Hungary: the FHA essentially operates on self-generated revenue (*HUD 2025*). The FHA basically offers these products to low- to middle-income customers for home ownership who expect their income to increase significantly in the future and, in the case of GPMs, know that they will pay more interest than they would under a traditional annuity scheme (*FHA 2025b*). In the case of GEMs, the increasing instalments are mainly used for principal repayment; thus, the maturity is reduced (*FHA 2025b*).

In the author's opinion, in line with the example of the FHA, by adding credit insurance – i.e. by spreading the risks arising from specific industries and individual life and career situations across the insurance risk pool – a significant part of the

above risks could be managed and the product itself could be made adequate from a banking perspective, while still not being a significant fiscal burden. Of course, a version of the product similar to the GEM could also be created, which translates higher instalments into shorter maturities.

The impact of a rising repayment burden on consumption (other than housing) as income rises is certainly a phenomenon, but I would highlight the finding of *Kovács – Pásztor* (*2018*) that the current amortisation schedule is at odds with the life cycle of households: it imposes a high burden when borrowers' income is lower and a lower (even lower in real terms) burden when income is higher. In the author's opinion, the increasing consumption needs of a family with the arrival of children are, on the whole, better supported by a lower initial instalment (this is the logic behind the suspension of the repayment of the prenatal baby support loan upon the birth of a child), but the fact is that in the later years, with the debt no longer increasing the household budget, the household can no longer choose to increase its consumption for housing purposes at the expense of other aspects of family maintenance.

The financial benefits of the model need to be carefully considered, due to the higher amount of interest paid. However, in addition to the direct cost of moving, the human costs mentioned earlier need to be taken into account, and it is worth considering alternatives (e.g. moving from rented property to own, which in some life situations would not be feasible with a traditional annuity loan, but may be feasible with a career-cycle mortgage loan). A career-cycle loan also allows for more leverage in the first period compared to an annuity loan (larger contract size for any LTV means higher loan-financed housing market exposure), which tends to increase household wealth in a growing housing market – of course, the opposite is true in a declining market.

5. Summary and further research opportunities

This paper reviews the operation of Hungarian and North Atlantic mortgage finance models through a literature review. It was found that, despite numerous – sometimes problematic – innovations, the Hungarian mortgage market has never afforded borrowers the same degree of choice as several other mortgage markets, including those within the European Union. Therefore, the presentation of mortgage products with either constant real repayments or repayments indexed to life-cycle income growth, both of which are primarily designed to improve housing affordability and access to homeownership, represents an important contribution in the domestic literature.

Building on these results, a career-cycle income-based mortgage framework was elaborated. The core of the model is the representation of income changes occurring

along a career path as a vector, which, when aggregated across professions, yields a matrix. Based on this structure, a repayment schedule was constructed based on the assumption that the ratio of repayments to income remains constant, so that rising income over time translates into increasing repayment capacity. When back-calculated, this implies a substantially higher borrowing capacity.

In a numerical illustration, the model was applied to the tenure-dependent wage scales of the medical profession. In this scheme, and given the assumed interest rate and maturity, an entry-level physician would be able to borrow more than 50 per cent more than the initial loan amount available through a conventional annuity loan with identical terms.

The example calculation (also based on the medical wage scale) was carried out for Budapest and five Hungarian cities, in order to show the impact of the loan scheme on affordability through the housing affordability index of the MNB Housing Market Report. The results indicate that, at a given affordability ratio, households of entry-level physicians could purchase significantly larger dwellings, in fact sufficient to meet the MNB's benchmark housing requirement for a four-person household. This outcome supports the argument of *Kovács – Nagy* (*2020*), as at least one residential move (and the associated transaction costs) could be avoided by such households.

The product raises fundamental regulatory-prudential concerns, as it requires the inclusion of an increase in income that can only be expected to occur in the future. In this form, it is obviously incompatible with the current Hungarian regulatory environment. Its popularity may also be affected by the fact that total interest payments over the life of the loan are higher than with a traditional annuity structure.

Nonetheless, evidence from the United States demonstrates that there are mortgage insurance schemes –operating even without direct government subsidies – that enable products with increasing repayment schedules to remain viable and beneficial in advanced regulatory environments. It is therefore likely that a career-cycle-based mortgage would also require such insurance support.

The topic opens up many more research opportunities. First, in order to obtain a more comprehensive picture of the possible market effects, it is essential to examine the scheme using a broader database than the medical wage scale. This even allows for the examination of regional differences, as the income gains achieved on a career path are not necessarily the same in all regions of the country.

Moreover, further future research should be based on a comprehensive examination of the bank profitability, risk management aspects and capital requirements of the career-cycle mortgage lending model, as these aspects were not addressed in the present analysis. The creation of a variable interest rate scheme may also be worth

considering. Examination of the institutional and legal background required for the implementation of the product is also relevant, which, based on international experience, seems to be a prerequisite for complex loan products such as this. Finally, it would be valuable to investigate whether career-cycle-based mortgages could generate broader social effects, such as bypassing the "starter home" stage, that may in turn influence housing supply dynamics.

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The Increased Strategic Role of Rare-Earth Metals*

Norbert Szőcs

This feature article guides the reader through the process by which rare-earth metals have become a geopolitical and economic weapon. Their strategic importance stems from their use, as the last decade has seen the proliferation of smart devices and the technological innovations that go with them, with rare-earth metals at their core. Due to today's increasingly severe international trade restrictions, a country with an abundance of rare-earth metals can start from a better bargaining position. I discuss where the global race for rare-earth metals is heading and which countries can benefit the most in the coming years.

1. Introduction

Rare-earth metals are essentially a group of 17 chemical elements. They have similar properties, which means that several rare-earth metals can be found in a single mined deposit. Demand for rare-earth metals skyrocketed in the 1960s, in parallel with the spread of colour television (*Voncken 2016*).

In his 2020 book, taking a historical perspective, *Guillaume Pitron* draws attention to the importance of raw materials and highlights the current situation of rare metals: "From tea to crude oil, nutmeg to tulips, saltpetre to coal, commodities have been a backdrop to every major exploration, empire, and war, often altering the course of history. Today, rare metals are changing the world" (*Pitron 2020:23*). In ancient times, humankind used only seven metals, but since then this number has risen to over 80, with rare-earth metals playing a crucial role. Thus, technological progress leads not only to product innovation, but also to a transformation of raw material needs (*Pitron 2020; Liu et al. 2023*).

Despite their name, most rare-earth metals are relatively widespread in the Earth's crust. The difficulty is in extraction, as they occur in low concentrations. One key challenge to effective mining is to ensure an appropriate technological background and compliance with environmental standards (*Hiskey – Copp 2018; Braun 2018*).

* The papers in this issue contain the views of the authors which are not necessarily the same as the official views of the Magyar Nemzeti Bank.

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Rare-earth metals are essential to modern industry and are mostly used in the production of electronic devices, automotive industry, batteries and military technologies. Thus, countries with significant refining and storage capacity are more competitive, can benefit from technological advances and can start from a more favourable bargaining position in trade agreements (*Alonso et al. 2012*).

2. Chinese dominance

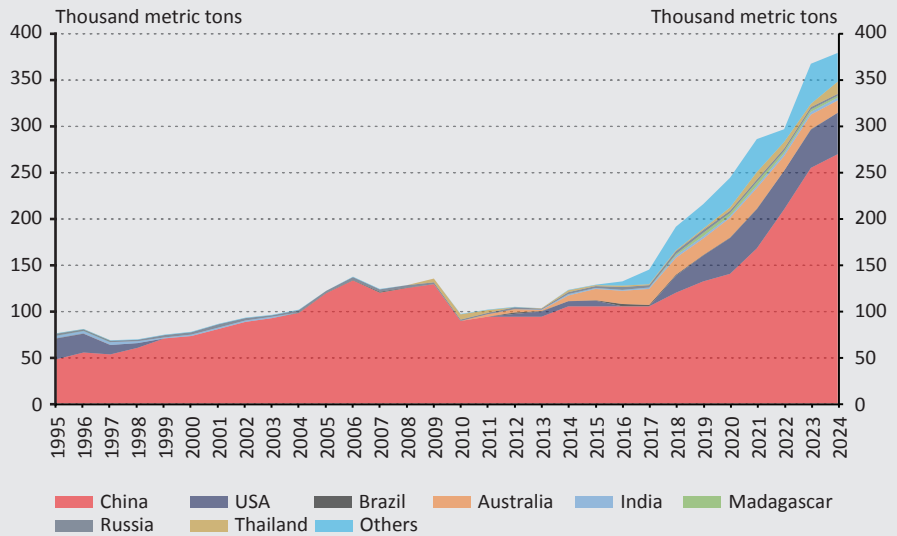
2.1. The strategic commitment

The fact that rare-earth metals are the engine of technological innovation was recognised early on in China. In the mid-1970s, China launched its targeted rare-earth metal strategy, which by the 1990s had given it global influence in the rare-earth metals market. One of the key players in the success of this strategy was the researcher *Xu Guangxian*, who pioneered the first 99.99 per cent pure rare earth separation technology, which he demonstrated in 1974, fundamentally changing international extraction practices (*Braun 2018*). The long-term plan was for China to play an increasing global role in both extraction and stockpiling. The next part of the plan was to use their own manufactured product to make use of the rare-earth metals already in circulation.

For nearly 20 years until the mid-1980s, the United States dominated the market for mined rare-earth metals. However, China's production strategy took advantage of the fact that it could sell its reserves much cheaper, and the United States was no longer able to compete on price, which meant that they virtually stopped mining altogether and withdrew from the market. From that time on, China became dominant in the rare-earth metals market, and it further strengthened its dominance in the 2000s by acquiring majority stakes in several international companies involved in rare-earth metal extraction. Since then, Chinese dominance has continued. In China, rare-earth metals are considered to be "the vitamins of modern industry" (*Hurst 2010a; Hurst 2010b*).

Compared to 1985, global extraction of rare-earth metals has now increased seven and a half times (*Liu et al. 2023*), with a sharp increase in the second half of the 2010s (*Figure 1*). Chinese dominance seemed to be declining, but from 2020 onwards, there was again a significant increase in extraction.

Figure 1
Trends in rare-earth metal production over the past 30 years by major producing countries



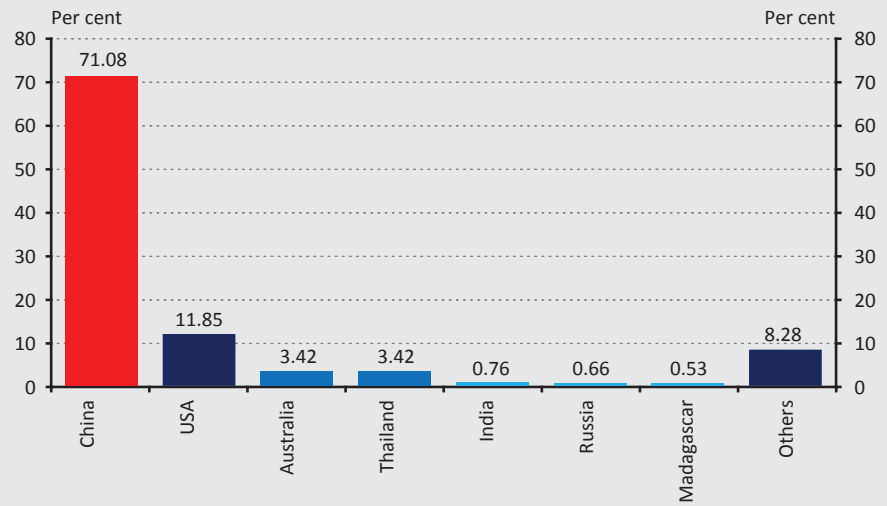
Source: Energy Institute (https://www.energyinst.org/statistical-review. Downloaded: 7 July 2025)

According to data from Energy Institute, China had the largest influence in the production of rare-earth metals in 2005, and between 1999 and 2013, China's share of global production was over 90 per cent. The statistics are distorted by the fact that there are several countries that are extracting but not declaring it, but the Chinese dominance is unquestionable. As it stands, China produces more than 70 per cent of the world's rare-earth metals. After 2015, in particular the United States and a number of countries that had been less involved in extraction increased their capacity, resulting in a decline in Chinese dominance. In addition to the rise in extraction in other countries, the breaking of the monopolistic situation and rapid technological advances, especially in the automobile and defence industries, played a role. China's continued dominance in the production chain is due to the fact that while China increased its extraction more than one and a half times from 2020 to 2024 (from 170,000 tonnes to 270,000 tonnes), the rest of the world's total production increased only slightly (from 104,000 to 110,000 tonnes).

2.2. Production and stockpiling advantage

China thus remains the world leader in rare-earth metal mining (*Figure 2*). Its dominant role is best illustrated by the fact that Chinese extraction is more than 8.5 times higher than that of the second largest producer, the US. The long-lasting research and industrial policy on rare-earth metals put China in such a position that it could supply virtually any country's electronics production with sufficient quantities of rare-earth metals.

Figure 2
Distribution of rare-earth metal production by country in 2024



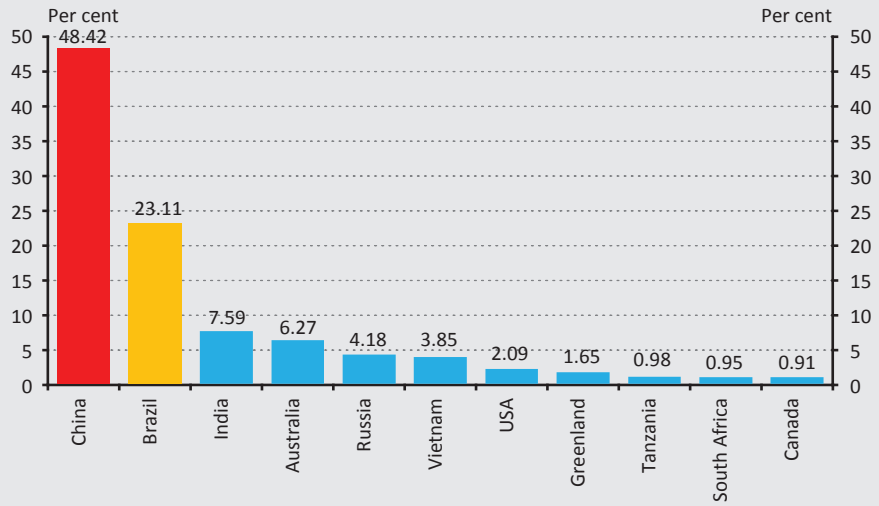
Source: Energy Institute (https://www.energyinst.org/statistical-review. Downloaded: 7 July 2025)

The superiority that China has achieved in recent decades is due to a combination of factors:

- Geographically favourable conditions for mining.
- The early and consistent public strategy mentioned above.
- Significantly less stringent environmental rules for mining, refining and the management of waste compared to other countries.
- Pricing policy: in the initial period, China eliminated competitors by exporting below the market price, thus creating a monopolistic situation, and then started to raise prices.
- In addition to mining and refining, China also focused on technological development, creating high added value manufactured products.

China is also in a prominent position in terms of stocks, holding nearly half of the global stock by 2024 (*Figure 3*).

Figure 3
Distribution of rare-earth metal stocks by country in 2024



Note: Stocks = the estimated amount of rare-earth metal bearing minerals in the earth's crust that can be economically extracted by mining companies.

Source: U.S. Geological Survey – Mineral Commodity Summaries 2025 – Rare Earths (https://catalog.data.gov/dataset/mineral-commodity-summaries-2025-rare-earths-data-release)

3. Market movements in rare-earth metal prices

There are significant differences in the pricing of different rare-earth metals, as prices are affected by the quantities that can be mined and the cost of producing and stockpiling. In addition, the extent to which the rare-earth metals are used in modern technological devices also determines their valuation (*Walters et al. 2011*).

3.1. Historical overview

As early as the late 19th century, the mining of rare-earth metals was already underway. Due to moderate demand, the price of rare-earth metals remained stable until the mid-1950s, after which the volatility of rare-earth metal prices increased due to the opening of more and more mines and technological advances. In the 1960s, with the opening of the Mountain Pass mine in California, prices began to fall, significantly increasing supply. In the 1970s, supply and demand went hand in hand, but by the end of the decade, prices started to rise due to inflation and higher energy costs. The early 1980s brought stability in prices, but in 1985, the petroleum

industry underwent a technological changeover due to environmental regulations, and less rare-earth metals were needed. In response to the fall in demand, mines reduced extraction, which eventually led to a rise in prices (*Hedrick 1997*).

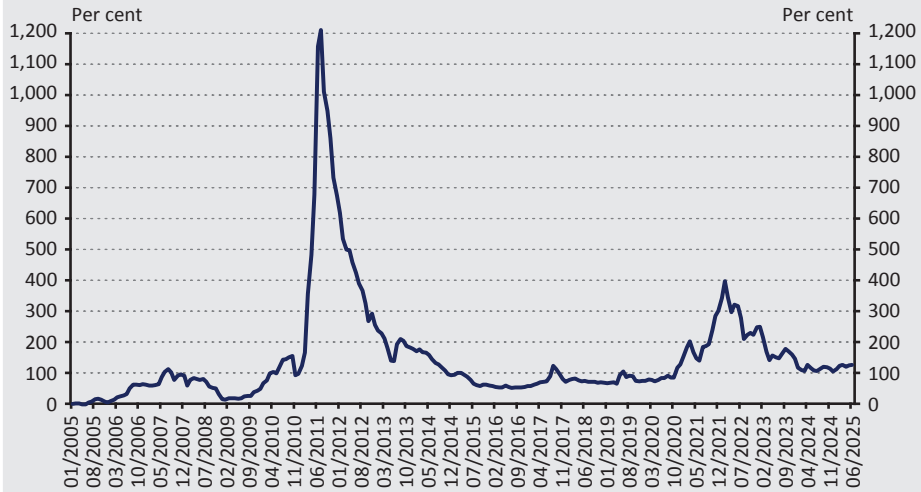
In the 1990s, rare-earth metal prices were depressed by oversupply dominated by Chinese hegemony. After 1995, technological progress led to an increase in demand, which started to push up prices, but China responded by increasing production, stabilising price pressures in a short time (*Naumov 2008*). The 2000s were characterised by a gradual increase in demand, coupled with an increase in supply; however, there was a gradual rise in the price of rare-earth metals. The 2008 crisis also hit the rare-earth metal-based industries, with prices for most rare-earth metals falling back to almost 2005 levels by the end of 2008. In 2010, increased imports from Japan and the widespread use of magnetic applications started to drive up the price of rare-earth metals (*Walters et al. 2011*).

3.2. Market impact of Chinese export restrictions

Price volatility can be significantly affected by Chinese dominance. In July 2010, China announced a 70-per cent cut in its export quota for the second half of the year. For 2011 H1, China announced a further 35-per cent cut in export quotas, but demand remained very strong. As a result, by July 2011, the price of most rare-earth metals had risen to a historic peak (*Figure 4*), meaning that rare-earth metals were on average more than twelve times more expensive than at the beginning of 2010 (*Walters et al. 2011*). The surge in rare-earth metal prices in 2011 also led to a substantial increase in the price of the products made using them (*Nicoletopoulos 2011*).

Following the surge in prices, it took several years for the price of rare-earth metals to return to near pre-2010 levels – following the lifting of China's export quota after the World Trade Organisation's response. During the pandemic period, increased global demand and a high inflationary environment pushed prices back up several-fold in the early 2020s, but the increase was less significant than the surge in late 2010. Today, the pricing of rare-earth metals has stabilised, but even after removing market turbulence, the trend is upwards, with rare-earth metals now costing on average more than twice as much as they did 20 years ago.

Figure 4
Average change in the market price of rare-earth metals since 2005

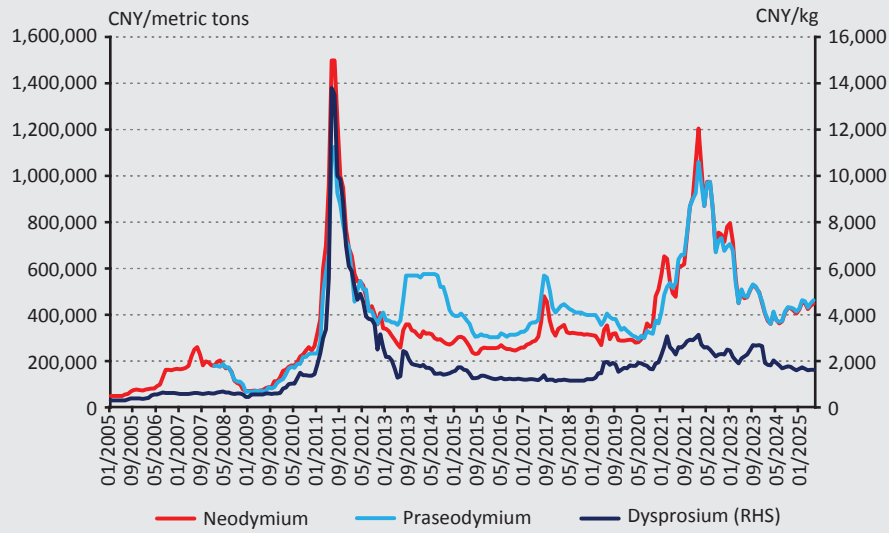


Note: the figure is based on the average of the available prices of the following 15 rare-earth metals: scandium, yttrium, lanthanum, cerium, praseodymium, neodymium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, ytterbium, lutetium. Base: 1 January 2005

Source: Bloomberg

A similar picture emerges when looking at the price trends for some of the key rare-earth metals. The strongest known magnet is neodymium combined with iron and boron. By adding dysprosium and praseodymium, the performance and properties of certain magnets can be changed. Magnets made from these elements are essential for hybrid and electric cars, wind turbine generators, hard disks, mobile phones and other smart devices. The events of 2010 did not spare the market prices of these materials (*Figure 5*), and within a few months, their prices had increased several-fold (*Walters et al. 2011*).

Figure 5
Price trends for some key rare-earth metals over the past 20 years



Source: Bloomberg

Price volatility may persist in the market of rare-earth metals, as price movements continue to be driven by the upward trend in demand. This could be counterbalanced by adding new production sites on the supply side or by reopening mines that have previously closed (*Haque et al. 2014*).

4. Geopolitical and economic weapon

The use of rare-earth metals has played a major role in technological breakthroughs, but during the Cold War, the geopolitically motivated production and stockpiling of rare-earth metals also came to the fore as a result of the nuclear arms race. Recognising this situation, China made the greatest efforts to exploit the foreign trade benefits from its dominance in the production of rare-earth metals (*Kosynkin et al. 1993*). China's main export markets for rare-earth metals are Japan, the US and France. However, meeting foreign demand is not determined by the capacity of the mining industry, but by Chinese ministries setting production and export quotas. In addition to dominating production and supply, China has also become one of the largest consumers. Rare-earth metals are mainly used in the manufacture of

electronic products in China, some of which are exported. China is followed in the consumption competition by Japan and the United States. As competition between the two poles of the world intensifies, geopolitical considerations also play a role in the quantities and prices at which China is willing to export rare-earth metals (*Van Gosen et al. 2017*).

4.1. The situation of the USA

The United States broke into the market of rare-earth metal extraction in the mid-1960s and quickly established a leading role. Technological advances, such as the widespread adoption of colour television, were the main driver of US production growth. In the mid-1980s, China entered the production market and in the early years exported its rare-earth metal reserves at much lower prices than the market, forcing US mines to close down in succession as they could no longer make the profits needed to survive (*Drobniak – Mastalerz 2022*).

By the 2010s, China had taken the lead in terms of total exports, with the United States slipping back to second place, despite its dominance in previous decades. Since rare-earth metals are essential for the production of modern products, the US is strongly dependent on the amount of rare-earth metals it can import from China. If China restricts the export of rare-earth metal resources, as it has already begun to do, US manufacturing and military industries could suffer the most (*Ferreira – Critelli 2022*).

In April 2025, China announced export restrictions on rare-earth metals in response to US trade tariffs, and in the following month, it extended the scope of its rare-earth metal export controls outside its territory, ordering Korean producers to stop exporting to the US articles containing rare-earth metals, putting pressure on the US government (*JP Morgan 2025*).

In May 2025, Chinese exports of rare-earth metals decreased significantly, mainly to the United States, where they fell by 92 per cent (!) compared to May 2024. Vietnam and Germany, major rare-earth metal trading partners of China, have been much less affected by the export restrictions than the US; therefore, it can be assumed that the restriction has a political message much more than it is a supply problem. That is, the trade conflict between the two countries is at the root of the downturn, which supports my assumption, along with others, that China, using its dominance over rare-earth metals, could improve its bargaining position in tariff negotiations.

4.2. The situation of the EU

Europe's mining role in the world has been steadily declining since 1860, and so has the rare-earth metal mining industry, with EU countries together accounting for only a few per cent of global production. It is also worth pointing out that the EU imports almost all of its rare-earth metal imports from China. The EU has successfully implemented technological opportunities in a large part of its Member States, but these technologies are dependent on Chinese inputs, increasing the risk of exposure to China (*Massari – Ruberti 2013; Jancsek 2023; Botos 2025*).

In the European Union, the areas with the greatest potential for some of these extractions are Greenland and the Scandinavian Peninsula. Recognising this, the US administration has made several efforts to strengthen its relations with the Danish autonomous region. However, this is hampered by the fact that the Greenland Parliament has banned mining in the area (*Jancsek 2023*).

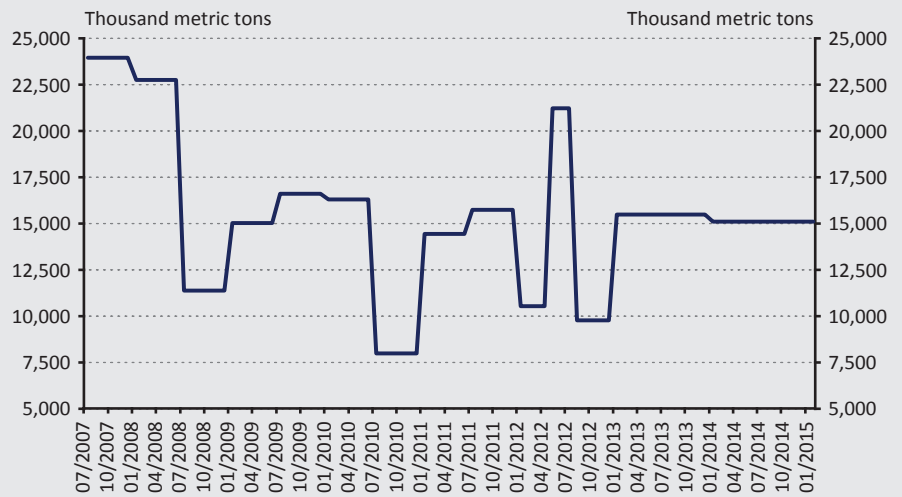
4.3. Supply risks

In general, when a single country controls almost all global supply, all trading partners are at high risk. It can decide to reduce exports or even to impose concentrated restrictions on a single country, which tightens supply and thus raises prices, while a major trade restriction can lead to market panics due to disruptions in the supply chain.

The announcement of Chinese restrictions on rare-earth metal exports, which started in 2010 H2, was sudden and drastic: the export quota was effectively halved (*Figure 6*). The market reaction was that the rate was too high. China justified the decision on the grounds that it wants to secure the supply of rare-earth metals needed for domestic production, and environmental reasons were also cited.

After the announcement, the price of rare-earth metals started to rise sharply, peaking in 2011, when the Chinese ministry increased the quota by one and a half times and kept it at roughly the same level for the following years. The market situation was further exacerbated by the fact that Chinese-owned companies operating in foreign countries received nearly three-quarters of the limited quota for exports, while other internationally owned trading companies had to share the remainder. The restrictions have been challenged by the US, Japan and the EU at the World Trade Organisation. In 2014, the World Trade Organisation enacted a resolution against export restrictions, which led China to suspend the export quota on rare-earth metals in 2015 (*Van Gosen et al. 2017*).

Figure 6
Evolution of the export quota imposed on Chinese rare-earth metals between 2007 and 2015



Source: Bloomberg

International companies responded to Chinese trade restrictions by raising the prices of their products, embarking on projects to find substitutes for rare-earth metals and trading with other rare-earth metal producing countries (*Watts 2011*).

It should be noted that, in addition to the market risks, the environment also suffered from the impact of the restrictions, as the volume of illegal mining activity increased, with the Chinese Ministry of Industry and Information Technology (MIIT) estimating that the annual extraction of rare-earth metals exceeded 40,000 tonnes (*Van Gosen et al. 2017*).

5. Where is global competition heading?

Although China still dominates the market, more and more countries are seeking to reduce their vulnerability. For example, the US is working intensively to open new mines and build processing capacities. According to research by the United States Geological Survey (USGS), the quantity of undiscovered resources is easily sufficient to meet projected demand (*Hedrick 2008*).

There is also a strong focus on alternative sources, such as space mining, which in the longer term could open new dimensions in rare-earth metals supply. Samples taken from asteroids show that they contain high levels of rare-earth metals (*Braun 2018*).

In some developed countries, government measures are being taken to encourage the development of rare-earth metal reserves. For example, a law adopted by the European Commission to fund projects associated with rare-earth metals supply and to speed up licensing deadlines. The Canadian government's strategic objective sets out a commitment to increasing the supply of rare-earth metals. Such efforts are clear evidence that developed countries are seeking to reduce as much as possible China's long-standing dominance, especially in the context of recent geopolitical and trade tensions.

Global competition is made more difficult by the fact that China alone has the knowledge and technology to manage the entire supply chain. Technology development is essential to manage the waste from the extraction of rare-earth metals as cheaply and efficiently as possible (*Liu et al. 2023*). These initiatives can be seen as positive, but as the Chinese example shows, it takes many years to develop a functioning supply chain, and a proper long-term strategy is needed (*Ferreira – Critelli 2022*).

6. Summary

Rare-earth metals are not only industrial raw materials, but can also be used as geopolitical tools. Their role has recently been enhanced, and countries with larger reserves or the ability to produce larger quantities of rare-earth metals may be in a better position in the future in terms of technological innovation and can benefit from the superiority of abundant rare-earth metal resources in international trade, thus improving their long-term competitiveness.

Chinese export restrictions in 2010 encouraged decision-makers in developed markets to reactivate previously closed mines and to work on technological improvements to enable more efficient mining and processing. These could reduce Chinese dominance in the market of rare-earth metals. The difficulty lies in the fact that mining produces substances that are harmful to the environment, in addition to the extracted and refined rare-earth metals. More emphasis should be placed on addressing this in technological developments.

The question arises as to whether there may be a substitute product in the future that can replace rare-earth metals in the production of technology products. This would solve the problem of countries' dependence on China. The experience so far is that in trials where some substitute product has been used, the results have been less effective and ultimately more costly.

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The Economic Measurement of Real Progress*

Magdolna Csath

Diane Coyle:
The Measure of Progress: Counting What Really Matters
Princeton University Press, 2025, p. 320
ISBN: 9780691179025

Diane Coyle is the Bennett Professor of Public Policy at the University of Cambridge and co-director of the Bennett Institute. She is a member of the UK Government's Industrial Strategy Council and has previously served on the Competition Commission. Her main areas of expertise are digital economy, productivity and measuring progress. In her latest book, published in April 2025, she seeks to answer the question of how real progress can be measured in significantly changed circumstances, given that it has become increasingly clear that GDP is no longer fit for the purpose of capturing new, important outcomes.

The main reason for this is that when GDP was created, the leading sector of economies was manufacturing, the expansion of which was not yet constrained by natural resources. At that time, GDP was still a good method of measuring economic growth. Today, however, the structures of both the economy and consumption have undergone major changes and are still evolving. For example, in the USA, in 2023 manufacturing accounted for only 11 per cent of total value added in the economy. One decisive factor here is digitalisation, whose outcomes GDP can only partially measure. By contrast, current economic, industrial and economic policy decisions have long-term effects, making it essential that they be based on indicators that use data collected by appropriate methods and that describe the real state of the economy as accurately as possible. Coyle argues that GDP no longer meets these requirements. It no longer accurately measures what is actually happening in the economy, i.e. whether there is genuine progress or merely unhealthy growth, and supports her case with an extensive range of literature, theoretical reasoning and practical examples. The following highlights some of her most important arguments.

* The papers in this issue contain the views of the authors which are not necessarily the same as the official views of the Magyar Nemzeti Bank.

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Measurement problems

According to the author, roughly 4/5 of actual economic activities today are difficult to assess using traditional performance measurement methods. This is because the structure of the economy is in constant transformation. Technological changes and digitalisation blur the boundaries between production and services. The spread of "servitisation" – the intertwining of manufacturing and service activities – is a case in point. Companies increasingly offer various services alongside products; in some cases, they may not sell the product at all, but rather lease it instead, providing maintenance and, after a set period, replacement – for a monthly subscription fee. In other words, companies offer solutions to customers rather than products. Disintermediation, the removal of intermediaries, is also becoming more common, shortening value chains and shifting the emphasis of value creation. An example is the growth of online orders, where customers interact directly with the company, or the emergence of cryptocurrencies. Companies increasingly find opportunities for value creation not in manufacturing, but in running networks and platforms and in so-called intangible activities enabled by digitalisation – activities that are hard to measure, but are of growing importance. One such area is the "attention economy", in which companies seek to capture people's attention, since attention itself is an intangible and "scarce resource". Influencers are often used in this effort. Other features of today's economy that we see more and more of include "intellectual value chains", call centres and data centres, where vast quantities of data move around the globe and no one can measure yet exactly where and how much real value is being created. In general, value creation by digital service providers is hard to track – for example, the performance of cloud service providers. The author groups these under the term "invisible economy". Free digital services, which create significant new value and improve people's quality of life, are also absent from national performance measurement. Coyle also notes the difficulty of measuring new forms of work in the changing labour market, which are hard to capture with traditional data collection and indicators. Examples include the problems of measuring the value created by "digital nomads", "freelancers" in the creative industries and the short-term contractors of the so-called "gig economy", who work for multiple clients at the same time.

Through these examples, the author demonstrates that GDP – created in a world dominated by industry and physical goods – is no longer suitable for measuring national economic performance in today's changed circumstances. Indeed, it may even be misleading, because it cannot measure the new value generated in the digital sphere, while it may overstate activities that are potentially harmful to progress. This leads directly to the broader question of how progress can be measured.

Added value, market value, social value

Coyle emphasises that the economy is not independent of the natural and social environment, since it uses their resources. Therefore, even if we could measure economic growth accurately, this alone would not tell us whether there is progress and therefore whether the economy is creating social value. It is equally important to ask whether the functioning of institutions is improving and whether the quality of products and services is getting better. These factors are characteristics of progress, not merely growth. What is needed for better quality? More knowledge, better organisation, more innovation – in other words, a growing share of intangible assets. This, in turn, improves productivity, the author argues, and productivity improvement is one of the most important signs of progress. However, we should not think only in terms of the traditional per capita or per hour measures. We should also measure the efficiency of using natural resources, energy, time, knowledge and space and that of the functioning of public services and institutional systems. For example, saving time frees up valuable hours for higher-value activities. This can be called the "time economy". Overall, the traditionally measured added value should be expanded to include the measurement of the additional social value created. As a solution, the author proposes using "shadow prices". Shadow pricing could measure real value creation when the market value does not fully reflect – or fails entirely to show – the total new value generated, including social value.

Conclusion

Drawing on a vast body of background material, Diane Coyle tackles a subject that has been in the spotlight for some time: the more objective measurement of economic performance and its relationship to progress. The "Beyond GDP" research programmes, which mainly demonstrate the disadvantages of measuring GDP, are well known, as are analyses focusing on GDP's shortcomings from the perspective of environmental and social externalities. However, Coyle's book goes beyond these. She proposes measuring the full real economic and social value created. She shows that the economy, natural environment and society can function successfully only when seen as a balanced system. This means measuring progress, including the current state of different forms of capital (stock) and the ongoing activities (flow) that bring about the changes in their state – either increasing or reducing them.

What is required, therefore, is a balance sheet–type approach: a comprehensive inventory of wealth that measures tangible physical and intangible (knowledge, intellectual) assets and inputs. This must take into account time lags – for example, an investment made today that, in future, will increase life expectancy or reduce

industrial emissions is, while a cost now, a significant creator of value in the long term, improving social and environmental quality. Without such thinking, we risk becoming poorer, as today's economic decisions may increase environmental, social and human damage. Coyle includes debt in this category: it may serve current growth, but in the longer run, it can hinder progress. Changing the measurement methodology is important even though we currently lack the necessary data and a universally accepted methodology. However, poor measurement is better than none, the author warns. After all, data and measurement underpin the decisions we make today, which have long-term consequences for the functioning of the whole system, and measuring with GDP alone is like driving with only our rear-view mirror, Coyle says.

Report on the Roundtable Talk 'Trump's Tariff Policy and the Reshaping of the World Order – the End of Orthodoxy or the Beginning of the New Normal?'*

Pál Péter Kolozsi

The Center for Economic Policy of Mathias Corvinus Collegium (MCC) and the Financial Section of the Hungarian Economic Association (MKT) held a panel discussion with the title 'Trump's tariff policy and the reshaping of the world order – the end of orthodoxy or the beginning of the new normal?' on 10 July 2025. The participants in the roundtable meeting were *Gyula Pleschinger*, President of the MKT and former member of the Monetary Council of the Magyar Nemzeti Bank, *Zoltán Pogátsa*, Associate Professor at the University of Sopron and professor at Eötvös Loránd University (ELTE) and the University of Verona, *Géza Sebestyén*, Associate Professor at Corvinus University of Budapest and Head of the MCC's Center for Economic Policy, and *Barnabás Virág*, Deputy Governor of the Magyar Nemzeti Bank and Member of the Board at the MKT's Competitiveness Section. The discussion was organised and moderated by *Pál Péter Kolozsi*, General Deputy CEO of the Government Debt Management Agency (Államadósság Kezelő Központ Zrt.) and Chair of the Financial Section of the MKT. The participants explored the potential economic effects of US tariff policy, the responses to this policy and the transformation of global financial architecture.

In his introduction, *Pál Péter Kolozsi* noted that the major changes in the economic policy environment in recent months had primarily been driven by three factors. The first was the tariff war launched by Donald Trump on 2 April 2025, which was suspended by the US president for 90 days – this period ended on 9 July, which prompted this discussion. In the 100 days that had passed since 'Liberation Day', announcements about tariffs were made in the US on average every three to four days, showing how uncertain the international economic and market environment had become. The second factor was the responses to the US tariff measures, in particular the Chinese restrictions on strategic raw materials, notably rare-earth metals, and other trade restriction measures, such as the digital services tax proposed by Canada. The third factor was connected to the Rio de Janeiro summit

* The papers in this issue contain the views of the authors which are not necessarily the same as the official views of the Magyar Nemzeti Bank.

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of the BRICS countries during this period – these countries were working to devise and eventually build an alternative to the Western world order.

The experts first reviewed the period between 2 April and 9 July 2025. *Géza Sebestyén* explained that the events associated with 2 April had in fact started earlier and that we had to go back at least to the first Trump administration and possibly to the 2008 financial crisis to find the causes. "In the new economic policy environment, investment decisions are less financial in nature; they rather follow a non-economic logic and fit in the context of security, sovereignty and geopolitics," said the researcher, who believed that the current US–China conflict was following the pattern of previous periods and that several aspects of it could be compared to the US–Japan rivalry in the 1980s. "What we see today is not the effect of the trade war, it is the effect of the threats of tariffs," said Sebestyén. *Gyula Pleschinger* agreed that the trade war had not started recently and pointed out that the initial panic had led to a significant increase in US imports in the first quarter, as everyone was trying to protect themselves against the tariff measures. "We can expect changes in the regulatory environment where products and countries that are important for the US will have more favourable tariffs than indifferent or hostile ones," said the President of the MKT. *Barnabás Virág* highlighted we might lose focus if we only pay attention to trade, as this was about so much more than trade policy. "Two issues lie beneath the trade war that everyone needs to consider: the first is geopolitics, and the other is how budgets and debts are and can be financed," he explained, adding that when it came to tariffs, the time window we consider was also important. "The past 50 years have really been characterised by hyper-globalisation, but for centuries before that, there were tariffs in place. The fact that countries today want to have more active tariff policies is not unprecedented historically speaking. In today's world economy, supply-side barriers to economic growth are increasingly effective. This is something we must consider when trying to understand the trade war," he added. Virág pointed out that there were three macrotrends that were close to the tipping point in many countries around the world: the deterioration in the demographic situation, the increase in sovereign debt and the changes in the political environment. In relation to debt, he pointed out that public debt in the most developed countries was around 40 per cent in the 1970s and now stood at 110–120 per cent. What exacerbated the situation was that the cost of debt was now beginning to rise. "The debt service-to-GDP ratio is an important metric of financial sovereignty, and today, it is higher than defence spending in an increasing number of countries. The situation will or may become truly dangerous when debt service exceeds nominal GDP growth," said the Deputy Governor, who believed that the biggest challenge for policymakers would come from the interaction between the need for adjustment and political instability. "The most important question will be how a country can maintain its stability in such a global economy. All of this is

exacerbated by the significant distribution anomalies in the world economy, which are present in at least three areas: economic resources, the monetary system and wealth," said Virág, adding that in the future, he expected tariffs to be higher than in recent years, but not high enough for trade to grind to a halt.

According to *Zoltán Pogátsa*, nobody could have expected the trade war. "Very few people are alive today who saw tariffs go up, not down, in their adult life. Practically from 1947, the trend has been that quotas are being eliminated and tariffs are going down. It does not follow that we are about to enter an era of high tariffs, but surely there is no longer a strong consensus that the world will always be moving towards free trade," said the economist, who believed the US president was using tariff policy as a kind of political tool to make other states meet his expectations. "I agree with those who say that one key aim of the trade war is to 'stop' China, but it is also important that tariffs are a source of revenue. And so far, the numbers confirm this," said Pogátsa.

The second question to the panel was about the sustainability of budgets and debts, considering, in particular, that significant fiscal easing had started in major economic centres. *Gyula Pleschinger* pointed out that, even before the Covid pandemic, the debt ratio of the developed world exceeded the ratio seen during the 2008 financial crisis. "For fiscal sustainability, you need productivity growth and real growth. Otherwise, the interest on debt makes fiscal planning impossible, which may lead to increasing dissatisfaction," said the former member of the Monetary Council, emphasising that the currency in which countries finance their debt was particularly important and that financing in domestic currency offers many advantages. *Géza Sebestyén* added that in the long term tariffs were not a solution to budgetary problems. "The aim in the US is not to impose tariffs, but to bring production home. This is in line with the fundamental idea that the sustainability of debt and whether a country can or cannot manage its debt will depend on growth. This is why the US strategy that aims to strengthen its domestic economy through tariffs is good. The situation of China is also important from this aspect. So far, its outstanding growth has suggested that debt is sustainable, but the question arises as to what will happen when growth slows down. Japan was in a similar situation, which shows a potential way out from such a debt burden – there, the central bank has become the main source of financing for the debt," said Sebestyén.

According to *Zoltán Pogátsa*, there was an alternative to fiscal orthodoxy and not everything needed to be balanced immediately. "Spending more is not a problem in itself, if you are spending on the right things. If investments are directed to areas that are necessary for competitiveness and the green transition, there will not be a downside. It is also important that public debt should be in the domestic currency, because when there are reasonable investments and debt is in the domestic currency, it means there is no budgetary limit. From here on, the question is

simply whether these economic policy measures and stimuli support investment in education, human capital, the green transition and a sustainable society. Obviously, currently, this is not the case," said the professor, who believed that yield curve control was also an option. "The challenge comes from the fact that there are no guarantees that these stimulus packages are really spent on 'reasonable' and progressive projects that support social and economic development. The real problem is when these incentives do not promote growth, justice and sustainability," concluded Pogátsa.

Barnabás Virág presented three ways known from economic history to tackle higher debt. The first was that debt must be outgrown, for which the conditions are currently not fully met. The second was fiscal orthodoxy, for which you needed political consensus, but that seemed difficult to achieve now. The third was yield curve control, an option mentioned before. According to him, this was a potential solution in certain countries, including directing liquidity to the government bond market. "I'd be very cautious about what the central bank of a small, open country can do in this regard. The path and possibilities of large economies will be very different from those of small, open economies," he explained. Virág pointed out doubts regarding the role of the central bank, explaining that while central banks were very active in the 2010s, the results were far from unambiguous. "We could rather say this decade was wasted. For example, in Europe, what was achieved with regard to the energy transition, the green transition, innovation and infrastructure development in a permanently negative yield environment? Europe could have financed a number of important technological developments for free, but it didn't," explained the Deputy Governor of the MNB, who believed the key question would be who could finance the transition and at what cost. "To be able to meet the global challenges, we will also need monetary reform. We saw the effects of simple monetary easing in the past decade. Therefore, we need a monetary system where the process of money creation can be much more controlled and targeted," Virág said.

Finally, the participants of the roundtable talk discussed the fragmentation of the global financial system, the potential change in the position of the US dollar, and the importance of innovations related to central bank digital currency (CBDC) and gold. *Zoltán Pogátsa* emphasised that while the financial aspect was important, the outcome of the rivalry between China and the US would eventually depend on the real economy and technology. "The primary questions are who will produce what, who will provide what services and in what quality," according to the researcher, who believed we had to pay attention to the achievements of the two countries in sectors such as electric cars, high-speed trains, artificial intelligence, space technology and chip production, and that China had already surprised the world

several times. According to Pogátsa, what will be important in finance is who will be the first to really use central bank digital currency, as it will allow for targeted money creation and may influence the global position of the dollar as well. "Gold is an underdiscussed field in international finance. The fact that central banks have started to add to their gold reserves is a paradigm shift similar to the tariff war. In part, it is gold fetishism, but one of the underlying causes is that certain countries have started to experience the controlling role of the US," said the professor, referring to the seizure of Russian dollar reserves.

Géza Sebestyén believed the development of the Chinese electric car industry was impressive, but in his opinion, the US was still ahead in artificial intelligence, and he agreed that the fragmentation of the world would not depend on the events in finance, but rather on developments in the real economy. "The Chinese CBDC project is currently stagnating; it is not in use abroad. But if a fragmentation happens in the global economy, a number of countries will likely use the digital yuan in their transactions," according to Sebestyén, who believed that while the increasing trust in gold was linked to mounting international uncertainty, it was not a permanent trend but probably a periodical 'wave'.

Gyula Pleschinger agreed that the future of the global economy hinged on developments in the real economy, but he added that the developments in the real economy must be supported by money as well. "As far as central bank digital currency is concerned, China is ahead, but the European Central Bank is also working hard on the digital euro. Digital central bank money does allow for targeted money creation, but the question arises what will happen to the banking system if it is introduced," he said. Pleschinger believed that gold was a very good risk management tool, since when there was uncertainty on the markets, it was seen as a safe haven. "Therefore, it is really useful if central banks have gold in their reserves. However, I don't think we could go back to the gold standard system," he said.

Speaking about the rivalry between the US and China, *Barnabás Virág* pointed out that economic history suggests that its outcome would depend on who could control more of the scarce resources. "There are three types of relevant scarce resources: rare-earth metals, human capital and data. If we consider these, we see that China has a very good hand in the current geopolitical game," said the Deputy Governor, supporting his claim with statistics. China's direct and indirect share in rare-earth metals was 60–80 per cent. In terms of human resources, the advantage of China and Asia was increasing: last year, 40 per cent of science degrees were awarded in China, 20 per cent in Europe and about 15 per cent in the US.

There were 27 million IT engineers globally. One-third of them were in China, one-third were in India, and one-third were in all the other countries. “Data is also the basis for financial transformation. This means we must not underestimate the Chinese central bank digital currency project – data that will make development possible are being gathered now. It is important to add that 70 per cent of digital payment transactions in Europe use the American payment infrastructure, which means this data can be utilised by US companies, Visa and MasterCard. One of the reasons that the ECB has launched its digital euro project was to compensate for this,” Virág pointed out. He believed that, in relation to essential resources, the trend was clear and pointed to the further rise of the Chinese economy. “Where the US clearly still has an advantage is management capabilities, as US companies can translate new innovations into economic growth much more quickly and dynamically than competing countries. It is also true, however, that Asian countries are more ready to adopt new technologies than Western countries, which puts Asian countries at an advantage,” he pointed out. Finally, he said that the monetary system would definitely see a technological revolution. “The bad news is that when we look at the history of money, we see that these revolutionary transformations have always happened in crises. The crypto world can potentially be the starting point of such a future crisis,” he added. Virág believed that the financial system would gravitate towards centres, meaning that there would be a US dollar area, a euro area and a renminbi area, and there would be mobility between them. “Since the 1970s, the US economy has been running a current account deficit, and for a currency to become a global currency, the issuing country must also have an external deficit. Currently, this is not true either for the euro area or for China,” said Virág, pointing out a macroeconomic nexus.

The panel discussion is available on the MKT’s YouTube channel (in Hungarian).

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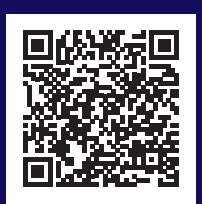

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