CYPRUS

SELECTED ISSUES

May 2024

This selected Issues paper on Cyprus was prepared by a staff team of the International Monetary Fund as background documentation for the periodic consultation with the member country. It is based on the information available at the time it was completed on May 9, 2024.

**International Monetary Fund
Washington, D.C.**

INTERNATIONAL MONETARY FUND

CYPRUS

SELECTED ISSUES

May 9, 2024

Approved By
European Department

Prepared By Robert Beyer, Moheb Malak, Emanuele Massetti and Filippos Tagklis.

CONTENTS

DISINFLATION AND MONETARY TRANSMISSION IN CYPRUS[1]

Inflation in Cyprus dropped in 2023 due to the diminishing impact of supply-side shocks and moderating demand. But some domestic price pressures persist, mostly from non-fiscal aggregate demand. ECB tightening has significantly impacted interest rates, including for outstanding mortgages. Deposit rates saw delayed and smaller increases, likely driven by high banking sector liquidity and low competition. Continued commitment to containing aggregate demand is supporting the final stage of disinflation.

A. Introduction

1.   Like many other countries, Cyprus experienced a post-pandemic inflation surge. Inflation has been sensitive to energy price pressures following Russia's war in Ukraine and the strong rebound in tourism after the pandemic (Beyer 2023). Headline inflation peaked at over 10 percent in July 2022. While initially driven by external shocks, inflation pressures became more broad-based over time. Robust wage growth also drove up core inflation, which surpassed 6 percent in July 2022.

2.   Inflation declined markedly in 2023. By the end of the year, headline inflation had dipped below 2 percent, while core inflation declined to 2.4 percent (Figure 1). Last year's inflation dynamics compared favorably to those in the euro area, where in December headline and core HICP inflation still stood at 2.9 percent and 3.4 percent, respectively. The strong decline in headline inflation in Cyprus has been supported by energy price normalization.

3.   Some domestic price pressures remain. Inflation of goods and services with low import content, the so called *LIMI* inflation index, is a good

Figure 1. Different Inflation Measures in Cyprus Over Time
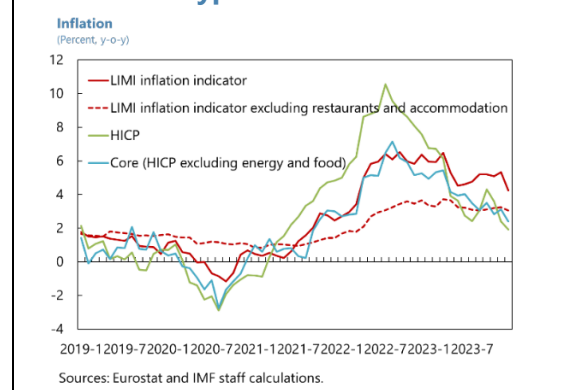
Inflation
(Percent, y-o-y)

- LIMI inflation indicator
- LIMI inflation indicator excluding restaurants and accommodation
- HICP
- Core (HICP excluding energy and food)

Sources: Eurostat and IMF staff calculations.

measure of domestic price pressures (Fröhling, O'Brien, and Schaefer 2022). It has been stickier than core HICP inflation and remained above 4 percent at the end of last year (Figure 1). *LIMI* inflation excluding restaurants and accommodation (for which second-round effects play an important role), provides an even narrower measure of domestic price pressures. It remained stable during the pandemic, when other prices fell, and throughout 2021, when other prices surged. However, it started picking up slowly in 2022 and has been close to 3 percent since mid-2022, also indicating remaining internal price pressures.

---

4. **Against this backdrop, this Selected Issue Paper analyzes the drivers of disinflation and discuss implications for the inflation outlook.** Section B analyzes the role of supply and demand, and Section C differentiates fiscal from non-fiscal demand. Section D considers the role of unit profits and labor costs. Section E discusses monetary transmission to lending rates, a key driver of weaker (non-fiscal) demand pressures. Section E uncovers weaker pass-through to deposit rates and touches upon reasons and implications. Section F discusses policy conclusions.

B. Supply and Demand Drivers of Inflation

5. **Inflation dynamics can be decomposed into supply and demand drivers.** Bayesian Vector-Error-Correction models (BVARs) with output growth and inflation—in which aggregate supply shocks move prices and quantities in opposite directions and aggregate demand shocks move them in the same direction—allow for such a decomposition (see Appendix I for more details). The cumulative effect of demand and supply shocks, and their lagged effects on inflation, can then be investigated with a historical decomposition of excess inflation (i.e., deviation of inflation from target).[2] While such a simple BVAR model can provide useful insights, it has shortcomings. First, such models can be sensitive to model specification. In addition, it can be difficult to properly identify supply and demand shocks. This is especially the case for headline inflation and when supply and demand shocks hit at the same time, as arguably was the case during the pandemic and subsequent recovery. We hence restrict this analysis to core inflation.[3]

6. **The analysis suggests that high core inflation in 2023 was driven both by demand and supply factors** (Figure 2). The post-pandemic inflation surge is attributed to both supply and demand factors, with the latter dominating most of the time. Supply factors peaked in 2022Q3—contributing 2.4 percentage points to core inflation—and then declined, but still accounted for over a third of excess core inflation in 2023 (Figure 2, left panel). Demand factors, while also declining since the second half of 2022, have been sticker, even though their remaining quarter-over-quarter impact was tiny at the end of the year (Figure 2, right panel). The significant impact of demand aligns with a positive output gap estimate (IMF 2024b) and lingering effects of monetary and fiscal policy easing in response to the pandemic.

Figure 2. Supply and Demand Drivers of Inflation

Historical Decomposition of Excess Core Inflation 1/
(Percent, year-over-year)

Historical Decomposition of Excess Core Inflation 1/
(Percent, quarter-over-quarter)

Sources: Eurostat and IMF staff calculations based on IMF FAD Toolkit.
1/ excess inflation = deviation from deterministic trend

---
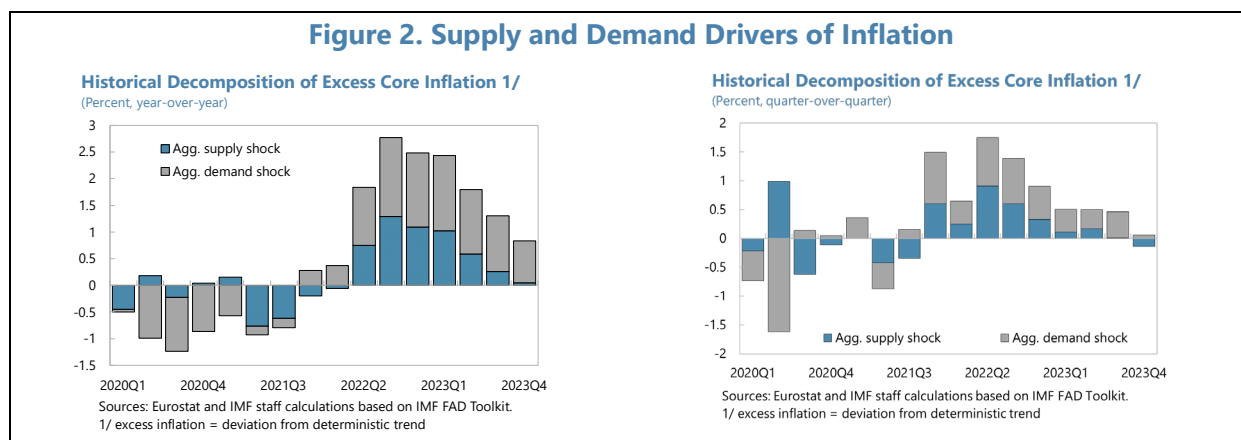
[2] For the estimations we use an internal toolbox developed by the Fiscal Affairs Department of the IMF (Davoodi, Nguyen, and Poplawski-Ribeiro 2023).

[3] Other shortcomings include the exclusive reliance on statistical relationships (and not economic theory), potential oversimplification, and biases if demand and supply shocks are not fully exogenous.

7.   This finding of the importance of demand factors aligns with a bottom-up decomposition of core inflation developed during the COVID-19 pandemic. HICP core components can be classified into four distinct groups at the 2-digit level: 1) those sensitive to supply-chain disruptions; 2) those influenced by re-opening dynamics, indicating pent-up demand; 3) rent; and 4) miscellaneous items (Gonçalves and Koeste 2022). We aggregate the components in each category using the corresponding HICP weights. The classification is kept invariant during the sample period and does not directly account for second-round effects from energy prices. In line with previous results, the contribution from supply disruptions declined during 2023 and were very small at the end of the year (Figure 3). As before, demand factors have been around twice as large on average last year, with supply disruptions still accounting for around a third of 2023 excess core inflation.

Figure 3. Bottom-up Decomposition of Core Inflation

Core HICP Composition
(Percent, year-over-year)

Sources: Eurostat and IMF staff calculations.
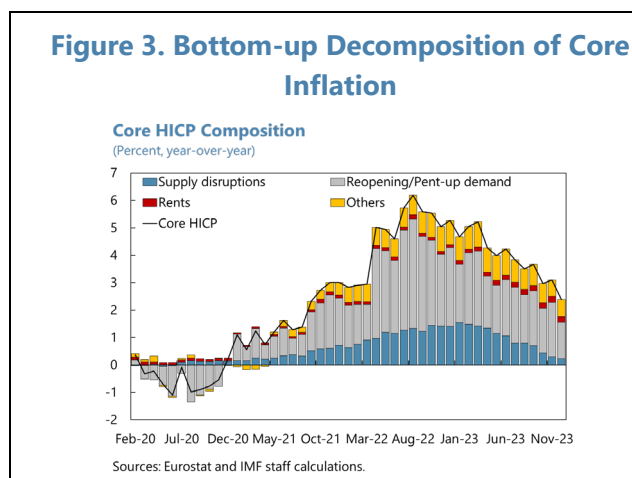
C.   Fiscal and Non-Fiscal Demand Pressures

8.   The theoretical links of fiscal expansion and inflation are well established. Expansionary fiscal policy tends to be inflationary through the textbook Keynesian channels of private consumption and investment. This relationship is also inherent in a typical downward sloping Phillips curve. If expansionary fiscal policy raises inflation expectations, the impact on inflation is amplified. The relationship also holds in Representative Agent New Keynesian models, in which fiscal policy shocks move output and inflation in the same direction. In the Euro Area, model-based simulations suggest that a uniform cut of public expenditure by 1 percent of GDP across member states is equivalent to a monetary policy tightening of around 50 basis points, both reducing inflation by around 0.2 percentage points (Beyer *et al.* 2023).

9.   As other countries, Cyprus employed fiscal measures to mitigate the impact of the pandemic and energy price shock. Cyprus has maintained fiscal discipline since the 2013 crisis, resulting in fiscal space that enabled Cyprus to mount an effective policy response via temporary and mostly targeted support measures (IMF 2023a). The fiscal balance turned strongly negative in 2020 and 2021 but returned to a surplus in 2022.

10.   The contribution of fiscal policy shocks to inflation can be assessed empirically. To do so, we estimate a similar BVAR model as before. It now includes four variables: output growth, inflation, the short-term interest rate, and the fiscal balance. A contractionary (expansionary) fiscal shock is restricted to lead to an increase (decrease) in the primary balance and a negative (positive) impact on output growth and inflation (see Appendix II for more details). This specification can capture the response of inflation to a fiscal shock, and hence be used to decompose excess inflation into fiscal and non-fiscal drivers (again with a historical decomposition). Importantly, fiscal policy in the model also responds endogenously to supply and non-fiscal demand shocks (i.e., to the business cycle). The contribution of fiscal policy shocks to excess inflation is hence always in addition

to how fiscal policy usually reacts to the other shocks (i.e., in addition to the estimated endogenous response).[4] In addition, the fiscal balance only captures the costs of the fiscal measures.[5] Concerns about model stability and proper shock identification become more severe as models gets more complex. We hence confirm the robustness of the main findings with respect to model specification (see Appendix D).

11.   By the end of 2023, demand pressures were likely dominated by non-fiscal factors. For 2022, our estimation attributes around 1.2 percentage points of core inflation to fiscal policy (Figure 4, left panel).[6] However, this contribution declined in 2023 and dropped to 0.4 percentage points in 2023Q4, even declining slightly quarter-over-quarter (Figure 4, right panel). A corresponding partial yet substantial reduction in non-fiscal demand pressures has likely been supported by monetary tightening, discussed in Section F.

Figure 4. Fiscal and Non-Fiscal Drivers of Inflation

Decomposition of Excess Core Inflation 1/
(Percent, year-over-year)

Sources: Eurostat and IMF staff calculations based on IMF FAD Toolkit.
1/ excess inflation = deviation from deterministic trend

Decomposition of Excess Core Inflation 1/
(Percent, quarter-over-quarter)

Sources: Eurostat and IMF staff calculations based on IMF FAD Toolkit.
1/ excess inflation = deviation from deterministic trend

D.   The Role of Profits and Labor Costs

12.   Persistent inflation can also arise from conflicts over relative prices between firms and workers. Due to nominal rigidities, particularly with wages being stickier than prices, cost-push shocks can lead to persistent inflation if firms and workers sequentially adjust prices and wages. For instance, following an import price shock, increased profit shares from initial price hikes may subsequently drive workers to demand higher nominal wage increases to restore their purchasing power (Blanchard 1986; Lorenzoni and Werning 2023).

---

[4] One could consider an alternative identification scheme and assume that within-quarter fiscal policy does not respond to the business cycle or supply shocks within that same quarter. This would change the interpretation of the fiscal factor and increase its contribution.

[5] To the extent that the fiscal measures had a positive impact on growth and—in turn—tax revenue, the overall contribution of the fiscal factor is likely to have been somewhat larger.

[6] Note that the model shows a negative contribution of fiscal shocks at the beginning of the pandemic in 2020. This is due to a smaller fiscal response to the large non-fiscal shocks in 2020Q2 than the model predicts based on historical relationships. The endogenous response contributed positively to inflation.
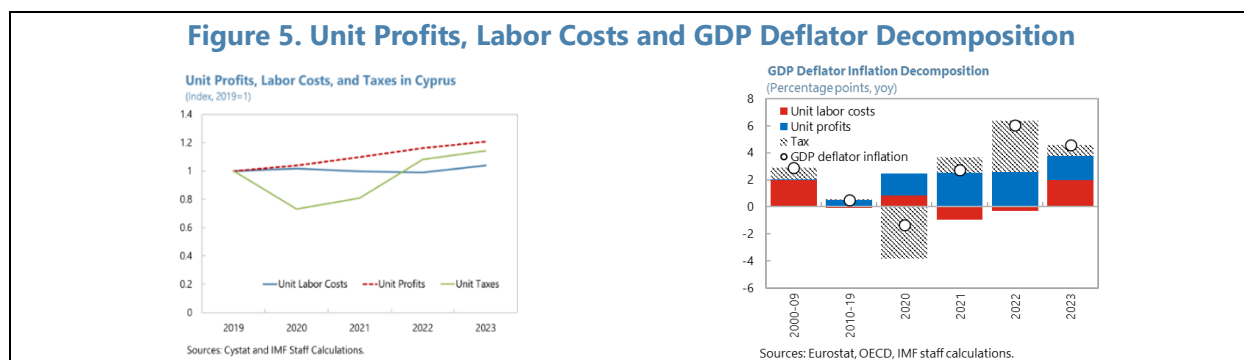
13. **Increasing prices can consequently reflect higher profits or higher labor compensation per unit of GDP.** From the income side, GDP is the sum of labor compensation, gross operating surplus, and net taxes:

$$GDP = GVA + Net\ Taxes = Profits + Compensation\ of\ Employees + Net\ Taxes$$
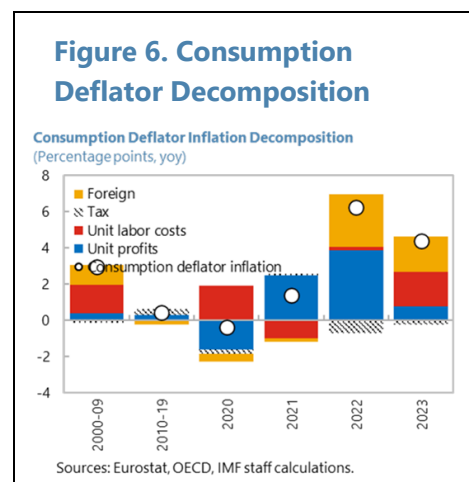
Based on this identity, the GDP deflator (nominal GDP divided by real GDP) can hence be expressed as the sum of unit labor costs, unit profits, and unit net taxes:[7]

$$GDP/Real\ GDP = GDP\ Deflator = Unit\ Profits + Unit\ Labor\ Costs + Unit\ Taxes$$

14. **So far, inflation has been accompanied by higher unit profits and lower labor costs.** Since 2021, unit profits increased while unit labor costs declined (Figure 5, left panel). In 2022, nearly three-quarters of inflation was driven by unit profits. The remaining portion came from higher unit taxes, with a negligible contribution from unit labor costs. Following the spike in energy prices, firms have hence passed on more than just the immediate nominal import cost shock. The increasing profit share implies that firms have so far been relatively more shielded from inflation than wage earners. Across the euro area, the increase in nominal profits was largest in sectors benefiting from rising international commodity prices and those exposed to recent supply-demand mismatches (Hansen, Toscani, and Zhou 2023). Last year, unit profits and unit labor costs contributed equally.

Figure 5. Unit Profits, Labor Costs and GDP Deflator Decomposition

Unit Profits, Labor Costs, and Taxes in Cyprus
(Index, 2019=1)

Sources: Cystat and IMF Staff Calculations.

GDP Deflator Inflation Decomposition
(Percentage points, yoy)

Sources: Eurostat, OECD, IMF staff calculations.

15. **Decomposing the consumption deflator introduces a role for import prices and reinforces previous findings.** The consumption deflator, like HICP but unlike GDP, includes imports but excludes exports. The consumption deflator can hence provide an additional perspective on inflation, particularly regarding the post-pandemic inflation surge. By employing a set of simplifying assumptions, the deflator can be dissected into contributions from domestic profits, labor, foreign factors, and net taxes (Hansen, Toscani, and Zhou 2023). In 2022, foreign factors contributed significantly, though less than domestic profits (Figure 6). Consequently, domestic profits remain a

Figure 6. Consumption Deflator Decomposition

Consumption Deflator Inflation Decomposition
(Percentage points, yoy)

Sources: Eurostat, OECD, IMF staff calculations.

---

[7] National accounts report profits as gross operating surplus and mixed income, which differ from profits shown in company accounts in several ways. For a discussion of the different concepts and their relationships, see Hansen, Toscani, and Zhou (2023).

significant driver of inflation, even after explicitly considering the import price shock. Consistent with the decomposition of the GDP deflator above, unit labor costs started contributing last year.

E.   Monetary Tightening and Lending Rates

16.   In response to the inflation surge, the ECB tightened its monetary policy stance. The ECB started a tightening cycle in July 2022 and raised its policy rate from 0 to 4.5 percent. This has been the steepest tightening since the inception of the euro by far. Not surprisingly, bank retail rates increased as well (Figure 7). The 'pass-though' of changes in policy rates to bank retail rates is a crucial intermediate step in the transmission of monetary policy to aggregate demand.

Figure 7. Policy and Bank Retail Interest Rates Over Time
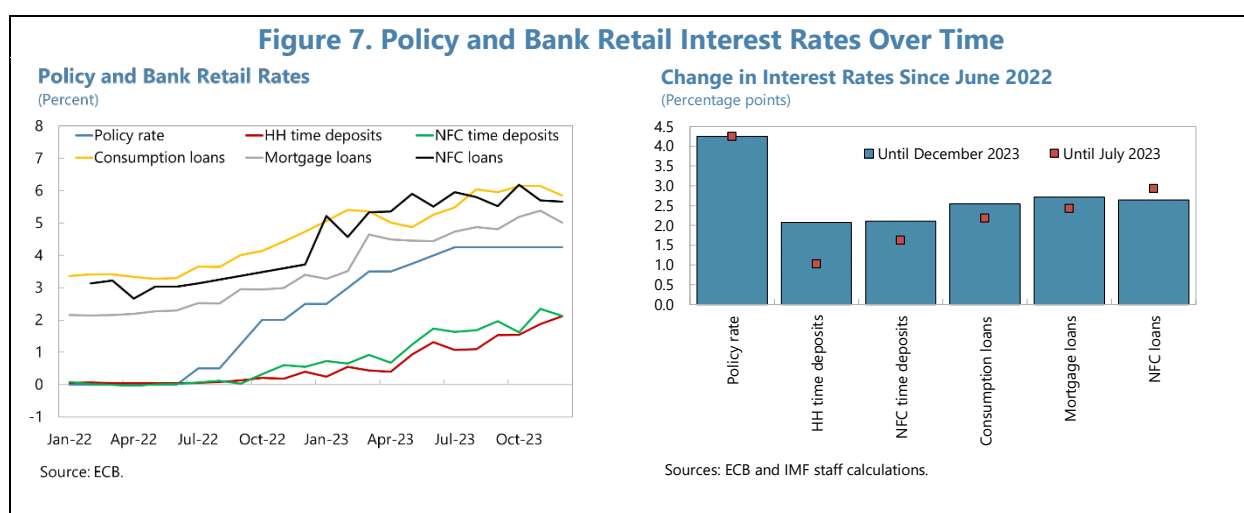
17.   The pass-through to bank retail rates can be assessed with so-called *beta coefficients*. They are defined as the ratio of the cumulative change in bank retail rates to the cumulative change in the policy rate. To assess pass-through during a tightening cycle, it is useful to compute *beta coefficients* for different bank retail rates for both households and non-financial corporations (NFCs).[8]

18.   The pass-through to new lending rates in Cyprus has been comparable to that in other European and Euro Area countries. Although quite similar, there has been a somewhat weaker pass-through to new loans for NFCs. The pass-through to consumption and mortgages, in contrast, has been somewhat stronger than in other European and euro area economies (Figure 7, left panel).

19.   The pass-through to outstanding mortgages has been much stronger. For mortgages, which usually have a longer maturity than other loans, we also assess the pass-through to the outstanding stock. Due to the high share of mortgages in household debt, pass-through to outstanding mortgages plays an important role in the transmission of monetary policy to output and prices (IMF 2024a). This pass-through has been more than twice as strong as in Europe and the euro area (Figure 8, left panel).

---

[8] Usually, the transmission is nearly complete after three months, so for international comparison we compute beta coefficients from the first increase of the policy rate to three months after the last increase (see Appendix C for more information and robustness checks). For the international comparison, the data ends in August 2023.

Figure 8. Policy Pass-Through to Lending Rates and Flexible Rates Mortgages

Policy Pass-Through to Bank Lending Rates
(Δ lending rate / Δ policy rate)

New Flexible-Rate Mortgages
(Percent of total loans)

Sources: ECB, Beyer et al. (2024), and IMF staff calculations.

Sources: ECB, European Mortgage Federation, and National Central Banks.
1/ or latest available
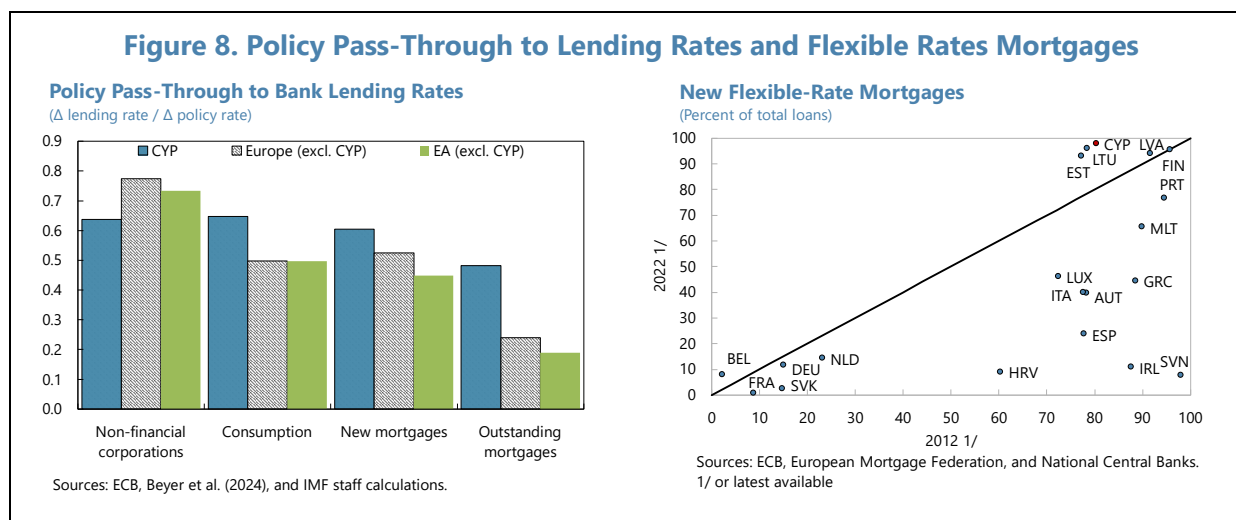
20.   The high share of flexible rate mortgages plays a key role. Cyprus has among the highest share of flexible rate mortgages in Europe, and—in contrast to most other countries—the share has not declined over the last decade (Figure 8, right panel).[9] This explains the higher pass-through than elsewhere to both new and outstanding mortgages. New *flexible*-rate mortgages are more closely related to short-term interest rates than *fixed*-rate, and outstanding flexible-rate mortgages are adjusted more often than other types of mortgages.

21.   Despite a high share of flexible rate mortgages, only half of the policy rate change has been passed on to outstanding mortgages. Possible reasons include constraints on mortgage rate adjustments (interest rate collars) and the reference to a bank-specific base rate, tied to the deposit rate, which exhibited a notably weaker pass-through (see next section).

22. The impact of higher mortgage rates on aggregate demand has been somewhat mitigated. Usually, higher mortgage rates lower disposable income (due to higher interest rate payments) and wealth (due to declining house prices). However, robust external demand for houses have so far—property sales increased in 2023, with foreigners accounting for close to half the demand—offset the impact of higher mortgage rates on house prices, thus weakening the wealth channel.

F.   Monetary Tightening and Deposit Rates

23. Deposit rates have increased less than lending rates. Around two-thirds of the increase in policy rates has been passed on to new mortgage and consumption loan rates. In contrast, only a quarter has been passed on to household time deposits, and none to household overnight deposits. As a result, the share of time deposits in all deposits started increasing again (after falling strongly before). The deposit pass-through has been somewhat higher for corporations, likely reflecting

---

[9] The stable share could either signal strong market power of banks, an inability of banks to absorb long-term funding risks, or low financial literacy. Most likely it has been a combination of these factors. Interestingly, the share has declined recently, with the share of fixed-rate mortgages for house purchases increasing from 7 percent in June 2022 to 32 percent in January 2024.

more sophisticated financial planning and more bargaining power, but their loan rates increased by more as well.

24.   Deposit pass-through has been lower and slower than in other countries, contrasting with the relatively similar pass-through to lending rates (Figure 9, left panel)**.** Usually, bank retail rates react quickly to changes in the policy rate, with nearly all the transmission happening within the initial three months following a rate change (Beyer *et al.* 2024). In Cyprus, however, rates on time deposits continued increasing for much longer. Even so, the pass-through remained much lower, even by the end of 2023 (Figure 9, right panel).[10]

Figure 9. Policy Pass-Through to Deposit Rates

Policy Pass-Through to Bank Deposit Rates
(Δ deposit rate / Δ policy rate)

Policy Pass-Through to Bank Deposit Rates
(Δ deposit rate / Δ policy rate)

Sources: ECB, Beyer et al. (2024), and IMF staff calculations

Sources: ECB, Beyer et al. (2024), and IMF staff calculations.
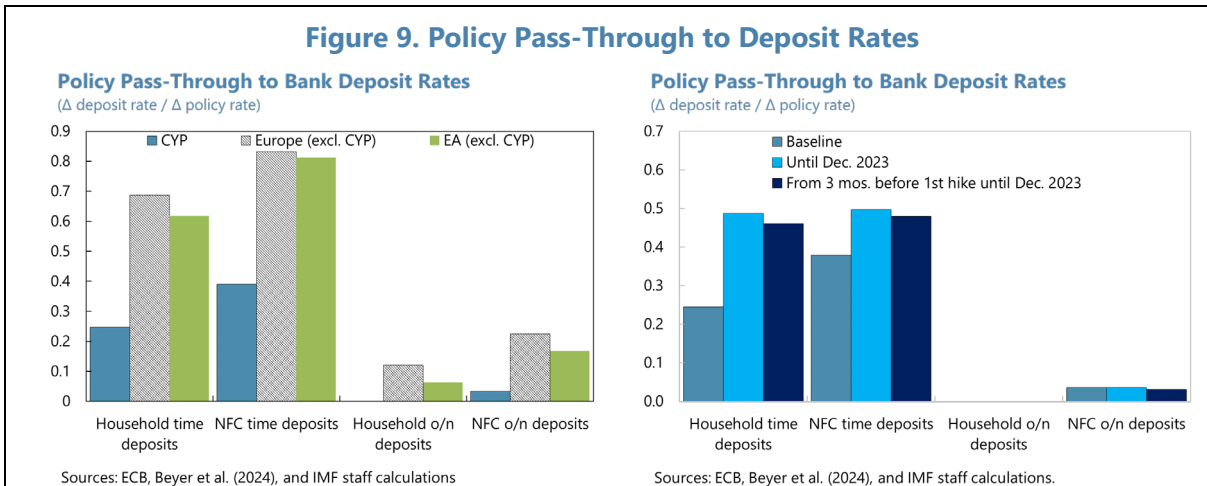
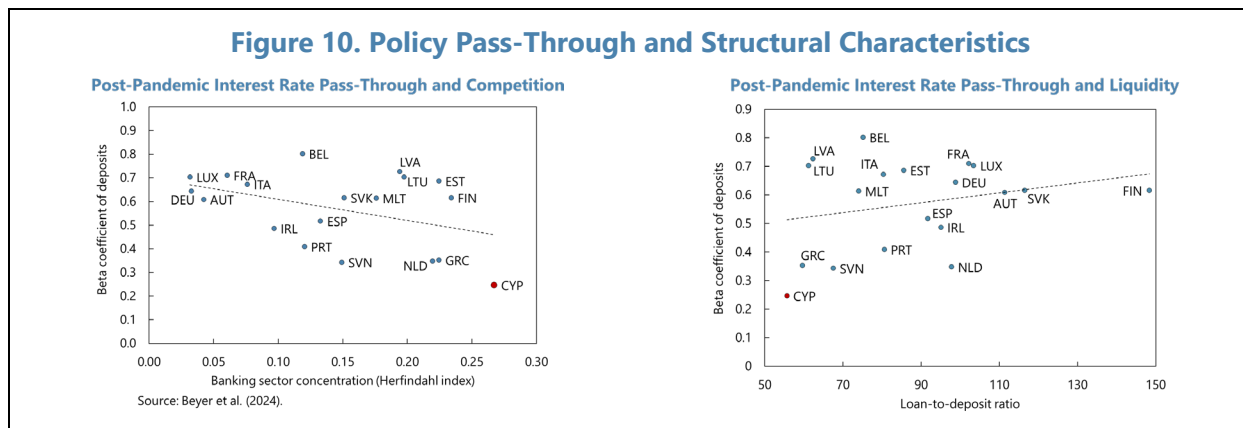**25.   Structural characteristics appear to have contributed to the limited and delayed deposit pass-through in Cyprus.** Low competition and high banking sector liquidity can weaken pass-through to deposit rates (Beyer *et al.* 2024). Cross-country analysis reveals Cyprus as an outlier in both banking sector concentration (a measure of competition) and the loan-deposit-ratio (a measure of liquidity and lending opportunities), likely influencing the lower and slower pass-through to deposit rates than elsewhere (Figure 10). The impact of low deposit pass-through is likely to weaken transmission to output and prices, as it disincentivizes saving. However, this is mitigated by lower income-flows to those saving in deposits.

Figure 10. Policy Pass-Through and Structural Characteristics

Post-Pandemic Interest Rate Pass-Through and Competition

Source: Beyer et al. (2024).

Post-Pandemic Interest Rate Pass-Through and Liquidity

---

[10] For lending rates, the pass-through in the baseline and until December 2023 are very similar, indicating delayed transmission.

26.   The heterogeneous lending and deposit pass-through increased interest rate margins, supporting bank profits. Net interest income increased strongly after the start of the monetary

policy tightening cycle (Figure 11). The lower deposit pass-through added to higher revenue from reserves held at the ECB, pushing up bank profits further.

G.   Policy Implications

27.   The last mile of disinflation would benefit from containing aggregate demand. While supply disruptions are no longer materially impacting inflation, domestic demand continues to put pressure on prices. The remaining contribution from fiscal policy is small. Given a still positive output gap and robust growth projections (IMF 2024b), a neutral fiscal policy stance is appropriate.

Figure 11. Banking Sector Profitability Over Time

Sources: EBA and IMF staff calculations.
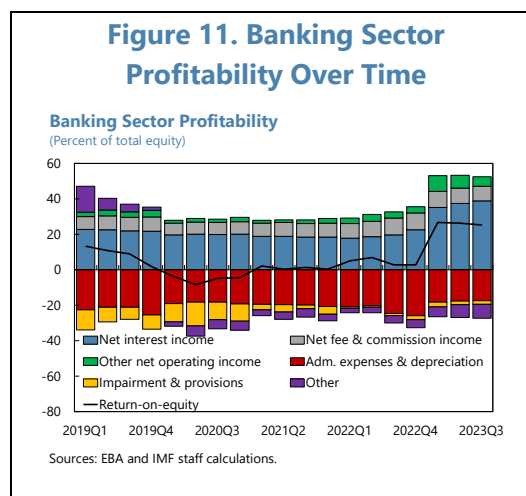
28.   Transmission through the real estate sector should not be hindered. Without monetary tightening and significant pass-through to mortgage rates (around half), last year's increase in house prices likely would have been larger. However, robust external demand for housing and the Interest Rate Subsidy Schemes for real estate announced in May 2020 have weakened the wealth channel of monetary policy. Policy measures like a lower VAT for first time house buyers or interest rate subsidization schemes would further dampen transmission through the real estate market.

29.   The low competition in the banking sector and its interaction with financial literacy warrant further analysis. For instance, the current situation could be primarily an endogenous or exogenous outcome. On one hand, the small size of the Cypriot economy in comparison to the Minimum Efficient Scale of banks may be a significant factor. On the other hand, anecdotal evidence about substantial rigidities in switching between banks point to the latter. In any case, improving financial literacy, enhancing consumer protection measures, and altering perceptions of risks associated with smaller banks and new market entrants (e.g., fintech companies from outside of Cyprus) could offer substantial benefits to consumers and foster competition. With possible further banking consolidation in the future, the roles of financial literacy and consumer protection would become even more crucial.

30.   Wage dynamics will influence the inflation outlook. While risks of a wage-price spiral have declined substantially, the extent to which remaining demand pressures will impact future inflation will partly depend on wage dynamics. Wage pass-through of inflation tends to be higher in countries with higher union density (Baba and Lee 2022). In line with this, wage pass-through has been strong in Cyprus in the past (Beyer 2023) and has been driving inflation last year. Wage pressures could intensify further this year due to labor market tightness, indicated by a record-high high vacancy-to-unemployment ratio. An increase of labor supply—including from immigration or from increased participation—could help meeting employment needs. Nevertheless, in the current situation, it would be prudent for the public sector to lead the way by controlling public sector wage growth. Above all, the cost-of-living allowance should not be raised further.

31. **Elevated corporate profits could offer some room for absorbing potential wage increases.** In the euro area, illustrative simulations show that a profit share compression to historic norms will likely be necessary to achieve timely disinflation under plausible wage growth assumptions (Hansen, Toscani, and Zhou 2023). Similarly, disinflation in Cyprus will likely need to go hand in hand with an increase of wages relative to profits and a normalization of the profit share.

Appendix I. Bayesian Vector Autoregression Model

1.   A BVAR to decompose inflation into supply and demand drivers.

For the estimation of the BVAR model, we rely on a toolbox developed by the Fiscal Affairs Department of the IMF (Davoodi, Nguyen, and Poplawski-Ribeiro 2023). The BVAR model can be described as follows:

$$A_0 X_t = B_0 + \sum_{l=1}^{q} B_l X_{t-1} + \epsilon_t,$$

where X_t is a vector of n endogenous variables, q is the lag length, which we set to three; B_0 represents deterministic terms; B_l is a matrix of parameters associated with the lagged variables; A_0 is a matrix of parameters, capturing the contemporaneous relationships between the endogenous variables; and ϵ_t is a $n{\times}1$ vector of orthogonal structural shocks with a Gaussian distribution of mean zero and identity covariance matrix.

2.   The reduced-form representation can be expressed as:

$$X_t = C_0 + \sum_{l=1}^{q} C_l X_{t-1} + u_t$$

where $C_0 = A_0^{-1} B_0$, $C_l = A_0^{-1} B_l$ and $u_t = A_0^{-1} \epsilon_t$. Reduced-form estimation does not provide sufficient information to identify A_0. Hence, additional restrictions/information are needed to identify the shock of interest. We rely on sign restrictions that combine prior knowledge from economic theory with a data-driven modelling approach (Canova and De Nicolò 2002, Uhlig 2005, ECB 2021, and IMF 2023b). The restrictions are imposed only on the contemporaneous responses and the data determines the impact size and the sign and size of the impulse response functions (IRFs) in the subsequent periods. Shocks are identified as in Gambetti and Musso 2017:

Table 1. Cyprus: Sign Restrictions for Supply and Demand Shocks

Shock type	Output growth	Inflation
Demand	- (+)	- (+)
Supply	- (+)	+ (-)

3.   We estimate this model with quarterly output growth and both HICP and core inflation from 1996Q1 to 2023Q4. All variables enter as differences of log levels (of output and price indices, respectively) and we estimate the mode both for y-o-y and q-o-q changes. The results presented above are for the former.

Appendix II. Bayesian Vector Autoregression Model with Fiscal Variables

1. **The second model follows the same structure as the first model but includes four variables: output growth (difference of log GDP), inflation (difference of log price indices), the short-term interest rate, and the primary fiscal balance (seasonally adjusted as percent of GDP).** It adds monetary and fiscal policy to the simple AD/AS framework of the first model (as in Bianchi and Melosi 2017). It hence can capture the response of output growth and inflation to fiscal shocks and can be used to decompose inflation into fiscal and non-fiscal drivers.
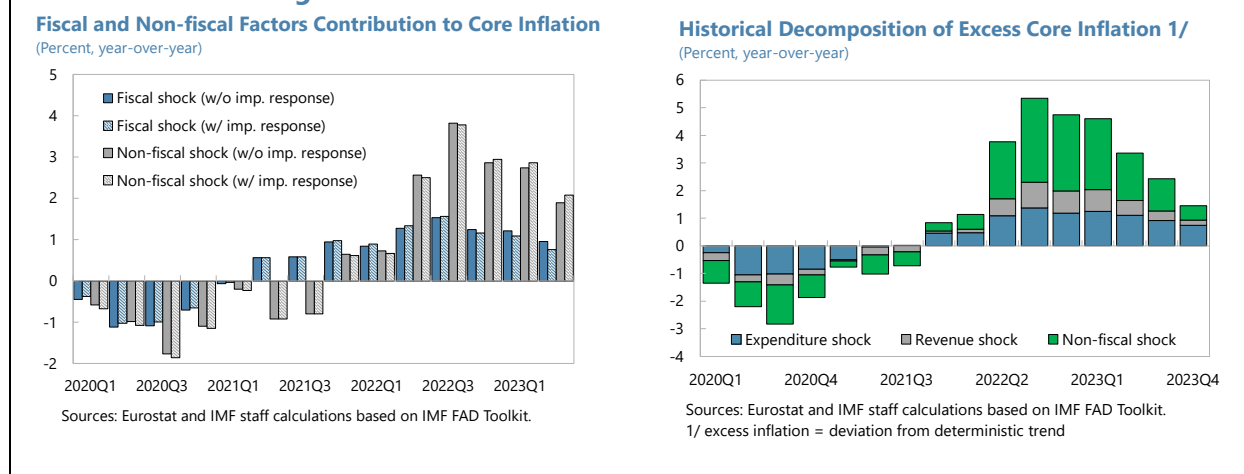
2. **The fiscal shock is identified by restrictions on the sign of variables' contemporaneous responses, with a contractionary (an expansionary) fiscal shock leads to an increase (a decrease) in the primary balance and has a negative (positive) impact on output growth and inflation.** A negative (positive) non-fiscal aggregate demand shock decreases (raises) output growth and inflation, leading to a decline (an increase) in the primary balance-to-GDP (via automatic stabilizers):

3. **Following Gambetti and Musso (2017), only $n - 1$ shocks are identified in system of n endogenous variables.** This leaves one reduced-form residual shock unidentified. It captures the effects of omitted variables and other shocks, including monetary policy shocks.

Table 1. Cyprus: Sign Restrictions for Fiscal and Non-Fiscal Shocks				
Shock type	Output growth	Inflation	Primary balance	Interest rate
Fiscal	- (+)	- (+)	+ (-)	
Demand	- (+)	- (+)	- (+)	- (+)
Supply	- (+)	+ (-)		

4. **We again estimate this model with quarterly data from 1996Q1 to 2023Q4, both for HICP and core inflation, and both for y-o-y and q-o-q changes.** For the short-term interest rate, we replace the policy rates with the shadow rate (Krippner 2013) when the zero-lower bound has been binding.

5. **Since Cyprus has had an independent monetary policy only until adopting the Euro in January 2008, it is not clear whether the response of the interest rate should be restricted as well.** We hence estimated the model twice: with a sign restriction on the response (reflecting monetary policy autonomy) with a negative (positive) non-fiscal aggregate demand shock leading to a decline (an increase) in the interest rate, and once without that restriction (reflecting no monetary policy autonomy). The differences for the decomposition of inflation in fiscal and non-fiscal factors are minimal (Figure 1).

Figure 1. Robustness of Fiscal Contribution to Inflation

Fiscal and Non-fiscal Factors Contribution to Core Inflation
(Percent, year-over-year)

Historical Decomposition of Excess Core Inflation 1/
(Percent, year-over-year)

Sources: Eurostat and IMF staff calculations based on IMF FAD Toolkit.

Sources: Eurostat and IMF staff calculations based on IMF FAD Toolkit.
1/ excess inflation = deviation from deterministic trend

6.   We conducted an additional robustness check. We included expenditure and revenue separately (instead of the fiscal balance), which shows that the fiscal contribution to inflation can be attributed mostly to expenditure, with revenue playing some role as well (Figure 1).

References

Baba, C., & Lee, J. (2022). Second-Round Effects of Oil Price Shocks—Implications for Europe's Inflation Outlook. *IMF Working Papers*, WP/22/173.

Beyer, R. (2023). Causes and Implications of Elevated Inflation in Cyprus (No. 2023/042*). IMF Selected Issues Paper, 2023/042*.

Beyer, R., Chen, R., Li, C., Misch, F., Ozturk, E. O., & Ratnovski, L. (2024). Monetary Policy Pass-Through to Interest Rates: Stylized Facts from 30 European Countries. *IMF Working Papers*, WP/24/9.

Beyer, R., Duttagupta, R., Fotiou, A., Honjo, K., Horton, M. A., Jakab, Z., ... & Zeng, L. (2023). Shared Problem, Shared Solution: Benefits from Fiscal-Monetary Interactions in the Euro Area. *IMF Working Papers*, WP/23/149*

Bianchi, F., & Melosi, L. (2017). Escaping the Great Recession. *American Economic Review*, *107*(4), 1030-1058.

Blanchard, O. J. (1986). The Wage Price Spiral. *The Quarterly Journal of Economics*, *101*(3), 543-565.

Canova, F., & De Nicolo, G. (2002). Monetary Disturbances Matter for Business Fluctuations in the G-7. *Journal of Monetary Economics*, *49*(6), 1131-1159.

Colonna, F. Torrini, R. and E. Viviano. (2023). The profit share and firm mark-up: how to interpret them? *Banca d'Italia Occasional Papers, 5/2023*.

Davoodi, H., Nguyen, A. D. M. and Poplawski-Ribeiro, M. (2023). *Fiscal and Non-fiscal Drivers of Inflation: A Decomposition Analysis*. Internal IMF-FAD Toolkit and Note, International Monetary Fund, Fiscal Affairs Department, Washington DC.

European Central Bank (ECB). 2021. Monetary-fiscal Policy Interactions in the Euro Area. *ECB Occasional Papers, 273*.

Fröhling, A., O'Brien, D., and S. Schaefer. (2022). A New Indicator of Domestic Inflation for the Euro Area. *ECB Economic Bulletin, 4/2022*.

Gambetti, L., & Musso, A. (2017). Loan Supply Shocks and the Business Cycle. *Journal of Applied Econometrics*, *32*(4), 764-782.

Gonçalves E. and G. Koeste. (2022). The Role of Demand and Supply in Underlying Inflation–Decomposing HICPX Inflation into Components. *ECB Economic Bulletin, 7*.

Hansen, N., Toscani, F., and Zhou, J. (2023). Euro Area Inflation after the Pandemic and Energy Shock: Import Prices, Profits and Wages. *IMF Working Papers*, WP/23/131*.

International Monetary Fund. (2023a). Cyprus: Staff Report for the 2023 Article IV Consultation. Washington, DC.

International Monetary Fund. (2023b). Inflation and Disinflation: What Role for Fiscal Policy?, Chapter 2 in Fiscal Monitor, April. Washington, DC.

International Monetary Fund. (2024a). World Economic Outlook, April 2024. Washington, DC.

International Monetary Fund. (2024b). Cyprus: Staff Report for the 2024 Article IV Consultation. Washington, DC.

Krippner, L. (2013). Measuring the Stance of Monetary Policy in Zero Lower Bound Environments. *Economics Letters*, *118*(1), 135-138.

Lorenzoni, G. and Werning, I. (2023). Inflation is Conflict. *NBER Working Paper, w31099.*

Uhlig, H. (2005). What are the Effects of Monetary Policy on Output? Results from an Agnostic Identification Procedure. *Journal of Monetary Economics*, *52*(2), 381-419.

GREEN TAXATION: ALONG THE PATH TO CLIMATE MITIGATION IN CYPRUS[1]

Cyprus has set ambitious climate targets, but achieving these will be challenging, even with full implementation of current plans. Carbon taxation is a crucial tool for Cyprus to meet its climate objectives, especially given its low existing carbon prices relative to European peers. The green taxation reform is a positive step, with manageable economic and distributional impacts. In its current form, it is expected to close about one-third of Cyprus's emissions gap but leaves carbon prices low in several sectors. A uniform carbon tax, across more sectors—combined with targeted sectoral policies and measures to mitigate distributional impacts—can go further in achieving Cyprus's targets.

A. Context

1.   Stepping up mitigation efforts is essential for the world to meet its climate objectives. Under a business-as-usual scenario, with no new measures, global GHG emissions are projected to increase 5 percent by 2030 relative to 2019 (Black, Parry and Zhunussova 2023). Even though countries have been raising the ambition of their Nationally Determined Contributions (NDCs), there remain both ambition and implementation gaps to achieve the objective of limiting global warming to 1.5 to 2°C.

2.   The European Union has been raising its climate ambitions. In 2020, the bloc committed to achieving climate neutrality by 2050, supported by policy initiatives in the European Green Deal. In line, the EU's NDCs under the Paris Agreement were revised, pledging a steeper 55 percent GHG reduction by 2030 compared to 1990 levels, up from the previous 40 percent. More recently, the European Commission (EC) proposed frontloading the remaining effort to achieve a 90 percent emission reduction by 2040. To translate these goals into concrete action, the EU unveiled the Fit-for-55 package, which includes a comprehensive set of legislative proposals to reduce emissions from transport, buildings, and industry, as well as proposals to strengthen the EU Emissions Trading System (ETS) and introduce a Carbon Border Adjustment Mechanism (CBAM).

3.   Enhanced EU climate goals will require member states to adjust their national policies. Emission abatement responsibility in the EU is shared between the supranational and the national authorities. The EU ETS administered by the EC is the key mitigation instrument in the power and emission-intensive industrial sectors through a cap-and-trade system which implicitly imposes carbon prices through the auctioning and trading of increasingly scarce emission allowances that are phasing down to zero by 2040. The rest of the emissions in the EU including from the transport, buildings, agriculture, and other sectors, fall under the national authorities' mandate, according to the Effort Sharing Regulation (ESR). EU member states prepare National Energy and Climate Plans (NECPs) in which they set their emission reduction targets and mitigation policies. An EU-wide ETS II

---

is anticipated in 2027, covering transport, buildings, and other sector emissions to assist national authorities in achieving the EU target.

4.   In this context, Cyprus has committed itself to ambitious climate targets. Cyprus prepared a long-term, low-GHG-emission development strategy—aiming to align itself with the EU's climate neutrality target by 2050—by enhancing energy efficiency, expanding the role of renewable energy sources (RES), promoting alternative fuels and technologies, and ensuring the sustainability of end-use energy consumption. The Cyprus NECP for the period 2021-2030 was revised, raising the national emission reduction target in sectors under the ESR to 32 percent, up from 24 percent.

5.   The EU Recovery and Resilience Plan (RRP) is an opportunity to further Cyprus's climate goals. As the key instrument at the heart of NextGenerationEU, the EU's pandemic recovery plan, the RRP aims to make European economies and societies more sustainable and resilient and better prepared for the challenges and opportunities of the green and digital transitions. A significant component of the EU-wide RRP is dedicated to facilitating the climate transition. For Cyprus, 41 percent of its €1.2 billion (4 percent of 2023 GDP) RRP budget is allocated to the green transition, including financing key investments such as an electricity interconnector project, various energy efficiency and RES investments, and electric vehicle promotion support schemes, as well as reforms to lower emissions, improve water and waste management, and preserve biodiversity.

6.   Green taxation reform is a key element of the Cyprus RRP. It aims to internalize environmental externalities, thus encouraging more efficient use of resources, promoting environmentally sustainable development, and incentivizing the adoption of renewable energy. It entails the introduction of: (i) a carbon tax for fuels used in non-ETS sectors; (ii) a levy on water to encourage water conservation and efficient use of water resources; (iii) a charge on landfill waste; and (iv) a nightly tourism tax. These are to be introduced in 2024 and progressively increased annually until 2033.

7.   The rest of the paper examines climate-mitigation trends in Cyprus and what role carbon taxation can play. Section B takes stock of Cyprus' progress on climate mitigation, including historical trends and the outlook for emissions against announced targets. Section C examines prevailing carbon rates. Section D studies the authorities' carbon taxation plan, assessing its environmental, economic, and distributional impacts using the IMF-WB Climate Policy Assessment Tool (CPAT). Section E provides recommendations and supportive policies to further promote climate mitigation. Section F concludes.

B.   Climate Mitigation in Cyprus

8.   A steady rise in Cyprus's emissions began to reverse in 2008. Annual net GHG emissions in Cyprus increased by more than 70 percent between 1990 and 2008, before reversing half of the increase by 2013, mainly due to the economic crises. Since then, emissions have been broadly stable.

9.   Emissions have started to decouple from economic activity. The "Kaya identity", which decomposes emissions into contributions from demographic, economic, and energy factors, can further shed light on the drivers of emissions in Cyprus:

$$GHG\ emissions = Population \times \frac{GDP}{Population} \times \frac{Energy\ consumed}{GDP} \times \frac{GHG\ emissions}{Energy\ consumed}$$

Emissions closely tracked per capita GDP trends until 2014, when the two began to diverge, as GDP per capita continued to grow while emissions stabilized. The decoupling has been mainly supported by an accelerated decline in the energy intensity of output, which has been a common trend in the EU, likely due to improved energy efficiency of available capital goods[2].

Figure 1. Emissions Developments

A steady increase in emissions began to reverse in 2008.

Emissions and economic activity have decoupled.

Greenhouse Gas Emissions Per Capita
(Tonnes per capita)

Kaya Decomposition of Emissions
(2000 = 100)

Source: Eurostat.

Sources: Eurostat, WEO, and IMF staff calculations.
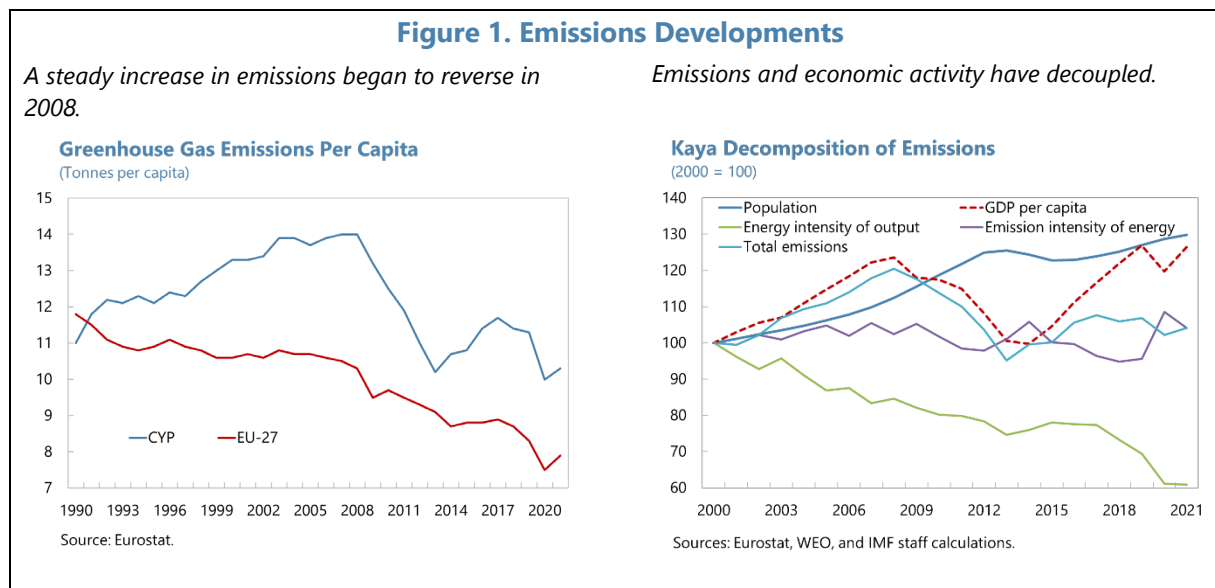
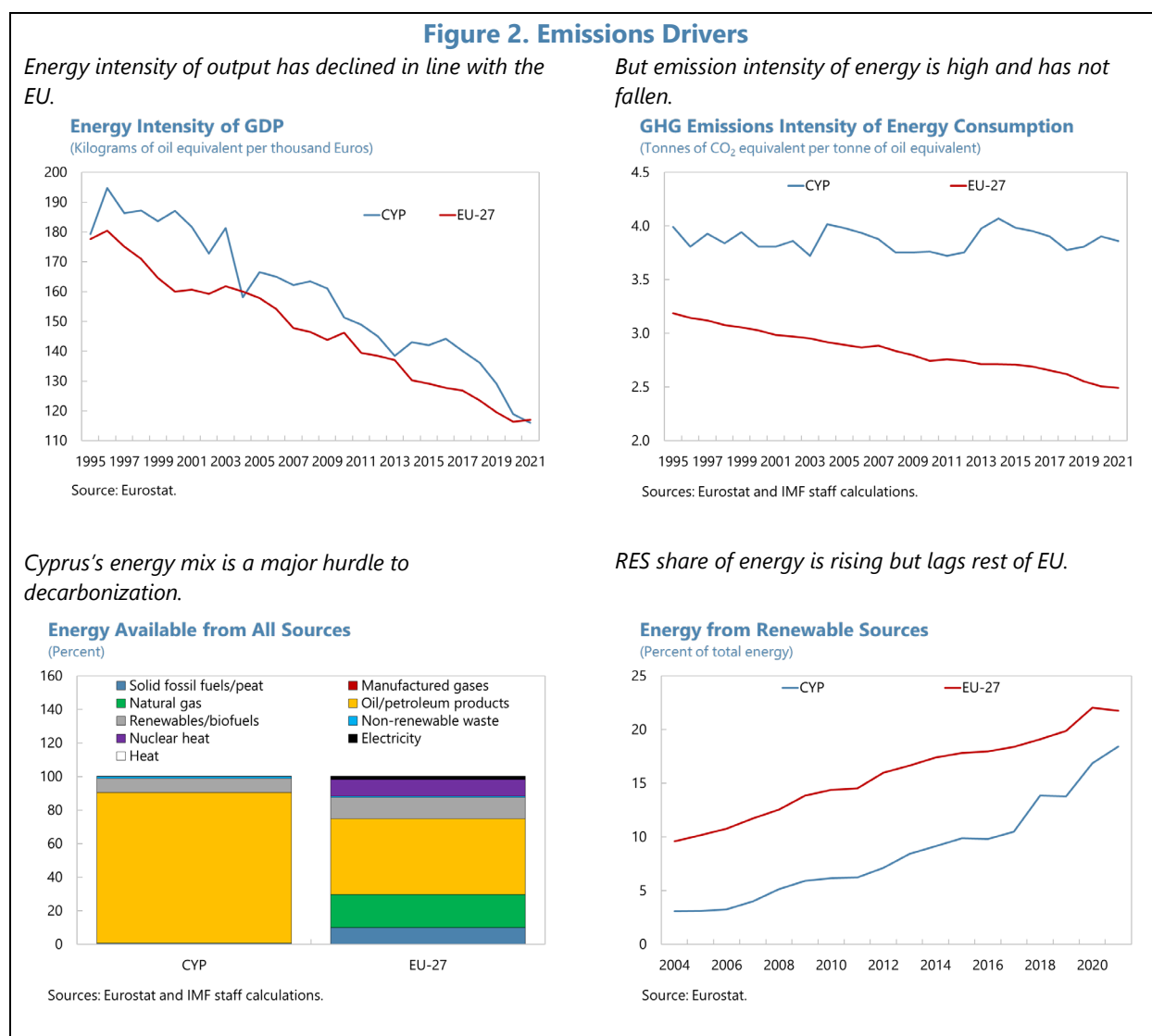**10.   Cyprus's energy mix is a major hurdle to decarbonization.** In contrast to the steady decline in the energy intensity of output, the emission intensity of energy has been stubbornly high and stagnant, a reflection of Cyprus' highly undiversified energy mix, where 90 percent comes from oil and petroleum products. Cyprus currently lacks connections to Europe's main energy infrastructure, mainly the electricity and natural gas grids. This inhibits diversifying into other sources of energy with lower emission intensity such as natural gas, which needs a regasification unit to import, or renewables, which require a larger grid or grid connectivity for it to significantly scale. Major energy infrastructure connectivity projects to import natural gas through a floating storage regasification (FSRU) terminal and to link Cyprus with the EU electricity grid via Greece are delayed mainly due to contractual issues. Meanwhile, RES development, while rising, continues to lag the rest of the EU.

11.   Emissions covered by the ETS have declined, but face challenges going forward. Almost half of Cyprus emissions in 2021 are covered by the EU ETS. The majority of which comes from the power sector (70 percent) with the rest from energy-intensive industry. ETS covered emissions are down 14 percent since 2005. However, going forward, these are expected to face challenges to decarbonize further, given the limited progress in diversifying the energy mix and the slow pace of

---

[2] The trend is consistent with an estimated income elasticity of demand for energy goods smaller than one as documented in Black and others (2023).

RES penetration. On the other hand, the phasing out of emission allowances under the ETS will maintain a strong market incentive to reduce emissions.

Figure 2. Emissions Drivers

Energy intensity of output has declined in line with the EU.

Energy Intensity of GDP
(Kilograms of oil equivalent per thousand Euros)

Source: Eurostat.

But emission intensity of energy is high and has not fallen.

GHG Emissions Intensity of Energy Consumption
(Tonnes of CO_2 equivalent per tonne of oil equivalent)

Sources: Eurostat and IMF staff calculations.

Cyprus's energy mix is a major hurdle to decarbonization.

Energy Available from All Sources
(Percent)

Sources: Eurostat and IMF staff calculations.

RES share of energy is rising but lags rest of EU.

Energy from Renewable Sources
(Percent of total energy)

Source: Eurostat.

12.   Decarbonization has been less pronounced in ESR sectors. Half of ESR emissions come from the transport with the rest distributed among buildings, agriculture, waste, and other sectors. Compared to ETS-covered emissions, ESR emissions saw a smaller decline between 2005-2013 and a larger rebound since then. By 2021, ESR emissions were up 3 percent relative to 2005. Implementation of policies outlined in the authorities' NECP are crucial to emission reduction in those sectors going forward.

13.   Cyprus has exceeded its emission targets in recent years. In 2013, the EC introduced annual emission allocations (AEAs) setting annual limits on national GHGs emissions under the ESR. AEAs are progressively declining over time along a path towards achieving the national targets by 2030. Initially, Cyprus emissions were lower than its allocations between 2013-2016 but have started

exceeding them since 2017 signaling a risk of deviation from the country's announced mitigation target.

14.   Current and planned measures are expected to reduce emissions going forward. Under a business-as-usual scenario (BAU)—extrapolating recent trends without accounting for the impact of recently announced or planned policies—ESR emissions are projected to continue rising. However, based on the authorities' plans and projections in the NECP, emissions are set to decline. According to a scenario incorporating the expected impact of measures already in place, a with-existing-measures (WEM) scenario, ESR emissions decline by 7 percent by 2030 compared to 2005. Whereas, under a more ambitious scenario assuming the implementation of planned policies, a with-additional-measures (WAM) scenario, ESR emissions would fall by 21 percent by 2030 compared to 2005.

15.   Further measures, along with the timely implementation of planned ones, are needed for Cyprus to meet its targets. Despite a significant projected reduction in emissions under the WAM scenario, emissions still fall short of the 32 percent pledged reduction in the revised NECP. Indeed, emissions are projected to exceed AEAs every year until 2030 and remain 13 percent above target by then. Additionally, most of the projected reduction in emissions comes from the transport sector, with little reduction in other sector emissions. This highlights the need for more measures to incentivize further emission abatement. Meanwhile, both the WEM and WAM scenario projections already imply steep declines in the emission intensity of energy relative to the BAU scenario. Realization of these scenarios' rests critically on the timely implementation of planned measures including completing the natural gas and electricity infrastructure projects, accelerating RES adoption and electric vehicles penetration, as well as promoting energy efficiency. Otherwise, Cyprus could be even further away from its targets.

Figure 3. Emissions Composition and Projections

Decarbonization has been less pronounced in ESR sectors.

Emissions Covered by ETS and Non-ETS Sectors
(2005 = 100)

Sources: Eurostat and IMF staff calculations.

Emissions are evenly split between ETS and ESR sectors.
.

Sectoral Emissions
(Millions of tonnes of CO_2 equivalent)

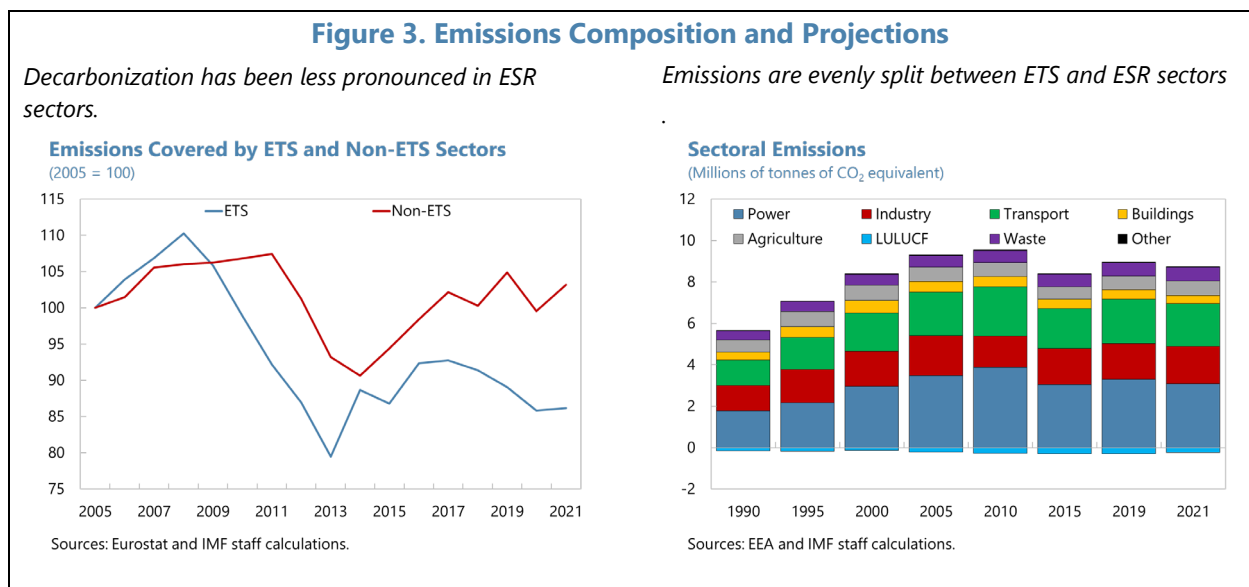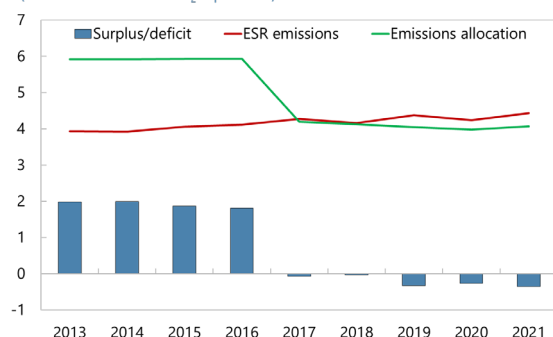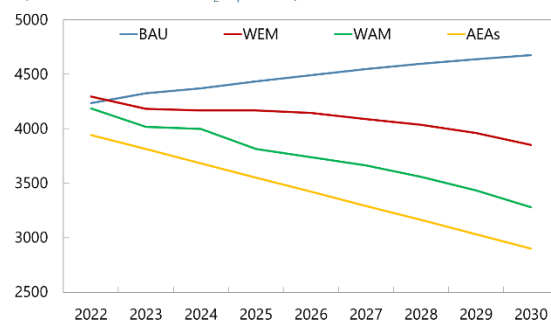Sources: EEA and IMF staff calculations.

Figure 3. Emissions Composition and Projections (concluded)

Cyprus has exceeded its emission targets in recent years.

ESR Emissions and Emissions Allocation
(Millions of tonnes of CO_2 equivalent)

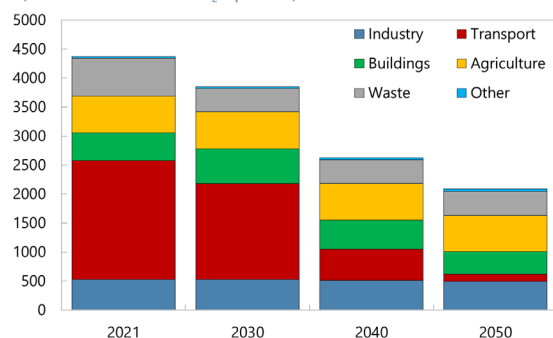Sources: Cyprus' NECP, EEA, and IMF staff calculations.

Current and planned measures are expected to reduce emissions going forward, but a gap remains.

ESR Emissions Projections 1/
(Thousands of tonnes of CO_2 equivalent)

Sources: Cyprus' NECP, CPAT, and IMF staff calculations.
1/ 13% gap between AEAs and WAM

Emissions from ESR sectors other than transport are not expected to see much decline.
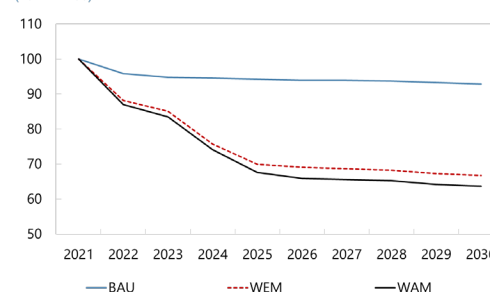
WEM Scenario: Sectoral Emissions Projections
(Thousands of tonnes of CO_2 equivalent)

Sources: EEA and IMF staff calculations.

Timely completion of energy infrastructure projects is critical to the planned reduction in emission intensity.

Emission Intensity of Energy
(2021 = 100)

Sources: Eurostat, WEO, IMF staff calculations.

C. Current Carbon Pricing and Taxation

16.   Gradually raising carbon prices is a key tool for climate mitigation. Raising the price of carbon to account for environmental externalities is the most economically efficient approach to mitigation. This is because carbon pricing incentivizes lower energy consumption, shifting towards cleaner energy, and improving energy efficiency. In addition, it incentivizes the innovation and adoption of low-carbon technologies and generates fiscal revenues, which can be used to address economic and distributional side effects (Parry, Black, and Zhunussova 2022).

17.   Carbon prices in some sectors in Cyprus lag the rest of Europe. Economy-wide Net Effective Carbon Rates (NECRs) are not too far off the EU average.[3] However, this is primarily due to the higher incidence of ETS permit prices on the electricity sector in Cyprus. In non-ETS sectors, effective carbon prices are lower than elsewhere in the EU. In the transport sector, where carbon

---

[3] NECR data are based on OECD (2021).

prices are typically the highest, Cyprus's NECR lags the EU average by about €20/tonCO2eq. The NECR gaps in the rest of the non-ETS sectors are even larger.

Figure 4. Net Effective Carbon Rates

Economy-wide Net Effective Carbon Rates (NECRs) are not far off the EU average…

… but are relatively low in some non-ETS sectors.

Fuel prices in Cyprus are low relative to the EU, mainly due to lower effective tax rates.

Effective tax rates were the lowest in the EU before the excise reduction phaseout.
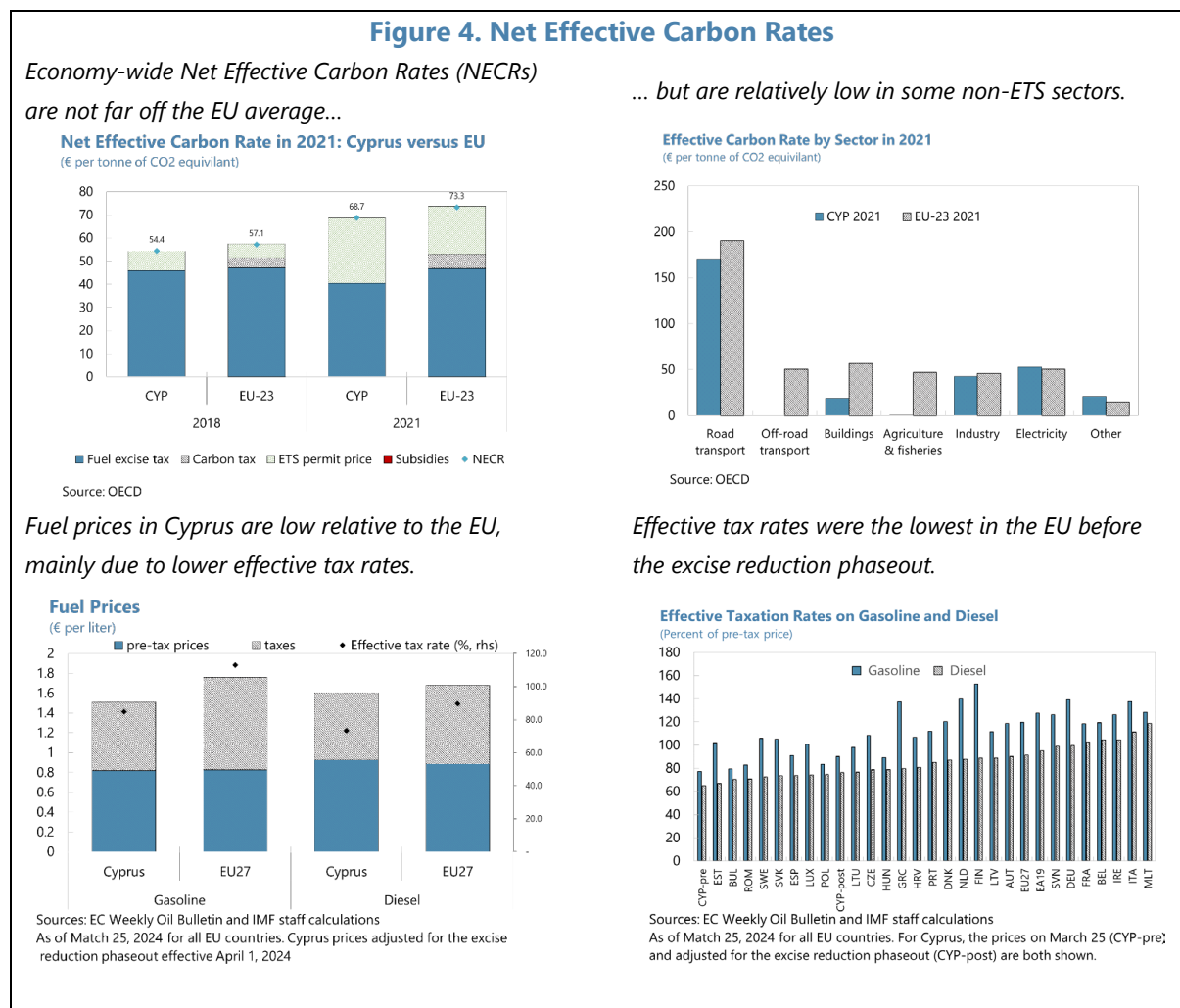
18.   Fuel taxation rates in Cyprus are low by European standards. Gasoline and diesel prices in Cyprus are among the lowest in the EU. This is primarily due to low effective taxation rates on fuel, since pre-tax prices in Cyprus are broadly similar to other European countries. Until end-March 2024, an 8 cents per liter reduction in fuel excises, implemented as part of a package of measures to ease cost of living pressures, kept gasoline and diesel excises at the minimum allowed by the European Energy Taxation Directive. In addition, diesel used in agriculture is fully exempt and partial exemptions are in place for fuels used for heating and industrial purposes. Fuel prices inclusive of excises are then subjected to the general VAT rate of 19 percent, as in other European countries (simple average VAT rate is 21 percent).

D.   The Green Tax Reform

19.   The green tax reform will raise carbon prices in the transport and non-ETS industry sectors. A carbon tax is currently envisaged to take the form of a fuel excise duty top-up. It is set to apply only to transport and non-ETS industry sector fuels with differentiated rates and schedules for

the two sectors. For transport, it is set to begin with 5 cents per liter in 2024, rising ambitiously to 25 cents per liter by 2033, roughly equivalent to a carbon tax of €20/tonCO2eq rising to about a €100 /tonCO2eq. For non-ETS industry, the excise starts at 7 cents per liter and rises to 20 cents per liter by 2029, equivalent to about €27/tonCO2eq going up to €76/tonCO2eq. Other elements of the green tax reform, namely the water and waste levies and the nightly tourism tax can have indirect emission abatement, along with other positive environmental impacts, but do not explicitly raise carbon prices in their respective sectors because they are not directly applied to fossil fuel usage or emissions. Hence, their impact is not analyzed in the rest of this paper.

Green Taxation Reform Proposed Carbon Tax Rates

	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Motor fuels										
€/liter	0.05	0.07	0.10	0.14	0.19	0.21	0.22	0.23	0.24	0.25
€/tonCO 2eq.	20.1	28.1	40.2	56.3	76.3	84.4	88.4	92.4	96.4	100.5
Non-ETS industry										
€/liter	0.07	0.11	0.14	0.17	0.19	0.20	...	...	...	...
€/tonCO 2eq.	26.7	42.0	53.4	64.9	72.5	76.3	...	...	...	...

Sources: Cypriot authorities and IMF staff calculations.

20.   The green tax reform will bring Cyprus closer to its emissions-reduction targets. Higher carbon prices operate via two channels to reduce emissions: (i) the extensive margin, which lowers the consumption of carbon and carbon-intensive goods (for example, fewer cars and less driving); and (ii) the intensive margin, which incentivizes higher energy efficiency and the shift to low-carbon technologies (for example, faster adoption of electric vehicles). The strength of these two channels influences the price elasticity of demand for emissions. For Cyprus, as for other developed countries, the elasticity is estimated to be generally lower than the global average due to an already closer proximity to the carbon-efficiency frontier, according to the empirical literature.[4] Factoring this in, the tax reform is expected to reduce emissions by an additional 55 thousand tons of CO2 or 3.8 percent of projected WAM emissions by 2030, thus closing about a third of the current gap between WAM and the 2030 target.[5]

21.   The tax will raise additional revenues but accelerate base erosion. The tax is expected to generate 0.1-0.2 percent of GDP per year in 2025, rising to 0.4 percent of GDP starting from 2028. The gross revenue increase resulting from the higher rate per unit of carbon is estimated to reach 0.5 percent of GDP. However, as higher carbon prices reduce demand for carbon-intensive goods and services, the tax base will shrink, reducing revenues both from the new tax and existing fuel excises and VAT. Thus, the erosion effect is directly proportional to the tax's abatement effectiveness. Most of the additional revenues (94 percent) is expected to arise from the tax on motor fuels due to its larger tax base and lower price elasticity.

---

[4] As documented in the CPAT manual working paper.

[5] CPAT computes impact of mitigation measures only relative to BAU due to the complexity of modelling the WEM and WAM scenarios. The deltas are then applied to WAM in an ad hoc manner to illustrate distance to target. The deltas may however be overestimated for WAM as the scenario is likely to have a smaller baseline tax base than BAU.

CYPRUS

Box 1. The IMF-WB CPAT Tool [1, 2]

The paper uses the IMF-WB CPAT tool to study the impacts of carbon taxation. CPAT was developed through collaboration between IMF and WB staff and was designed to overcome data and knowledge gaps in assessing and designing climate mitigation policies. It facilitates impact analysis of many mitigation policy instruments, including carbon taxation, emissions trading systems (ETSs), electricity and fuel taxation, emission standards and energy efficiency regulations, feebates, renewables subsidies, public investments, and others. It allows for a quantitative, evidence-based assessment of the impact of these policies on various indicators, including emissions, revenues, output, the energy system, households and industry, air pollution, and road congestion, among others.

Informed by the literature and multiple cross-country databases, CPAT provides country-tailored assessments. It draws on the available literature for parametrization of underlying variables and cross-checks parameters with a view to coming in the mid-range of other models. CPAT also collates multiple datasets to allow for country-tailored analysis. These include global datasets on GHGs, energy consumption and prices, price and income elasticities, NDCs, input-output tables and household budget surveys.

CPAT encompasses four modules, of which two are used in this paper. The mitigation module is a reduced-form macro-energy model for estimating impacts of climate mitigation policies on energy consumption, prices, GHGs, local air pollutants, revenues, GDP, and welfare. The distribution module is a cost-push microsimulation model for estimating incidence impacts from climate mitigation policy on industries and households, net of recylced revenues used for public investment, transfers, personal income tax (PIT) cuts among others. The air pollution and transport modules are reduced-form models for examining the development co-benefits of mitigation policies through better health, congestion and road accident outcomes. Given favorable air and road quality indicators in Cyprus, this paper mainly utilizes the first two modules for analysis.

_____
[1] More information on CPAT can be find in the model's manual by Black and others (2023)
[2] The CPAT model is publicly available– see https://www.imf.org/en/Topics/climate-change/CPAT

22.   There could be a transitory impact on growth. As for any fiscal measure, there will be a temporary impact on aggregate demand, which depends on the cyclical position of the economy, the overall fiscal stance, and most importantly, how the associated tax revenues are used. There will also be adjustment costs associated with the change in relative prices, as households and firms switch to cleaner fuels or technologies. While the latter are not captured by CPAT, the literature finds little evidence of a sustained negative impact from carbon taxation on growth or employment.[6] Using a range of assumptions for the size of the fiscal multiplier calibrated to global, income-group, and country-specific parameters, the direct impact is estimated to lower annual growth by 0.1-0.2 percentage points at its peak in 2029-2031, excluding any offsetting impact from revenue recycling. Current limitations of such estimates include the absence of inter-sectoral dynamics, such as the

_____
[6] For example, see Bretscher and Elise (2020) and Metcalf and James (2020).

increased demand for power due to electrification, and abstraction from the time-varying nature of price elasticities, as the impact is assumed fully realized in the following year.[7]
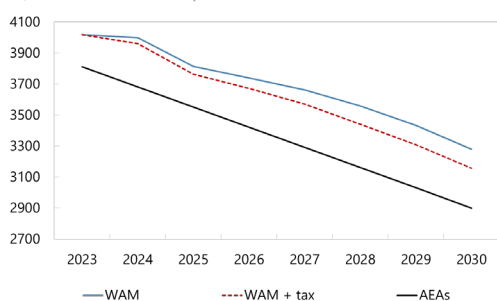
23.   The distributional impact of the tax is likely to be broadly proportional. The tax raises the prices of energy products (direct effect) and of non-energy products (indirect effect), depending on the degree of price pass-through and energy-intensity.[8] The distributional impact across income groups depends on the relative energy-intensity of consumption for each income group. Estimates suggest that the distributional impact is broadly proportional across income groups, uniformly lowering consumption by 0.4 percent. Rural households are expected to be more affected than urban households, reflecting a higher budget share of fuels.

24.   A limited share of revenue recycling is needed to mitigate the adverse direct impact on lower income groups. While the tax reduces consumption proportionally across income groups, it remains important to offset the consumption impact on lower-income groups with less income buffers to ensure a "just climate transition". The resources needed to achieve this are limited given the small incidence in absolute term. A quarter (third) of the revenues is sufficient to fully offset the impact on the four (five) lowest income deciles. These can be channeled via well-targeted social transfers. Alternatively, lower-income groups in high-income countries, like Cyprus, tend to incur personal income tax (PIT) liabilities that could be reduced. Since the PIT is progressive, reductions should take the form of absolute personal allowances or exemptions for lower income thresholds, rather than a generalized rate reduction which will disproportionately benefit upper income groups. Social transfers, if well targeted, are more able to capture the lowest income deciles more equally across population subgroups (working and non-working, as well by age and gender). On the other hand, PIT reductions are less susceptible to leakage—given the stricter income reporting requirements—and have better implications for work incentives.

Figure 5. Green Tax Plan Impact Assessment

The tax is expected to close a third of the gap...   *... generating more revenues and faster base erosion.*

Impact on Emissions
(thousand tonnes of CO2 equivilant)

Source: CPAT and IMF staff calculations.

Fiscal impact
(Percent of GDP)

Source: CPAT and IMF staff calculations.
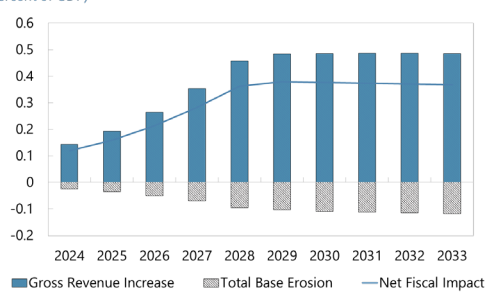
Transitory aggregate demand impact will depend on fiscal multiplier.   *Consumption impact is expected to be proportional.*

---

[7] For more details, refer to the CPAT manual.

[8] The model's default assumption is full price pass-through.

Figure 5. Green Tax Plan Impact Assessment (concluded)

Growth Impact under different fiscal multiplier assumptions
(percentage points difference to baseline)

Source: CPAT and IMF staff calculations.

Impact on Consumption by Decile (before redistribution)
(Percent Change)

Source: CPAT and IMF staff calculations.
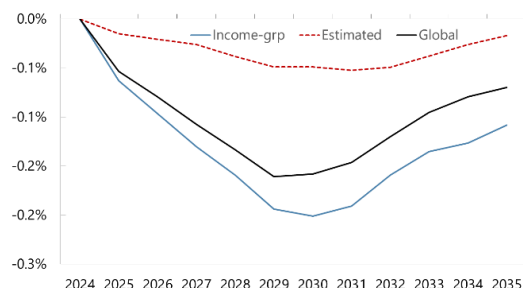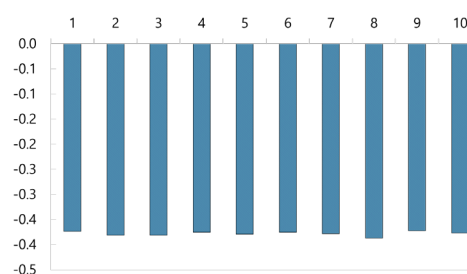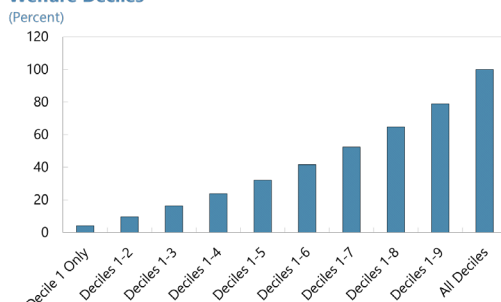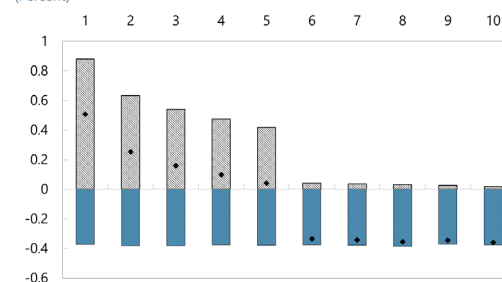
A quarter (third) can be used to offset impact on lowest four (five) income deciles...

Cumulative Share of Revenues needed to Compensate Welfare Deciles
(Percent)

Source: CPAT and IMF staff calculations.

... and can be achieved through direct cash transfers and PIT tax allowances.

Change in Consumption by Decile: (including redistribution)
(Percent)

Sources: CPAT and IMF staff calculations.

E. Recommendations and Supportive Policies

22.   Further effort is needed to meet climate targets, and non-ETS sectors other than transport should be considered. The authorities' plan is a significant step in the right direction, but it only closes a third of the gap along the path to target, so that more effort is needed. It also leaves carbon prices in most non-ETS sectors low by European standards. Applying the carbon taxation rates currently envisaged for the transport sector more widely and uniformly to all non-ETS sectors should be considered.

23.   A uniform and wide-scope carbon tax has several advantages. A wider application would raise the currently low NECRs in the rest of the non-ETS sectors, bringing them closer to EU averages. As a result, future emissions from these sectors, which are currently not projected to decline much under the WEM and WAM scenarios, can be effectively abated. Additionally, uniform application across sectors would enhance abatement efficiency while minimizing economic costs by leveling abatement incentives starting with the lower end of the marginal cost curve. Finally, the tax would ensure a smoother transition to ETS II.

25.   The augmented tax would go further in achieving mitigation targets while having similar fiscal and aggregate demand impacts. Applying a carbon tax of €20/tCO2 in 2024 that

gradually rises to a €100/tCO2 by 2033, similar to what is implied by the fuel excise top-up for motor fuels, is expected to have 1.5 times the impact of the current plan. As a result, ESR emissions would be expected to decline by an additional 5.7 percent by 2030, which closes almost half the gap between the WAM scenario and the 2030 target. Despite the wider application, the fiscal impact is roughly the same as in the currently planned design, as higher fiscal revenues (which reach 0.6 percent of GDP) are offset by faster base erosion (0.2 percent of GDP).

26.   The distributional impact becomes slightly regressive, but still manageable by directing a larger share of the revenues to redistributive measures. With a wider-scope tax, incidence becomes slightly regressive as the lowest income deciles see consumption decline by around 0.7 percent while consumption of the highest deciles falls by 0.6 percent. The higher incidence on lower income groups, compared to the narrow-scope design, requires more resources to mitigate it. With comparable fiscal revenues to the narrow-scope design, a larger share of the revenues will need to be channeled to redistributive measures. As such, a third (half) of the revenues is needed to offset the decline in consumption for the bottom four (five) deciles of the income distribution.

27.   Achieving the 2030 target *only* through carbon taxation could be challenging. Tax rates would have to be 2.5 times higher than the proposed rates, even with the wider scope. The tax will have to start at 13 cents per liter of fuel (€50/tCO2eq) in 2024 and ramp up to €0.5 per liter (€200/tCO2eq) by 2030. Such a quick escalation of carbon tax rates in a relatively short time span would have steeper economic and social implications and could face stronger political economy constraints.

28.   Although less economically efficient than carbon pricing, targeted non-price policies could have a complementary role. In absence of the price signal, these policies operate mainly on the intensive margin by encouraging better efficiency but not the extensive margin. Better carbon efficiency alone often modestly incentivizes higher consumption in what is called "the rebound effect", which further limits the effectiveness of such policies. Also, non-price policies do not raise additional revenues while still eroding the existing tax base, which adds additional fiscal pressure, particularly if redistributive measures are needed. Nevertheless, given the challenges with fully achieving the target via carbon taxation, there could be scope for non-price policies to complement carbon pricing, particularly in sectors where emissions are harder to abate such as buildings and agriculture. Feebates, such as those applied in the transport sector, could be used in other sectors to promote the use of carbon-efficient capital goods through financial rewards and penalties without dictating preferences. Regulations, like minimum recycled content quotas, ensure progress towards specific goals. Mandating a minimum share of recycled materials in products directly reduces reliance on resources, while construction waste reduction targets can promote more sustainable building practices. Subsidies can be used in buildings to incentivize the installation of rooftop solar panels, heat pumps and insulation upgrades and can be financed by the taxation of residential fuels. By strategically incorporating some of these policies in the national mitigation plan, Cyprus can rely on a multi-pronged approach to achieve its mitigation targets.

Figure 6. Wide-scope Tax Impact Assessment

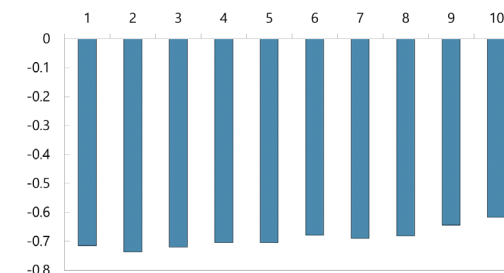*Tax reduces emissions by an additional 5.7 percent helping close roughly half the gap.*

Impact on consumption is slightly more regressive but still manageable.

Impact on Emissions
(thousand tonnes of CO2 equivilant)
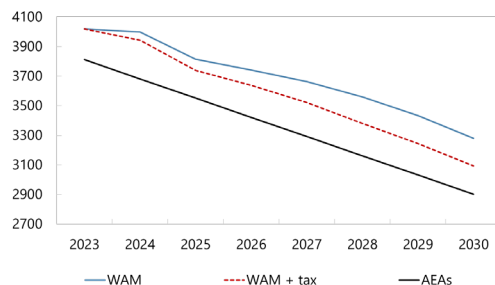
Change in Consumption by Decile
(Percent Change)

Source: CPAT and IMF staff calculations.

Sources: CPAT and IMF staff calculations.

F. Conclusion

29.   Cyprus's climate targets are ambitious, requiring decisive action. The revised targets pledging a 32 percent reduction in ESR emissions by 2030 are in line with the EU's greater climate ambition. Timely implementation of measures outlined in the NECP are critical to achieving the target. The RRP, with its climate focus, provides further support by providing financing for key investments and a framework for reforms. The green tax reform, of which carbon taxation is a main element, is a key policy of the RRP.

30.   Climate mitigation has progressed, but more is needed for Cyprus to achieve its targets. The steady rise in emissions was halted and a decoupling of emissions from growth is underway. But the undiversified energy mix remains a challenge and emissions have exceeded annual allocations under the ESR in recent years. Even accounting for current and planned policies, emissions are set to exceed the target by 13 percent by 2030. Thus, meeting the target requires timely implementation of planned measures as well as coming up with additional ones.

31.   Relatively low carbon prices suggest carbon taxation is the appropriate approach. Effective carbon rates in non-ETS sectors in Cyprus are lower than in the rest of the Europe. This reflects low fuel taxation rates in Cyprus relative to the rest of Europe.

32.   The green taxation reform is a step in the right direction with manageable economic and distributional impacts. The authorities' plan helps raise carbon prices in the transport and light industry sectors; this is expected to close about a third of the remining gap to target by 2030. While the tax will have economic and distributional side effects, fiscal policy can be used to mitigate both impacts. A third of generated fiscal revenues is sufficient to fully mitigate the impact on the lowest half of the income distribution via targeted transfers and PIT allowances.

33.   A uniform and wide-scope tax—combined with targeted sectoral policies—can go further in achieving Cyprus targets. The current plan only goes so far in reducing projected emissions and still leaves carbon prices in most non-ETS sectors still too low. Hence, consideration

should be given to widening the scope of the tax and applying it uniformly across non-ETS sectors. This would help raise overall carbon prices among non-ETS sectors, enhance abatement efficiency by leveling abatement incentives across sectors and ensure a smooth transition to the EU ETS II. Applying a carbon tax of €20/tCO2 in 2024 that gradually rises to a €100/tCO2 by 2033 to all non-ETS sectors would be expected to close almost half the remaining gap to target by 2030. With the carbon price levels needed to fully achieve the target being much higher in the near term, incorporating the use of targeted sectoral policies—like feebates or regulations—in the mitigation strategy could help close the rest of the gap.

References

Black, S., Parry, I., Mylonas, V., Vernon, N., & Zhunussova, K. (2023). "The IMF-World Bank Climate Policy Assessment Tool (CPAT): A Model to Help Countries Mitigate Climate Change". IMF Working Papers, 2023/128, International Monetary Fund, Washington DC.

Black, S., Parry, I., Zhunussova, K. (2023). "Is the Paris Agreement Working? An IMF Staff Stock take of Global Climate Action", IMF Staff Climate Note, International Monetary Fund, Washington DC.

Bretscher, L., and Elise G. (2020). "Exiting the Fossil World: The Effects of Fuel Taxation in the UK." Economics Working Paper Series, Center of Economic Research at ETH Zurich, https://doi.org/10.3929/ETHZ-B-000410578.

Metcalf, G., and James S. (2020). "Measuring the Macroeconomic Impact of Carbon Taxes." AEA Papers and Proceedings 110 (May): 101–6. https://doi.org/10.1257/pandp.20201081.

OECD (2021). "Effective Carbon Rates 2021: Pricing Carbon Emissions through Taxes and Emissions Trading", OECD Series on Carbon Pricing and Energy Taxation, OECD Publishing, Paris, https://doi.org/10.1787/0e8e24f5-en.

Parry, I., Black, S., Zhunussova, K. (2022). "Carbon Taxes or Emissions Trading Systems? Instrument Choice and Design", IMF Staff Climate Note 2022/006, International Monetary Fund, Washington DC

ADDRESSING CLIMATE CHANGE IN CYPRUS: POLICY OPTIONS AND STRATEGIES

Rising temperatures, a likely intensification of extreme weather, and sea-level rise pose macroeconomic risks that must be closely monitored. Slow-moving warming is expected to reduce GDP per capita and sea-level rise can cause permanent annual economic and welfare losses. This calls for effective and efficient adaptation integrated into development planning. In the case of sea-level rise, building coastal protection is highly cost-effective, but a balanced mix of protection and planned retreat from the coastline is likely the least-cost strategy.

A. Summary

1. **Warming, droughts, heavy-rainfall events, and sea-level rise already affect Cyprus and will likely intensify in the future**. The warming trend observed from the 1950s is expected to continue even with strong mitigation efforts globally. It is also certain that sea level rise will persist, posing a significant threat to key island infrastructure situated along the coast, including airports, ports, power and desalination plants, tourist resorts, and other critical facilities. These effects can lead to an economic cost, increased vulnerability to storm surges, and challenges in maintaining the functionality and sustainability of coastal regions.

2. **Adaptation can be very effective at reducing the cost of sea-level rise, but it requires careful planning and a balanced mix of protection and planned retreat**. IMF staff estimates and other studies indicate that SLR can cause costs up to 0.4 percent of GDP annually after 2050 without adaptation efforts. An adaptation strategy that combines protection and planned retreat of areas at risk of inundation would cut the overall cost of sea-level rise (including adaptation costs) by 70 to 90 percent to approximately 0.1 percent of annual GDP by mid-century. The cost of other adaptations can be contained by focusing on cost-effective measures and delaying adaptations that will be cost-effective only in worst case climate outcomes.

3. **To be effective and efficient, adaptation to climate change must be an integral part of development planning**. With many competing needs, the government must carefully allocate resources across all possible uses, including adaptation to climate change, while considering the distributional effects of its programs. This requires: (i) concentrating government efforts and resources in key areas; and (ii) collecting information on the effectiveness of spending across alternative programs and on how spending affects distinct groups in society (Bellon and Massetti, 2022a). The government can prioritize adaptation policies with positive externalities, by removing market imperfections and policies that hinder efficient private adaptation and by ensuring a just transition.
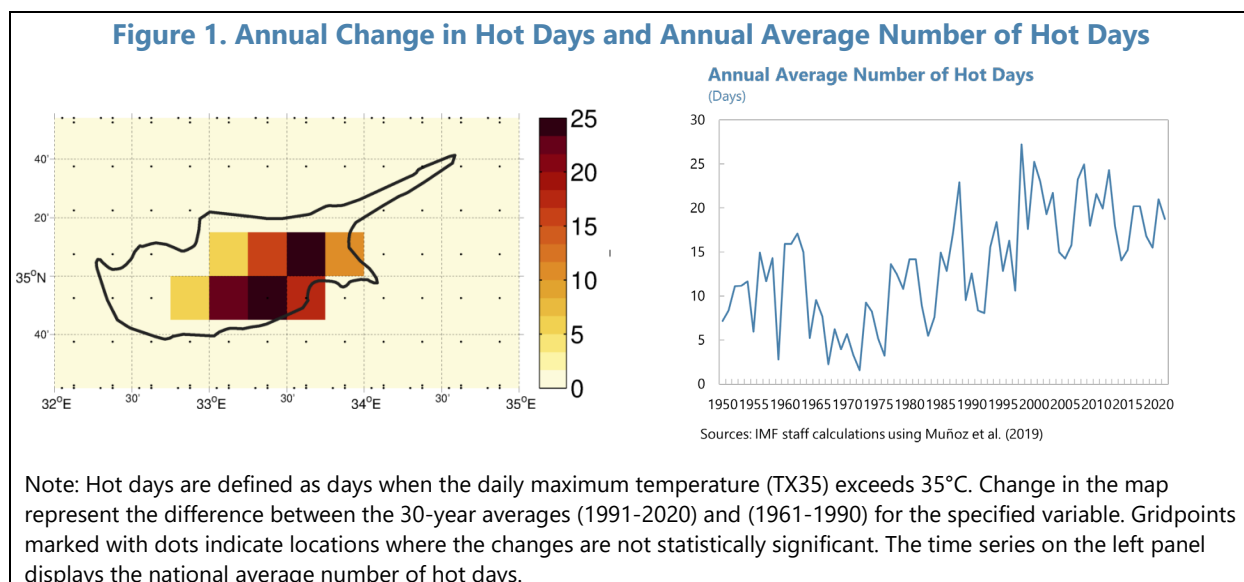
B. Overview of Climate Trends and Projections

4. **Cyprus experiences a pronounced Mediterranean climate characterized by distinct seasonal patterns in temperature, rainfall, and overall weather.** In the Eastern Mediterranean

and Middle East (EMME) region, Cyprus has a Mediterranean climate with average annual temperatures ranging from 16°C to 19°C and a mean of 17.5°C. The warmest year recorded was 2010 at 20.4°C, and annual precipitation varies, reaching a low of 200 mm in 1972-73 and a high of 800 mm in 1968-69, with a mean of 503 mm for 1961-90. The EMME is identified as a significant climate change hotspot. The region has experienced faster warming than the global average and other inhabited parts of the world areas, leading to noticeable changes in the hydrological cycle, including more severe and prolonged heatwaves, droughts, dust storms, and flash floods (Zittis et al. 2022).

5.   **Cyprus average yearly temperature in both urban and rural areas is on the rise.** Over the past decade, the majority of Cyprus, particularly the three major cities, has faced elevated temperatures, causing discomfort and significant challenges, including increased energy consumption for cooling, higher water usage, and a heightened risk of forest fires. Urban areas, impacted by urbanization[1], show a significant temperature rise, while rural areas also indicate a broader regional and global warming trend with their observed temperature increase (UNFCC for Cyprus).

6.   **Cyprus has experienced a noticeable surge in hot days.** With temperatures steadily rising, summers have become increasingly intense, characterized by prolonged periods of extreme heat and more frequent heatwaves (Figures 1 and 2). This uptick in extreme heat poses significant challenges to the island nation, in particular for agriculture, public health, and infrastructure. In Nicosia, the average annual temperature rose from 18.9°C to 20.9°C over the past 30 years, signifying a 2.0°C increase and an additional 20 days per year under extreme heat[2] (UNFCCC of Cyprus).

Figure 1. Annual Change in Hot Days and Annual Average Number of Hot Days

Sources: IMF staff calculations using Muñoz et al. (2019)

Note: Hot days are defined as days when the daily maximum temperature (TX35) exceeds 35°C. Change in the map represent the difference between the 30-year averages (1991-2020) and (1961-1990) for the specified variable. Gridpoints marked with dots indicate locations where the changes are not statistically significant. The time series on the left panel displays the national average number of hot days.

---

[1] Urbanization denotes the growth and expansion of urban areas through population influx, infrastructure development, and changes in land use, resulting in the transformation of rural regions into urban environments.
[2] Extreme heat refers to exceptionally high temperatures that exceed typical seasonal norms.

7.   With low and volatile rainfall, Cyprus is vulnerable to a small decline in precipitation. Observations highlight a notable centennial scale decline in the annual distribution of rainfall and changes in interannual variability during the 20th century. Since 1950, average total annual precipitation has remained nearly unchanged, but volatility is large. In this semi-arid Mediterranean climate, the island's water resources are vulnerable to frequent and prolonged periods of drought [3]. A reduction of total rainfall caused by climate change could worsen the already severe pressure currently experienced by the water sector.
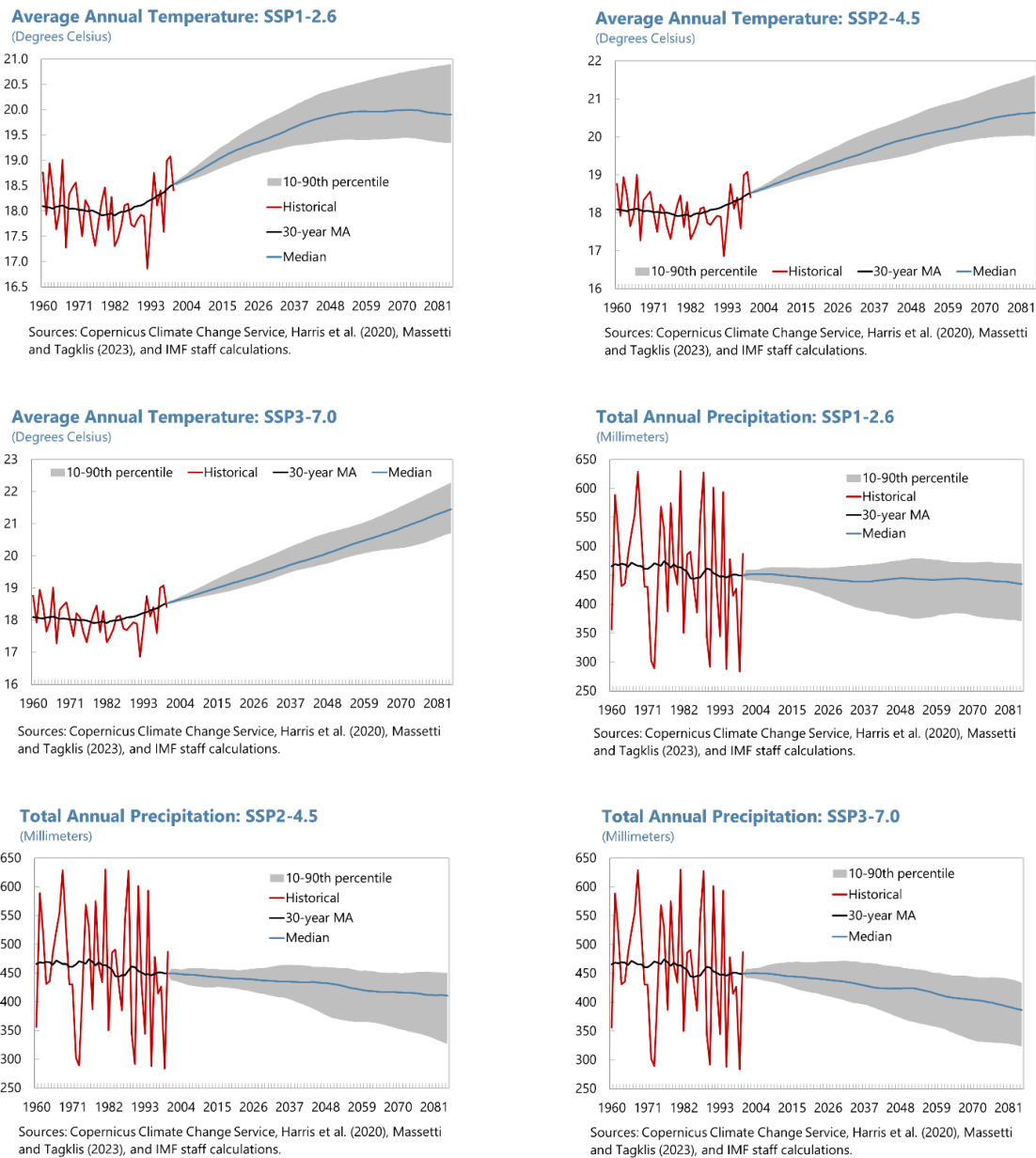
8.   Cyprus's temperatures are projected to continue to increase for decades. In the three IPCC emission scenarios[4] that cover both uncertainty in future emissions (scenario uncertainty), and uncertainty in the response of the climate, estimates suggest Cyprus will experience additional warming ranging from 1.1°C to 1.6°C by the end of the century relative to the 1995-2014 baseline, with a potential increase of up to 2.5°C in the high-emission SSP3-7.0 scenario. Cyprus is anticipated to undergo less extreme temperature increases compared to some other countries in the EMME. However, starting from baseline temperatures relatively high compared to most advanced economies, the island faces risks associated with heat stress that necessitate ongoing monitoring. The consensus among model projections is that total annual precipitations will decline using all emission scenarios, but there is large uncertainty on the magnitude on projected changes.

9.   Forest fires are a present threat but establishing robust trends in forest fires and attributing them to climate change are difficult. Forest fires in Cyprus present a threat to both ecosystems and residential areas, especially in periods with high temperatures, prolonged droughts, strong winds, and in presence of flammable vegetation (Alker, 2009). The 2021 record-breaking wildfire in Cyprus, the largest in decades, was exacerbated by a week-long heatwave with temperatures surpassing 40°C. However, establishing robust trends in forest fires and attributing them to climate change are difficult because of many concurring factors. Despite weather conditions that are favorable to forest fires becoming more common, forest fire statistics from 2000-2021 indicate a significant 50% reduction in number of fires and burnt area, potentially thanks to successful management measures implemented by the Department of Forests. This is an encouraging dynamic because weather conducive to forest fires, assessed through the Fire Weather Index (FWI) and a regional climate model (Kostopoulou et al., 2014), is expected to become more common. Both high fire risk days (5-15 days/year) and extreme fire risk days (1-10 days/year) are projected to increase in 2021-2050 compared to 1961-1990.

---

[3] Extended durations during which an area experiences significantly below-average precipitation, leading to water scarcity, agricultural stress, and environmental impacts over an extended timeframe.

[4] The SSP1-2.6 IPCC scenario keeps global temperature increase above its pre-industrial level below 2°C at the end of the century. In the SSP2-4.5 IPCC scenario emissions continue increasing in line with the continuation of present trends and stabilize at the end of the century. This scenario assumes that climate mitigation policies continue along the observed trend, but countries do not take more aggressive actions to fulfill their Paris commitments. In the SSP3-7.0 IPCC scenario. rather than intensifying climate mitigation efforts, countries start scaling back their implemented policies in a world with limited energy efficiency improvements and continued use of fossil fuels.
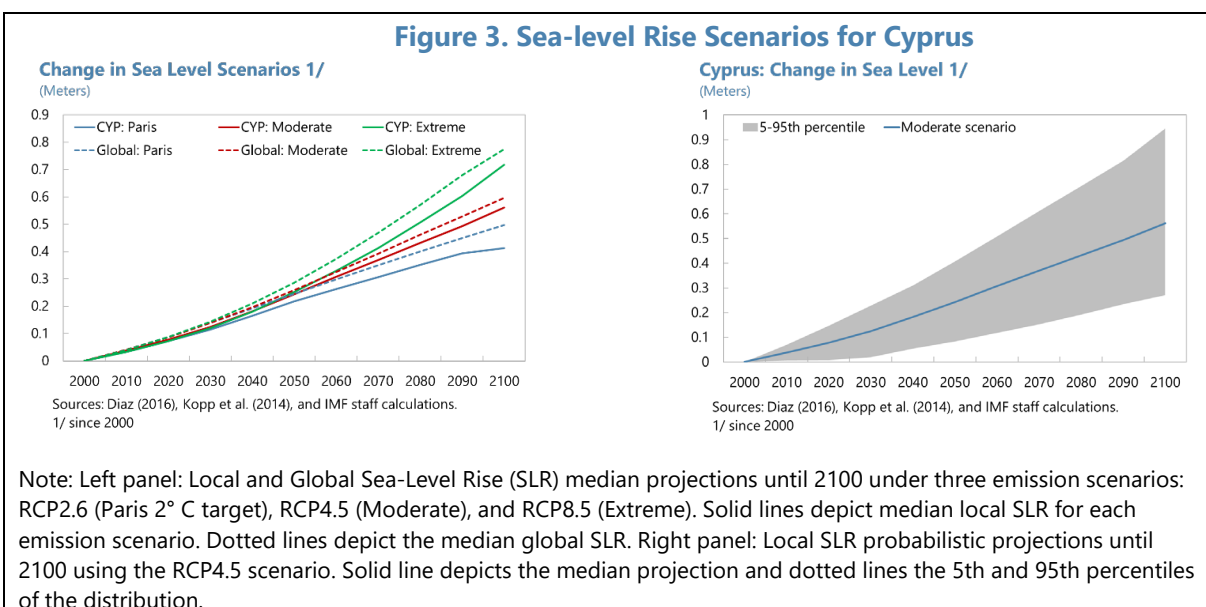
Figure 2. Average Annual Temperature and Total Annual Precipitation

Average Annual Temperature: SSP1-2.6
(Degrees Celsius)

Sources: Copernicus Climate Change Service, Harris et al. (2020), Massetti and Tagklis (2023), and IMF staff calculations.

Average Annual Temperature: SSP2-4.5
(Degrees Celsius)

Sources: Copernicus Climate Change Service, Harris et al. (2020), Massetti and Tagklis (2023), and IMF staff calculations.

Average Annual Temperature: SSP3-7.0
(Degrees Celsius)

Sources: Copernicus Climate Change Service, Harris et al. (2020), Massetti and Tagklis (2023), and IMF staff calculations.

Total Annual Precipitation: SSP1-2.6
(Millimeters)

Sources: Copernicus Climate Change Service, Harris et al. (2020), Massetti and Tagklis (2023), and IMF staff calculations.

Total Annual Precipitation: SSP2-4.5
(Millimeters)

Sources: Copernicus Climate Change Service, Harris et al. (2020), Massetti and Tagklis (2023), and IMF staff calculations.

Total Annual Precipitation: SSP3-7.0
(Millimeters)

Sources: Copernicus Climate Change Service, Harris et al. (2020), Massetti and Tagklis (2023), and IMF staff calculations.

Note: SSP1-2.6 is in line with the Paris goal to keep global mean temperature increase below 2 °C with respect to pre-industrial times. SSP2-4.5 represents continuation of present trends. SSP3-7.0 is a high emission scenario.

10.   It is certain that the sea level will continue to rise and that Cyprus faces an increased risk of coastal erosion, loss of land, and potential damage to infrastructure and communities. Figure 3 displays median projections of sea-level rise (SLR) using different emission scenarios from a leading study (Kopp et al. 2014). In Cyprus, the sea level is projected to increase by 0.4 to 0.7 m in 2090-2099 with respect to 2000-2009 (approximately 0.3 to 0.6 m above the present level)

depending on the emission scenario.[5] SLR is projected to be lower than the global mean, a result confirmed by other projections (Slangen et al., 2014). While there is no doubt that the sea level will continue to increase for ongoing decades (achieving the Paris goals slows down but does not stop SLR at least until the end of the century), projections are uncertain due to uncertain emission trajectories and uncertain response of the sea level to different warming rates. The right panel of Figure 3 illustrates the scientific uncertainty about sea-level rise for a moderate emission trajectory (RCP 4.5): the median projection is that sea level will rise by 0.6 m with respect to 2000-2009, but SLR in the range 0.30 to 0.95 m cannot be excluded.

Figure 3. Sea-level Rise Scenarios for Cyprus

Change in Sea Level Scenarios 1/
(Meters)

Cyprus: Change in Sea Level 1/
(Meters)

Sources: Diaz (2016), Kopp et al. (2014), and IMF staff calculations.
1/ since 2000

Note: Left panel: Local and Global Sea-Level Rise (SLR) median projections until 2100 under three emission scenarios: RCP2.6 (Paris 2° C target), RCP4.5 (Moderate), and RCP8.5 (Extreme). Solid lines depict median local SLR for each emission scenario. Dotted lines depict the median global SLR. Right panel: Local SLR probabilistic projections until 2100 using the RCP4.5 scenario. Solid line depicts the median projection and dotted lines the 5th and 95th percentiles of the distribution.

C. Macro-Economic Risks

Slow-Moving Warming and Extreme Weather

11.   IMF staff analysis and a review of the literature identify moderate risks from climate change in Cyprus with large uncertainties. Slow-moving warming and sea-level rise are expected to be a drag on the economy, especially without adaptation measures. There is no evidence of significant macro-economic impacts from weather disasters both using historical data and projections, but substantial uncertainty remains about future changes in climate and their potential economic impacts. Large negative shocks from abrupt climatic and environmental changes cannot be excluded but they are impossible to quantify.

12.   Several lines of evidence indicate that the cumulative effect of slow-moving warming can reduce real per capita GDP by 3 to 5 percent by 2100 in a fast-warming planet. This range is calculated using results from two econometric models and estimates from a European research project (Box 1). This warming scenario accounts for larger-than-expected warming rates

---

[5] This is in line with sea-level rise projections in the 2022 8th National Communication and 5th Biennial report under the UNFCCC of Cyprus, and Table 1 in Deliverable 4.4b "Report on storm surge levels for different scenarios and different time horizon" of the SOCLIMPACT EU-funded project.

(90th percentile of the temperature range projected by climate models using the high-emission SSP3-7.0 scenario), but effects of changes in extreme weather and sea-level rise are not included.

13.   Climatological disasters do not currently pose severe macro-economic risks, and risks are not projected to increase substantially, but large uncertainties remain. Heat waves present the main present risks for the population and are expected to become more intense (Ministry of Agriculture, Rural Development and Environment 2023; Chapter 2, Section 6.3.4.4). Heat waves in 1998, 2000, and 2022 caused an estimated total number of 158 deaths and in 2000 high temperatures have been associated with drought and forest fires (Figure 4), but the overall economic impact has been limited and cannot be easily assessed. Projected climate change impacts on infrastructure are limited (Ministry of Agriculture, Rural Development and Environment 2023, Chapter 2, Section 6.3.2). Flash floods pose risks, but they are linked more to land use changes than to changes in rainfall intensity. Advanced econometric analysis that relies on machine learning methods and very granular weather data does not reveal significant macro-economic shocks from a multitude of weather extremes in the present (Box 1). Projections by the Network for Greening the Financial System (NGFS) do not indicate significant changes in annual expected damages from river floods, and changes in other hazards are projected to be small.[6] There are however large uncertainties in how physical hazards will evolve due to the inability of climate models to predict with accuracy local events over short time scales, like storms. There is also uncertainty in potential economic, social, and environmental impacts of these events. The expected continuation and possible intensification of dry conditions represents a downside risk with potentially large yet unknown impacts in an already water-scarce country. This suggests monitoring risks and preparing contingency plans also for low-probability events.

Figure 4. Count of Climatological Natural Disasters According to the EM-DAT Database

Cyprus: Climatological Natural Disasters
(Number of climatological natural disasters)

Source: EM-DAT, CRED.

---
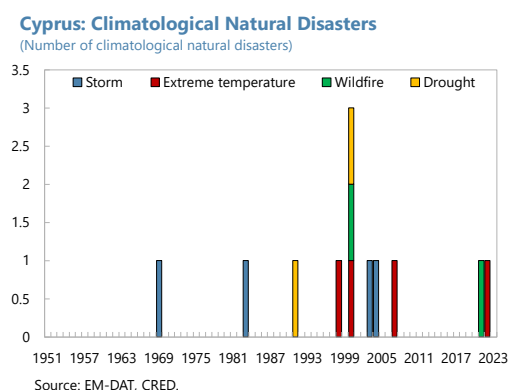
[6] Source: CLIMADA, Climate Impact Explorer of Climate Analytics for the NGFS. Cyprus page, consulted on 3/7/2024.

Box 1. Macro-Economic Impacts of Gradual Warming

Kahn et al. (2021)

IMF staff has used estimates of the impact of warming on GDP growth from Kahn et al. (2021) to estimate the long-term effect of gradual warming. Kahn et al. (2021) connect "deviations" of temperature and precipitation (that is, weather) from their long-term moving-average historical norms (that is, climate) to growth in real GDP per capita. This theoretical model is then estimated by using data from 174 countries over 1960–2014.

Per-capita real output growth is affected by persistent changes in the temperature trend. An acceleration of the warming trend relative to historical values, has a negative impact on GDP forecasts while a deceleration of the trend has a positive impact. Abiding by the Paris Agreement goals (SSP1-2.6), thereby slowing the warming trend with respect to historical values, raises projected GDP above reference. The SSP2-4.5 scenario is close to continuation of present trends and has generally small negative or positive impacts. The SSP3-7.0 scenario represents an acceleration of the present trend and generates negative impacts. The 90th percentile of the SSP3-7.0 scenario provides a worst-case outcome and generates the largest negative impacts.

Adaptation is implicitly included in the model, without accounting for its cost. After 30 years countries are assumed to have fully adapted to the observed trend. If the trend persists along the lines observed during the previous 30 years, there is no impact on projected GDP.

Network for Greening the Financial System (NGFS)

The NGFS estimates losses of GDP per capita using empirical work by Kalkhul and Wenz (2020). Using RCP8.5 warming rates, which are similar to warming rates in the SSP3-7.0 High scenario, the NGFS estimates a loss of GDP per capita equal to 7 percent in 2100.[1] This loss is measured against a hypothetical scenario of no climate change while losses in Kahn et al. (2021) are measured against a scenario in which temperature continues growing following historical trends. Comparing the elasticity of GDP losses to changes in warming rates reveals that estimates based on Kahn et al. (2021) are approximately 2 percentage points lower than those based on Kalkhul and Wenz (2020), which is a minor difference considering large uncertainties in very long-run projections.

Macroeconomic Impact of Gradual Warming
(Percent change of GDP)

Source: Centorrino, Massetti, and Tagklis (2023).
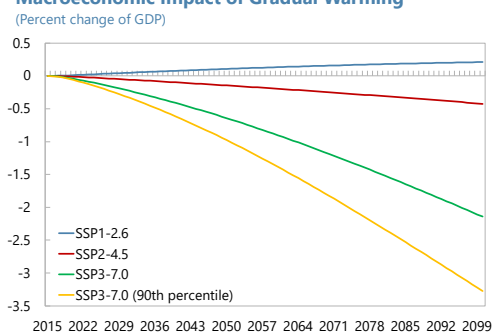
SOCLIMPACT

SOCLIMPACT is a research project funded by the European Union that assessed climate change impacts and their socio-economic implications for European islands, including Cyprus (https://soclimpact.net). Estimated impacts of temperature rise, fire risk, beach erosion, and sea-level rise on tourism, energy demand, and port infrastructure are aggregated at the macro-level using the computable general equilibrium model GEM-ER-ISL. Results show that with the RCP 8.5 scenario (analogous to the SSP3-7.0 High scenario) impacts are in the 3 to 5 percent range (SOCLIMPACT, 2020; pp. 64-81). Another CGE, GINFORS, reports results only up to 2050 that are within the 3 to 5 percent range but could become larger in the second half of the century.

Akyapi, Bellon, and Massetti (2022)

Akyapi, Bellon, and Massetti (2022) (ABM) use hundreds of billions of high-resolution and high-frequency weather observations to build hundreds of weather variables that can potentially affect macroeconomic variables.

Box 1. Macro-economic Impacts of Gradual Warming (concluded)

To select a limited and meaningful set of variables ABM use machine learning algorithms and then standard regression methods to estimate the macroeconomic effect of the selected weather variables. A global analysis that relies on a panel of all countries finds that severe droughts and days with maximum temperature above 35°C significantly reduce GDP per capita growth and have complex fiscal implications. An increase in the frequency of days with moderate temperatures between 9 and 12 C significantly increases GDP per capita. These variables do not have a significant effect on GDP growth of Cyprus. As other variables may be important in Cyprus, variable-selection algorithms are re-applied using only Cyprus macroeconomic time series but just one or two weather variables are selected as being relevant, and they do not have a statistically significant effect on GDP growth, government expenditure, or government revenue. This suggests that the economy of Cyprus is resilient to weather shocks and although weather extremes can cause damages, discomfort, and loss of life, their effect is not clearly distinguishable at macroeconomic level.

Source: CLIMADA, Climate Impact Explorer of Climate Analytics for the NGFS.

[1] Cyprus page, consulted on 3/7/2024.

Sea-Level Rise

14.   Cyprus cannot control global sea-level, but it can manage how it affects the country by adapting. Even if efforts to keep global temperature increase in line with the Paris Agreement goals, the sea level will continue increasing throughout this century and beyond (Figure 2). Mitigation policy is key to limiting the speed of sea-level rise (SLR) during this century and the overall extent of SLR in future centuries, but the only practical way to limit impacts of SLR this century is by adapting.

15.   IMF staff estimates, and other studies indicate that SLR can cause damages between 0.1 and 0.4 percent of GDP annually after 2050 assuming a moderate emission scenario, with large uncertainties. IMF staff estimates using the CIAM model are on the lower end of this range and are shown in detail in Box 2. The EU-funded project PESETA IV estimates costs on the higher end of this range due to larger storm-surge projections (Vousdoukas et al. 2020, Table 2). With an extreme projection of SLR, PESETA IV estimates costs of up to 4.9 percent of GDP in 2100, a very large potential loss (Vousdoukas et al. 2020, Table 2). These differences reflect large uncertainties in estimating SLR impacts.

16.   Adaptation can greatly contain SLR losses at modest cost, but the optimal mix of protection and planned retreat remains uncertain and deserves more granular analysis. The CIAM model indicates that protection is highly effective at reducing losses from permanent inundation of coastal land, but planned retreat from the coastline is the cheapest option (Box 2). The EU project PESETA IV is more pessimistic on the cost of SLR without adaptation, but more optimistic on the cost and effectiveness of coastal protections. A modest investment of €7-10 million per year (approximately 0.04 percent of GDP) can reduce SLR costs by approximately 90 percent (Vousdoukas et al. 2020, Table 5). SOCLIMPACT, another EU-funded study, finds that upgrading sea-ports to keep them operable with SLR costs €2.2 million per year in 2046-2065 and €4.3 million per year in 2081-2100 when using an extreme emission scenario (SOCLIMPACT Deliverable Report - D5.6). While the optimal mix of protection and planned retreat remains to be determined case-by-case using high-resolution analysis—like the ongoing COASTANCE and MAREMED projects (Ministry of Agriculture, Rural Development and Environment, 2023, p. 220), there is universal agreement that

a forward-looking adaptation strategy can be highly effective at reducing SLR impacts with relatively low costs.

17.   Cost-benefit analysis (CBA) can be used to select efficient coastal adaptation strategies. CBA can be challenging, but even preliminary and incomplete assessments are useful to identify trade-offs and the most attractive policy options using a transparent and systematic approach (Bellon and Massetti, 2022a). Best practices can be drawn from coastal protection analysis and policies in other countries, for instance in the Netherlands, where there is a long-standing tradition of using CBA and cost-effectiveness analysis for flood risk management and water governance. This tradition started in 1954 with the pioneering CBA of the Delta Works by Tinbergen (1954) and continues to this day (CPB, 2017).

Box 2. Estimating the Cost of Sea-Level Rise and Adaptation

The analysis of sea-level rise impacts, and adaptation options is done using complex models that rely on necessary simplifications but provide important insights. While there is uncertainty on the exact extent and cost of damages from SLR and on the cost of protection measures, there is consensus in this literature that long-term planning of adaptation can be highly effective at containing physical impacts and costs of SLR. For example, the large EU-funded research project PESETA IV finds that adaptation can reduce SLR damages in the EU by approximately 90 percent (Vousdoukas et al. 2020, Table 6) with an average benefit/cost ratio from 75 to 110 depending on the emission scenario. Model simulations fully agree that adaptation can be highly effective but may differ on the optimal mix of adaptation measures – e.g., hard protection, nature-based solutions, planned retreat – because they use different data, use different climate scenarios, or work under different normative criteria. There is also consensus that the transformations needed to adapt to SLR, while technologically feasible and economically sound, are complex and require strong governance (Hinkel et al., 2018).

IMF staff uses the state-of-the-art Coastal Impact and Adaptation Model (CIAM) to estimate the cost of sea-level rise under alternative adaptation strategies. CIAM is a global model used to estimate the economic cost and benefits of adaptation to sea-level rise (Diaz, 2016). The global coastline is divided into more than 12,000 segments of different length grouped by country. Cyprus's coastline comprises 7 segments that are 44 Km long on average, ranging from 1 Km to 111 Km. This analysis does not cover areas of Cyprus not under the effective control of the Republic of Cyprus and assumes no change in status quo. Each segment is further divided into areas of different elevation. For each segment, the model has data on capital, population, and wetland coverage at different elevations. By using projections of local sea-level rise from Kopp et al. (2014), it is possible to estimate the areas that will be inundated and the amount of capital and population at risk. Storms cause periodic inundations on top of sea-level rise. The model does not consider increased risks from river floods. See Annex I for additional information.

The model calculates the cost of SLR—protection costs plus residual losses—under alternative adaptation options:

- The ***no-adaptation*** scenario assumes that population does not move until the sea inundates the area and then relocates to areas with higher elevation. Society keeps building and maintaining capital until inundation causes irreversible losses and capital is abandoned. The cost of sea-level rise is calculated as Yohe et al. (1995), because as SLR progresses, coastal proximity rents will shift from land that is inundated to adjacent land. Population density and development opportunity costs are assumed to be capitalized in agricultural land values. The disutility cost of reactive migration is monetized and contributes to the cost of sea-level rise.

Box 2. Estimating the Cost of Sea-Level Rise and Adaptation (concluded)

- At the opposite, a ***protection*** scenario assumes that society invests in cost-effective seawalls and other barriers to avoid inundation from sea-level rise, but storms can still periodically inundate protected areas if protection is not sufficiently strong. Capital and land are not lost, the population does not move, but storms periodically cause capital and human losses. The cost of SLR is equal to the cost of protection plus the expected value of the cost of storms.

- Another adaptation option relies on ***planned retreat*** from areas that will be subject to inundation. The goal of retreat is to keep using coastal areas without building new capital and by letting the existing capital depreciate. For example, a coastal road is used until it needs major retrofitting investment. Then, a new coastal road is built in-land on higher grounds. This strategy accepts that land and some residual value of capital will be lost, but it avoids coastal protection costs. The population gradually moves to higher grounds before areas are inundated. The cost of sea-level rise is equal to the sum of the residual cost of capital, the value of inundated land, and the disutility cost of migration.

- ***Other adaptation strategies*** consider different degrees of protection against storms and different speeds of retreat. For each coastal segment, the model calculates the net present value of each adaptation strategy by summing discounted costs and benefits (avoided damages) over time. Loss of life is monetized using the Value of Statistical Life and loss of wetland is monetized using estimates of willingness to pay for biodiversity preservation.

- The cost of building and maintaining seawalls, and other key parameters are from the literature. Storm surge costs are incremental with respect to a baseline scenario in which storms occur with lower sea-level. The optimal strategy is the strategy with the largest NPV and can differ across coastal segments within the same country. For example, protection is usually the optimal strategy in areas with large existing capital and high population density while retreat is optimal in areas with low capital and population density.

Despite many uncertainties and some necessary simplifying assumptions, the model provides a useful framework to systematically think about costs and benefits of alternative adaptation options to sea-level rise. More granular coastal modeling and more accurate mapping of assets can provide a more precise assessment of costs and benefits, but the key insights developed with a baseline version provide a useful starting point to deal with a complex, multidecadal challenge.

Cost of Sea Level Rise, 2020-2099
(Percent of GDP)
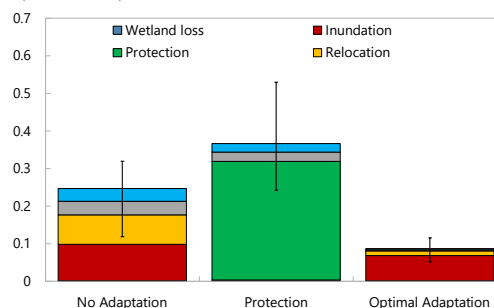
Sources: Diaz (2016), Kopp et al. (2014), and IMF staff calculations.

Note: Using a state-of-the-art model of sea-level rise costs and adaptation, IMF staff estimates the cost of local sea-level in Cyprus corresponding to the RCP 4.5 scenario in Kopp et al (2014) assuming three policy scenarios: (i) no planned adaptation – society reacts to sea-level rise by relocating, no protection is built and capital losses are large; (ii) Protection – society plans construction of cost-effective protection against sea-level rise by anticipating its effects without relocating people or assets; and (iii) Optimal Adaptation – society plans a mix of protection and retreat anticipating sea-level-rise, by comparing costs and benefits of each option and choosing the strategy with the largest net present value. Cumulative undiscounted costs divided by cumulative undiscounted GDP. Wiskers on top of each bar indicate the range of total cost using the 5th and 95th percentile of the probabilistic distribution of sea-level rise. Due to the highly non-linear nature of coastal impacts, adaptation costs, and effectiveness of adaptation measures, ranges are not always symmetric around total costs.

D. Adaptation

18.   Cyprus adopted a comprehensive National Adaptation Strategy in 2017 that identifies key intervention areas and specific adaptation actions. Starting from a vulnerability assessment, the Adaptation Strategy lists many adaptation measures in eleven priority sectors, among which water resources, coastline risks, biodiversity, and tourism have received priority. The implementation of several adaptation measures has already started (Ministry of Agriculture, Rural Development and Environment, 2023, p. 218).

19.   The IMF has developed principles that can help select and prioritize adaptation actions amid other investment needs in an economic environment with growing public finance constraints. It is useful to think about adaptation in holistic terms, as a strategy to maximize long-term economic and social development that needs to become integral part of economic planning (Bellon and Massetti, 2022a,b; Aligishiev, Bellon, and Massetti, 2022). As such, investment and public resources diverted to adaptation need to be assessed against other potential uses (Bellon and Massetti, 2022a). It is then useful to identify priority areas for government intervention and tools to select and prioritize adaptation actions and investments.

20.   With many competing needs, government efforts and spending would be most effective if concentrated on: (i) adaptation policies that are public goods; (ii) reforms that promote efficient private adaptation; and (iii) strengthening of social programs. Individuals and firms have strong incentives to adapt because many adaptation benefits tend to be local and private (Box 2). However, there is a clear role for government intervention when adaptation has large externalities, as in the case of coastal protection or strengthening of public infrastructure. As market inefficiencies and policy failures may limit private adaptation or create distortions, another key role for the government is to continue promoting reforms that foster the efficient use of all resources and ensure competitive access to markets (Bellon and Massetti, 2022a). Strengthening of social programs is likely needed to offset adverse effects of climate change and of adaptation policy itself on the most vulnerable part of the population. This will allow maximizing the impact of public spending and stimulate private adaptation, while ensuring a just transition and public support.

21.   Despite limitations, cost-benefit analysis (CBA) can play an important role in helping decision makers to consistently collect, aggregate, and compare information on public adaptation projects. As exemplified by the analysis of sea-level rise in Section C, adaptation investment and policy will typically have trade-offs that would be better assessed by comparing social costs and benefits using a systematic approach. What to do, when, how, and at what cost ultimately rely on ethical choices that should reflect the preferences of society. However, cost-benefit analysis (CBA), complemented by analysis and correction of distributional impacts, can help decision makers maximize overall social welfare by avoiding wasting scarce resources. To achieve this goal, it is essential that CBA is applied to adaptation as well as to all other development programs in a consistent manner (Bellon and Massetti, 2022a). Limitations of CBA (e.g., lack of data, uncertainty in long-term projections, sensitivity to choice of discount rates) need to be carefully assessed. Cost-effectiveness analysis—the choice of the least-cost strategy to attain a desired level of protection—can be an alternative to CBA if outcomes are considered too uncertain by policy makers Bellon and Massetti (2022a).

22.   According to standard CBA rules, only programs with NPV greater than zero should be financed. Competing programs should be ranked using CBA and only programs with the highest ranking should be financed. In the example of adaptation to sea-level rise, retreat is the strategy with the highest net present value. Similar comparisons can be developed when comparing alternative options to strengthen public infrastructure. By consistently investing in projects with the highest returns, governments can maximize the impact of their spending. This means, for example, saving the largest number of lives, providing high-quality public education, ensuring that social safety nets are well-funded, and boosting long-term growth (Bellon and Massetti, 2022a).

23.   Compensation might be more efficient than investments in adaptation to achieve society's equity preferences. Full protection of all assets and populations at risks may be very expensive in some cases, as shown in the case of adaptation to sea-level rise. As a result, adaptation projects may have a negative NPV (for example, protection against sea-level rise is more expensive than no action according to CIAM's estimates). While there can be specific reasons to warrant investment even with a negative NPV, the authorities should consider if it is possible to support the affected population in alternative ways. This can take the form of relocation subsidies or other forms of supports with less stringent conditionality (Bellon and Massetti, 2022a). For example, compensation could be used to redistribute the cost of sea-level rise from coastal landowners to society if planned retreat is cheaper than full protection.

Box 3. Market Reforms to Boost Adaptation in the Private Sector

In imperfectly competitive markets, adaptation is inefficient, and governments should intervene mirroring standard prescriptions for public policy from economic theory.

- Some market imperfections pertain to the nature of the adaptation goods themselves. For example, markets invest sub-optimally in adaptations with large positive externalities and public goods, such as information about climate change, emergency preparedness plans, seawalls, basic research in new materials, and technologies to cope with higher temperature.

- In many instances, resilience depends on networks, such as a system of dikes, a water network, or a transportation network. As adaptation in each part of a network has impacts on the rest of the network that may not be captured, private adaptation will tend to be underprovided. Government coordination may be needed to internalize all the benefits for society.

- The extent of needed cooperation for adaptation projects depends on the extent of the externality that is addressed by the project. Building a more resilient storm water drainage system may only require cooperation at the city level. If risks from sea-level rise are localized, each locality may invest in its own system of protection. The central government can provide adaptations with local effects, but that would be equivalent to a transfer of wealth between regions when projects are financed from national resources. As risks grow in scope and complexity, cooperation might be needed at the national or even the international level, for example to manage floods in transnational rivers. In general, the optimal distribution of responsibilities across levels of government also depends on the existing allocation of responsibilities.

- Other market imperfections affect the broad functioning of the economy and make adaptation to climate change inefficient. For example, a poor business environment and inefficient credit markets hamper opportunities for farmers to invest in new capital to grow crops that are more suitable to the new climate.

Box 3. Market Reforms to Boost Adaptation in the Private Sector (concluded)

- Moral hazard may cause insufficient investment in adaptation if consumers, firms, and local government expect central governments to provide relief. To avoid moral hazard, governments can implement regulations that minimize risk taking. Examples include zoning that prohibits construction in flood zones, building codes, mandatory evacuations, and mandatory insurance.

- The government may also consider correcting market distortions resulting from their own policies (policy failure). For example, subsidies to inputs can lead to inefficient use. Of particular concern is subsidized water use, which may worsen water scarcity problems due to climate change. Barriers to international trade also prevent efficient climate-change-induced reallocation of capital, land use, and other resources to maximize their productivity. The government may consider removing these distortions as part of a comprehensive plan to improve the efficiency of the economy, while taking into consideration the distributional implications of these measures.

Source: Bellon and Massetti (2022a)

References

Aligishiev, Zamid, Matthieu Bellon, and Emanuele Massetti. 2022. "Macro-Fiscal Implications of Adaptation to Climate Change," IMF Staff Climate Notes, No. 2022/002.

Akyapi, B., M. Bellon and E. Massetti. 2022. "Estimating Macro-Fiscal Effects of Climate Shocks From Billions of Geospatial Weather Observations." IMF Working Papers 2022.156, International Monetary Fund, Washington, DC.

Alker A., 2009. Impact of Global Warming on Infectious Disease in Cyprus. Cyprus Climate Change Assessment Papers – 2009 Compiled by the Master's Degree Candidates of the Cyprus International Institute in the "Cyprus Climate Workshop", as part of the Institute's "Global Climate Update" course, June 2009

Bellon, Matthieu, and Emanuele Massetti, 2022a. "Economic Principles for Integrating Adaptation to Climate Change into Fiscal Policy." IMF Staff Climate Note 2022/001, International Monetary Fund, Washington, DC.

Bellon, Matthieu, and Emanuele Massetti, 2022b. "Planning and Mainstreaming Adaptation to Climate Change in Fiscal Policy." IMF Staff Climate Note 2022/003, International Monetary Fund, Washington, DC.

Bosello, Francesco, Robert J. Nicholls, Julie Richards, Roberto Roson, and Richard SJ Tol. "Economic impacts of climate change in Europe: sea-level rise." *Climatic change* 112 (2012): 63-81.

Diaz, Delavane B. "Estimating global damages from sea level rise with the Coastal Impact and Adaptation Model (CIAM)." Climatic Change 137, no. 1 (2016): 143-156.

Delforge, D. et al.: EM-DAT: The Emergency Events Database, Preprint, https://doi.org/10.21203/rs.3.rs-3807553/v1, 2023.

Gonguet, Fabien, Claude Wendling, Ozlem Aydin, and Bryn Battersby. 2021. "Climate-Sensitive Management of Public Finances—"Green PFM." IMF Staff Climate Note 2021/002, International Monetary Fund, Washington, DC.

Harris, Ian, Timothy J. Osborn, Phil Jones, and David Lister, 2020. "Version 4 of the CRU TS monthly high-resolution gridded multivariate climate dataset." Scientific data 7(1): 109.

Hinkel, Jochen, Jeroen CJH Aerts, Sally Brown, Jose A. Jiménez, Daniel Lincke, Robert J. Nicholls, Paolo Scussolini, Agustín Sanchez-Arcilla, Athanasios Vafeidis, and Kwasi Appeaning Addo. "The ability of societies to adapt to twenty-first-century sea-level rise." Nature Climate Change 8, no. 7 (2018): 570-578.

Kahn, Matthew E., Kamiar Mohaddes, Ryan NC Ng, M. Hashem Pesaran, Mehdi Raissi, and Jui-Chung Yang. "Long-term macroeconomic effects of climate change: A cross-country analysis." Energy Economics 104 (2021): 105624.

Kostopoulou, E., C. Giannakopoulos, M. Hatzaki, A. Karali, P. Hadjinicolaou, J. Lelieveld and M.A. Lange (2014) Spatial and temporal patterns of recent and future climat extremes in the Eastern Mediterranean and Middle East region. Nat. Hazards Earth Syst. Sci. 14, 1565-1577

Kopp, Robert E., Frederik J. Simons, Jerry X. Mitrovica, Adam C. Maloof, and Michael Oppenheimer. "Probabilistic assessment of sea level during the last interglacial stage" Nature 462, no. 7275 (2009): 863-867.

Lincke, Daniel, and Jochen Hinkel. "Economically robust protection against 21st century sea-level rise." Global environmental change 51 (2018): 67-73.

Massetti, Emanuele, and Filippos Tagklis, 2023. "Reference Guide on the FADCP Climate Dataset: Temperature and Precipitation." Unpublished manuscript, forthcoming, International Monetary Fund, Washington, DC.

Muñoz Sabater, J. (2019): ERA5-Land hourly data from 1950 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/cds.e2161bac

Ozlem, Aydin, Bryn Battersby, Fabien Gonguet, Claude Wendling, Jacques Charaoui, Murray Petrie, and Suphachol Suphachalasai (2022). How to Make the Management of Public Finances Climate-Sensitive—"Green PFM" Fiscal Affairs Department, How to Note, Washington, DC: International Monetary Fund, 2022.

Slangen, A.B.A., Carson, M., Katsman, C.A. et al. Projecting twenty-first century regional sea-level changes. Climatic Change 124, 317–332 (2014).

Tinbergen, J., 1954, De economische balans van het Deltaplan, bijlage bij het rapport van de Deltacommissie.

Vousdoukas M., Mentaschi L., Mongelli I., Ciscar J-C, Hinkel J.(a), Ward P.(b), Gosling S.(c) and Feyen L., Adapting to rising coastal flood risk in the EU under climate change, EUR 29969 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-12990-5, doi:10.2760/456870, JRC118512

Vousdoukas, M.I., Mentaschi, L., Voukouvalas, E. et al. (2018). Climatic and socioeconomic controls of future coastal flood risk in Europe. Nature Clim Change 8, 776–780. https://doi.org/10.1038/s41558-018-0260-4

Zittis, G., Almazroui, M., Alpert, P., Ciais, P., Cramer, W., Dahdal, Y., et al. (2022). Climate change and weather extremes in the Eastern Mediterranean and Middle East. Reviews of Geophysics, 60, e2021RG000762. https://doi.org/10.1029/2021RG000762

2022 8th National Communication and 5th Biennial Report under the UNFCCC of Cyprus.

Annex I. The Coastal Impacts and Adaptation Model

1.   The Coastal Impact and Adaptation Model (CIAM) is a global optimization model for cost-benefit analysis of adaptation to sea-level rise (SLR) (Diaz, 2016). The model starts from coastal characteristics on more than 12,000 coastal segments covering the entire global coastline from the Dynamic Integrated Vulnerability Assessment model (DIVA), a tool to assess the biophysical and socioeconomic impacts of SLR. The DIVA tool estimates the SLR impacts by considering coastal erosion, coastal flooding, wetland change and saltwater intrusion (DIVA Modeling Framework). For each coastal segment, CIAM develops economic, population, and SLR scenarios. The SLR scenarios are from Kopp et al (2014). On top of SLR, the model considers the expected value of storm surges to include rare but potentially high-impact events.

2.   Using data on costs of alternative coastal protections, land values, value of assets along the coastline, the value of statistical life, willingness to pay for preservation of coastal ecosystems, and assumptions on the social cost of relocation. CIAM determines costs and benefits of alternative adaptation strategies (including no adaptation) for each coastal segment. The efficient (optimal) coastal protection strategy has the largest net present value of among all strategies considered by the model. Protection can be full (excluding any inundation also under extreme storm surges), partial (accepting some storm costs) or minimal (with capital and population progressively moving away from the coastline).

3.   The model can be used to develop insights on different costs from SLR (Table A1) and different protection strategies (Table A2) in each coastal segment or at higher levels of aggregation.

4.   Several impacts have been omitted from the analysis, which could lead to underestimate the cost of no protection, but protection and retreat decisions are fixed for many decades, which could lead to overestimate adaptation costs. Omitted impacts include saltwater intrusion, ocean acidification, erosion, coastal tourism, loss of recreation. The model assumes that protection and retreat decisions are made at the beginning of the planning horizon and remain constant for several decades. A smoother response to SLR would reduce adaptation costs.

5.   The general equilibrium effects of all impacts are also omitted, with uncertain effects on cost estimates. Several studies have used global General Equilibrium Models to calculate the macro-economic cost of sea-level rise impacts and adaptation costs (e.g., Bosello et al. 2012). In some countries secondary effects lead to an increase of costs estimated by simulation models like CIAM. In other countries, global market effects (redistribution of tourism flows for example) lead to positive secondary effects.

Table AI.1 Cyprus: Cost Specification in the CIAM

Category	Explanation of the Costs	Measurement of Cost[1]
Protection Cost	Constructing and maintaining protection (generalized as sea walls) to shield the land behind the sea walls from the SLR-caused inundation.	A function of the coastline length, the height of the sea walls, and the value of the land occupied by the sea walls.
Retreat Cost	Relocation of population and assets from the affected areas, including the forced emigration in case of no planned adaptation and the planned retreat.	The cost of relocating population and mobile capital in the incremental area of retreat, as well as the cost of demolishing the immobile capital.
Inundation Cost	The loss of land and assets due to the SLR-caused inundation. In case of no planned retreat the full value of capital assets is lost. In case of planned retreat only the depreciated level of capital assets is lost.	The cost is based on the extent of land endowment lost and the associated value of the land and the capital stock
Wetland Loss Cost	The loss of wetland due to the inability to migrate inland naturally, constrained by the rate of SLR and the lack of space.	The wetland losses take two forms, (1) the total service value of the wetland occupied by the sea walls; (2) the service value of the wetland lost related to the rate of SLR.
Storm Cost	The damage to population and assets due to floods caused by storm surge.	The expected damage associated with the risk of the storm surge. The likelihood of storm surge follows the generalized extreme value distribution by using the local surge frequency data from the DIVA tool, while the total land affected by the extreme surge depends on the elevation exposed to a given flood water height.

[1] Measurement of the cost per period. The model optimizes the adaptation strategies over 50 years.

Table AI.2 Cyprus: Adaptation Strategies in the CIAM	
Category	**Explanation**
No Planned Adaptation	As sea-level rises inundation and floods due to storm surges damage capital and force people to relocate. All asset values in inundated land are lost. Forced retreat is more costly than planned retreat.
Protection	A mix of coastal protection barriers which include dikes, floodgates, coastal dunes, etc... Protection is assumed to be 100 percent reliable. Protection can be sized to sea-level only, or to also avoid 10-year, 100-year, 1,000-year, or 10,000-year storm surge levels. Country-level costs in the Optimal Protection scenario presented in Box 1 are calculated by summing costs for the least-cost protection grade at segment level. Protection is planned over a 50-year time horizon in which the social planner has perfect foresight. After this period protection is re-optimized for the following 50 years.
Planned Retreat	Coastal land is intentionally abandoned. Population moves and capital is rebuilt behind the retreat perimeter. Immobile capital is efficiently depreciated in preparation of planned retreat. The population incurs relocation costs. The retreat perimeter can be chosen to ensure protection against sea-level rise alone, or to also avoid 10-year, 100-year, 1,000-year, or 10,000-year storm surge levels.
Both protection and planned retreat are planned until 2050 and from 2050 to 2100. Over these limited time horizons there is perfect foresight and sea-level is known with certainty. There is no edging against uncertain sea-level rise.	