MALTA FINANCIAL SERVICES AUTHORITY

Climate Transition Risk:
Quantifying the Impact of Carbon Taxation on the Investment Portfolio of Financial Institutions

by

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Abstract

This study aims to contribute to the growing strand of literature on climate transition risk by estimating the short-term implications of a carbon taxation on the investment portfolios of the Maltese financial system. Adopting a static balance sheet assumption, this research study quantifies the financial losses arising on the investment portfolio (excluding government bond) following the possible implementation of a carbon tax. These losses are assessed from different perspectives, with results presented on a financial instrument level and also at industry and entity levels. It is observed that losses driven by climate transition through the simulations would overall be limited. The investment portfolio of the Maltese financial sector appears to be resilient to the introduction of a carbon tax, albeit a few institutions could experience noteworthy losses.

JEL: E60, G10, G20, O44, Q54

Keywords: Climate Change, Transition Risk, Carbon Tax, Financial Institutions, Investment Portfolios, Maltese Financial Sector

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Introduction

This is the first research study carried out by the Financial Stability function within the MFSA to estimate the effects of climate risk on the stability of the Maltese financial system. The study looks into the short-term effects of climate risk, focusing specifically on the transition risk element, which could arise from the investments held in the portfolio of banks, insurance undertakings and investment funds licenced in Malta. Concerns related to the impact of climate change on the global economy and financial stability have exponentially increased over the past decade. Since the Paris Agreement[1] (2015), where governments gave their commitment to limit the cumulative rise in global average temperature to +1.5°C compared to pre-industrial levels, an increasing amount of resources have been devoted to investigate the challenges implied in pursuing this goal.

There is a general consensus that climate change risks are split into two main forms: physical and transition risks (NGFS, 2018). Physical risk refers to the impact arising on business activities following (i) extreme weather events and (ii) increase in global temperature due to the greenhouse gas emissions (GHG). Transition risk refers to the repercussions of the measures adopted to reduce GHG on the financial system. Such measures include technological shocks which may contribute in facilitating the decline in renewable energy production costs, and also policy and regulatory shocks among which the sudden introduction of a global carbon tax and/or changes in financial actors' climate sentiment (NGFS, 2020).

The implementation of timely and adequate policy measures is crucial to mitigate effectively climate change risks. Moreover, these measures, if implemented, could avoid having to resort to sudden and forceful interventions at a later stage, which would inevitably harm the financial system through a disruptive shift to low-carbon assets. In fact, an unanticipated introduction of climate change-oriented policies could impede market participants from performing smooth adjustments within their investment and business strategies to accommodate the changes without experiencing major losses. A disruptive policy or technology shock may trigger volatility in financial markets, possibly leading to a fire sale of carbon-intensive assets. The losses incurred in this "disorderly" scenario might be amplified in a highly interconnected system.

Central banks and supervisory authorities have been increasingly engaged in analysing climate risks from a financial stability perspective. This contributed to the development of tools that attempt to measure the financial implications of climate change, such as sensitivity analysis or stress testing. However, major obstacles are challenging these efforts as assessing climate risk is far more complex than evaluating traditional financial risks.

A key challenge that researchers are facing when assessing climate risk from a financial services perspective relates to the lack of reliable and consistent granular data on climate indicators. Specifically, the ECB Financial Stability Review (2019) highlights caveats in relation to environmental scores provided to companies, having misaligned criteria across rating providers such as Bloomberg, MSCI and Refinitiv. The ECB emphasises the urgency for having a harmonised definition of green activities. In light of this, the EU's "*Sustainable Finance Taxonomy*" and the "*Regulation on environmental, social and governance disclosures of*

[1] Paris Agreement : The first legally binding global agreement on climate change was adopted in December 2015, in occasion of the Paris climate conference (COP21)

financial institutions" are expected to play crucial roles in obtaining standardised definitions of green investment, providing also precise metrics to assess environmentally sustainable economic activities.

Another obstacle relates to the underlying uncertainty characterising climate change, especially when it comes to evaluating scenario narratives over the long-term horizon. It is essential to look at the possible vulnerabilities arising on the financial system due to climate risk over the long-term. Nevertheless, this requires complex forecasting models, which incorporate elements of uncertainty, non-linearity, and fat-tailed distributions (BIS, 2020). In a bid to alleviate such a challenge, the Network for Greening the Financial System (NGFS) has collaborated with the academic community to develop a set of standardised scenarios to analyse the long-term macro-financial implications of climate change.[2]

Assessing climate risk over a short-term horizon also has its benefits when used to identify the financial institutions' resilience and vulnerabilities to climate risks. Although the short-term approach does not lead to the same comprehensive conclusions achievable under more sophisticated and long-term analyses, it provides an indication as to the level of urgency and prioritisation in terms of policy intervention.

This study builds onto climate transition risk literature by introducing an innovative framework that allows financial loss evaluations for Maltese financial institutions that could arise on their investment portfolios following the introduction of a hypothetical carbon tax. Adopting a static balance sheet assumption, financial losses are estimated on three asset components, namely equities, corporate bonds and Collective Investment Schemes (CIS). Different methodologies are utilised for each asset component, namely the Enterprise Value to EBITDA is applied to assess the impact of the carbon tax on the equities' valuation, the Merton model for the bonds, and a regression model for the CIS.

Overall, vulnerabilities due to transition risk emanating from investment portfolios are found to be limited, with estimated losses on most financial institutions being negligible. Only a few entities experience noteworthy losses as consequence of the disruptive policy intervention.

Literature

Literature on climate transition risk has grown at a fast pace over the past few years, particularly from Central banks and International Institutions. One of the first and most eminent studies on transition risk is Battiston et al. (2017). This paper develops a network model for financial institutions, incorporating both direct and indirect exposures to the "climate-policy relevant sectors" (CPRS) for listed firms in the European Union and the United States. The authors find that policies aiming to pursue the Paris Agreement goals will impact the balance sheet of firms exposed to CPRS. Additionally, contagion will also play a role in disseminating transition risk across financial institutions, giving rise to indirect exposures such as through security holdings of firms directly affected by climate policy intervention. One of the main contributions of Battiston's analysis consists of providing an innovative classification of policy relevant sectors by building upon the standard NACE Rev2[3] and the

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[2] NGFS Climate Scenarios available at: https://www.ngfs.net/en/publications/ngfs-climate-scenarios.
[3] NACE Rev2 refers to the statistical classification of economic activities in the European Community. See Table A.1.

European Commission report 2014/746/EU. The author quantifies the real economy exposure to the climate-policy relevant sector by mapping information on securities held by shareholders, extracted from the Bureau Van Dijk Orbis database, with his reclassification. Moreover, by relying on a network model, the author reconstructs EU and US financial actors' portfolio holdings of securities issued by firms directly exposed to CPRS. In this way, the study allows a quantification of both the direct and indirect exposures to climate-sensitive activities.

In Battiston et al. (2021), the aforementioned framework was extended to assess how the interplay between climate transition risk and market conditions (e.g. recovery rate and asset price volatility) affect financial stability. The study relies on supervisory data obtained by Banco de Mèxico to describe the impact of transition risk, through a set of policy shocks, on both banks and investment funds, via a mechanism of common asset contagion. Combining the Climate Stress-test framework (Battiston et al., 2017) with the Network Valuation of Financial Assets framework (Barucca et al., 2020), the authors quantify the direct and indirect effects (up to fourth round losses) of a disorderly transition to a low-carbon economy. Three main policy implications arise from this exercise: (i) delayed policy intervention increases transition related losses; (ii) early albeit disorderly transition (under weak market conditions) allows more ambitious climate targets than a delayed transition having less ambitious goals; (iii) losses from a disorderly transition (under weak market conditions) stand higher when having less stringent climate targets.

Vermuelen (2018) conducts an additional study to shed light on the implications of climate risk for the financial system. It estimates financial stability energy transaction risks under a set of severe scenarios by constructing a comprehensive stress test framework for the Dutch financial sector. The model accounts for the role of climate policy and the availability of alternative technologies. Interestingly, the approach adopted in this study allows the quantification of financial entities' exposure to carbon intensive sectors by considering CO2 emissions in the production of an industry's final product. The information is extracted from input-output tables and allow to construct the so called "transaction vulnerability factors". The stress-testing framework was applied to over 80 Dutch financial institutions' assets (for a total of EUR 2.3 trillion). The results indicate that a disorderly energy transition would create significant stress on Dutch financial institutions, with Dutch banks experiencing drops in their CET1 ratio of up to 4%.

Climate transition risk is considered to pose major threats for investment funds, which are more risk taking than banks and insurance undertakings. Amazalla (2021) provides a comprehensive analysis of how investment funds' portfolio will be affected under a climate risk scenario. To gain insight into the carbon footprint of investment funds residing in the EU, the author maps the portfolios of 23,965 EU-domiciled funds with information on the corresponding issuer firms, including their CO2 equivalent emissions. These figures are then used to identify which firms fall under the "green" and "brown" categories, with "green funds" referring to portfolios predominant in assets within sustainable activities and "brown funds" as those highly exposed to polluting firms. Through a network analysis, it was observed that funds which hold a large number of polluting assets tend to present more 'portfolio similarities', thus hold assets issued by the same firms, than that observed from green funds. In fact, the author finds that brown funds often display higher concentration of investment to the same carbon intensive firms. This suggests that funds with a more polluting portfolio would be more vulnerable to climate transition risk, and given their high interconnectedness, they could turn out to be systemic.

In 2020, the EBA launched a pilot sensitivity exercise on climate risk to estimate banks' sensitivity to climate adverse scenarios[4]. The exercise was run on a sample of 29 banks, utilising data on non-SME corporate exposures towards EU countries. Different classification approaches utilising the EU taxonomy for sustainable activities were applied, allowing the estimation of banks' exposure to climate risk. The sensitivity analysis consisted of simulating shocks to risk parameters to estimate the expected losses for credit institutions. The results provided insights on the potential impact of physical and transition climate risks on banks' balance sheets.

The ECB has also been a significant contributor to the literature on climate risk, whereby it conducted a pioneering economy-wide climate stress. De Guindos (2021) presents a framework to estimate euro area's banks vulnerability to transition and physical risk under a variety of climate scenarios by assessing the resilience of their counterparty to climate phenomena. Approximately four million companies worldwide and 2,000 banks were used for this study, to which climate risk scores were assigned. ECB's projections extend to 30 years allowing the assessment of long-run trade-offs characterising climate policies. Combining the data with the aggregate trajectories for transition and physical risk, provided by the scenarios developed by the Network for Greening the Financial System (NGFS), the stress test allowed the estimations of the costs arising on companies hit by climate catastrophes together with their probability of default. This gives insight on the trade-off between transitioning towards a greener economy as against that of an inaction stance. The preliminary results suggest that climate change gives rise to larger threats of a systemic nature, for banks having investments concentrated in polluting economic sectors. The study provides an indication that there is an urgent need for enacting climate policies to prevent the materialisation of extreme weather events which will induce firms to incur remarkable costs, which might lead to a higher probability of default.

Other studies conducted by central banks approach climate risk thematic through their engagement with the financial industry. Bank of England (BOE) tested the resilience of large institutions to climate physical and transition risk within the BOE's 2021 Biannual Exploratory Scenario (BES)[5], which provides a comprehensive assessment of the UK financial system's vulnerability to transition and physical risk. It also provides an insight on climate risk challenges and implications arising on business models and the financial sector as a whole. Finally, it supports participating firms in addressing data gaps by developing tools to tackle climate risk and adopt long-term strategic approaches.

Banque de France (2020) implemented an analytical framework to estimate the implications on the financial sector arising from policies aiming to enhance the transition to carbon neutrality. This study applies both orderly and disorderly transition scenarios, driven by productivity shocks and sudden increase in carbon prices. The baseline scenario follows the NGFS narrative of an orderly transition. There are two disorderly scenarios displaying delayed transition: the first relates to the sudden and disruptive implementation of climate policies starting from 2030; the second depicts a sudden transition starting from 2025 with lower technological innovations and decreasing productivity. The exercise relies on a wide set of modelling frameworks.

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[4] EBA (2021). *Mapping climate risk: Main findings from the EU-wide pilot exercise.* Paris.
[5] Bank of England's Financial Policy Committee and Financial Policy (2019). The 2021 biennial exploratory. London: Bank of England.

The results show that a disorderly transition toward a low-carbon economy could trigger severe risks for financial stability, as the transition would significantly harm the economic sectors mostly impacted by the climate policies. The climate scenarios were also applied on a sample of banks and insurance companies.[6] An overall moderate exposure to climate risk was observed, although uncertainties on the speed and impact of climate change, as well as the assumptions applied on scenarios and methodological limitation, render the assessment merely indicative.

Methodology

The modelling framework presented in this paper aims to assess the Maltese financial sector's resilience to climate transition risk through the estimation of the impact of a carbon tax on financial institutions' portfolio holdings. For the purpose of this analysis a static balance sheet assumption has been adopted, thus not allowing for readjustments within the investment portfolios.

The study makes use of granular security-by-security asset data (SbSA) for both banks and non-bank financial institutions. Government bonds were excluded from the framework given the limited research available in understanding the effects of a carbon tax on sovereign security prices (on the one hand there might be a negative economic impact on the companies due to the higher costs, on the other hand there would be more fiscal income which could be redirected towards more sustainable investments, benefitting both the national GDP and the whole society). The granular data on CO2 submitted by the issuer of instruments in which the Maltese financial institutions are investing, allow the estimation of companies' carbon footprints. However, for instances where companies' CO2 emissions are not available, proxies based on peer sectoral CO2 levels are utilised. Additional data includes the tons of CO2 per million of revenue, with sectoral peers-based approximation for companies that do not disclose such information[7].

Using income statements and balance sheets figures available on Refinitiv, the impact of a carbon tax τ on asset prices is estimated. With a tax rate τ for each ton of CO2 emitted, a certain company i with revenue Rev_i and an estimated emission of tons of CO2 per million of revenue (in US Dollar) equal to $ton\$_i$ would need to pay a carbon tax CT_i equal to:

$$CT_i = \tau \times Rev_i \times ton\$_i \tag{1}$$

Different methodologies are used for each asset class - equities, bonds, and Collective Investment Schemes (CIS). These different methodologies adapt some already existing and well-established valuation models to a climate relevant context. In particular, the Enterprise Value to EBITDA is applied to assess the impact of the carbon tax on the equities' valuation, the Merton model for the bonds, and a regression model for the CIS.

Impact of a Carbon Tax on Equity Prices

Firms' EBITDA (earnings before interest, taxes, depreciation and amortization) is utilised to assess the carbon tax impact on the equity value. The multiple enterprise value (EV) to EBITDA

[6] 'A first assessment of financial risks stemming from climate change: The main results of the 2020 climate pilot exercise', https://acpr.banque-france.fr/en/analysis-and-synthesis-no-122-main-results-2020-climate-pilot-exercise

[7] Additional details on the peer-based information used are presented in Table A.2.

ratio, commonly used to identify whether a company is under or over-valued, is used to simulate how the company's market capitalisation would be ultimately impacted. Since the carbon tax is treated like a production cost, the EV/EBITDA ratio would increase, given that the EBITDA value would fall in view of the additional costs arising from the carbon tax.

Assuming that the EV/EBITDA would retreat to the original level, as a consequence, the EV would need to decrease. In a simplified framework, the EV is a function of (i) the market capitalisation, (ii) the value of the debt and (iii) the value of the cash held by the company. Assuming that debt is taken at book value (the use of debt market value would be more appropriate than debt book value, although generally the market value of the whole company is not available), the market capitalisation is the only component which could possibly change. This is a result of the fact that market capitalization is based on expectations, and it is not a book value. Finally, the percentage change in market capitalisation is used to obtain the new share price. More specifically, if company i has an EBITDA equal to $EBITDA_i$, a market value equal to $MarkValue_i$, debt equal to $Debt_i$ and cash equal to $Cash_i$, the EV to EBITDA can be computed as:

$$Original\ EV\ /EBITDA\ Ratio = \frac{MarkValue_i + Debt_i - Cash_i}{EBITDA_i} \tag{2}$$

If a new carbon tax τ is introduced such that company i will need to pay an amount equal to CT_i (as defined in Eq.1), the EV/EBITDA Ratio would become:

$$New\ EV\ /EBITDA\ Ratio = \frac{MarkValue_i + Debt_i - Cash_i}{EBITDA_i - CT_i} \tag{3}$$

Assuming that the original EV/EBITDA ratio need to be restored to the original rate, this would mean that the new market value of the company would become equal to:

$$New\ MarkValue_i = Original\ EV/EBITDA\ Ratio \times (EBITDA_i - CT_i) - Debt_i + Cash_i \tag{4}$$

Therefore, the share price P_i of company i will decrease by a percentage equal to:

$$\%\Delta P_i = \frac{New\ MarkValue_i}{MarkValue_i} - 1 \tag{5}$$

This analysis could be alternatively performed using other ratios such as the price to earnings (PE) ratio. Nevertheless, the EV to EBITDA ratio is deemed to be better given that companies may report a negative PE ratio and moreover the EV to EBITDA ratio, in this application, takes into consideration the balance sheet structure of the companies (more leveraged companies are more affected by a carbon tax).

Impact of a Carbon Tax on Bond Prices

The Merton model is applied within the framework to estimate the impact of a carbon tax on corporate bonds. Data on bonds' initial risk premium and issuers' financial statements are used to estimate the implied volatility of issuers' assets.

The following assumptions are applied: 1) profitability margins (earnings over revenue) of companies will remain constant; 2) return on assets (RoA) will remain constant; 3) since both the profitability margins and RoA are assumed constant, then revenue over assets is also assumed to be constant; and 4) companies do not undertake additional investments towards lowering emission levels.

From the assumptions it follows that tons of CO2 per million of revenue remain constant over time. Therefore, when a carbon tax is introduced, the amount to be paid by a company is linearly proportional both to the revenue and the assets value. In this way, it is possible to treat the tax as a sort of dividend, representing a fixed percentage of assets which the company pays out every year.

To compute the risk premium of a certain bond B issued by company i when a dividend is paid, the standard Merton Model needs to be transformed through the put-call parity:

$$d_1 = \left(\sigma_i * \sqrt{t}\right)^{-1} * \left(log\left(\frac{Assets_i}{Liabilities_i}\right) + (r + 0.5 * \sigma_i{}^2) * t\right)$$

$$d_2 = d_1 - \sigma_i * \sqrt{t} \tag{6}$$

$$RiskPremium_i = (-t)^{-1} \, * \log\left(1 - \mathrm{N}(-\mathrm{d}_2) + \frac{Assets_i}{Liabilities_i} \cdot e^{r \cdot t} \cdot N(-d_1)\right)$$

Where $Assets_i$ and $Liabilities_i$ are the book value of the assets and liabilities of issuer i, σ_i is the volatility of the assets, t is the number of years to maturity and r is the risk-free rate. Defining $\%T_i$ as the amount of carbon tax paid by issuer i as a percentage of the asset value, equation 6 becomes:

$$d_1 = \left(\sigma_i * \sqrt{t}\right)^{-1} * \left(log\left(\frac{Assets_i}{Liabilities_i}\right) + (r \, - \, \%T_i + 0.5 * \sigma_i{}^2) * t\right)$$

$$d_2 = d_1 - \sigma_i * \sqrt{t} \tag{7}$$

$$RiskPremium_{i,CarbTax} = (-t)^{-1} \, * \log\left(1 - \mathrm{N}(-\mathrm{d}_2) + \frac{Assets_i}{Liabilities_i} \cdot e^{(r - \%T_i) \cdot t} \cdot N(-d_1)\right)$$

If bond B has a duration equal to D, the price of the bond P_B following the introduction of the carbon tax τ will change by a percentage equal to:

$$\%\Delta P_B = -D \, \times \left(RiskPremium_{i,CarbTax} - \, RiskPremium_i\right) \tag{8}$$

Even though this model is based on very strong assumption, and although the Merton Model is intended for zero coupon bonds, this methodology is a good starting point to gauge insight on the effect of carbon tax on the value of corporate bonds.

Impact of a Carbon Tax on Collective Investment Schemes (CIS) Prices

The most effective way of computing the impact of a carbon tax on CIS prices is by estimating the effect of such tax on each CIS component. However, in doing this, two main challenges emerge: 1) it was not possible to retrieve the whole set of CIS components, 2) the number of components would be growing exponentially when a CIS is investing in other CIS (as in turn also the components of the target CIS would have to be retrieved). In the light of such impediments, an alternative estimation is adopted. The impact of a carbon tax on CIS prices is initially estimated on eight macro-financial indices, covering equity markets, investment grade corporate bonds and high-yield corporate bonds, using the methodologies applied for bonds and equities. Then the performance of the CIS is regressed on the performance of the indices, using principal component regression (to overcome multicollinearity among indices).

Finally, the parameters of the regression are used to estimate the change in price for each CIS following the introduction of the carbon tax.

Further details on the methodology are provided hereunder:

Step 1: the eight macro-financial indices are split into four covering equities and four covering bonds. Namely the equity indices are S&P500, FTSE 100, STOXX Europe 600 and Nikkei 225; while the bond indices are Bloomberg Barclays USD Liquid Investment Grade Corporate Index, Bloomberg Barclays Euro Corporate Bond, Bloomberg Barclays US High Yield and Markit iBoxx EUR Liquid High Yield Index. The effect of the carbon tax is computed using the EV/EBITDA Ratio and the Merton Model. Finally, these shocks are aggregated at index level, using the weight of each component in its respective index. The vector of the shocks suffered by each index is identified with $\boldsymbol{\delta}$.

Step 2: The weekly performances of the indices are obtained. Calling as $\mathbf{x}_t$ the vector containing the log returns of the indices at time t, we apply the mapping of $\boldsymbol{G}$ to find the normalized log returns $\tilde{\boldsymbol{x}}_t$, such that:

$$\tilde{\boldsymbol{x}}_t = \boldsymbol{G}(\mathbf{x}_t); \qquad with\ \tilde{x}_{i,t} \sim \mathrm{N}(0,1)$$

Then we compute the covariance matrix of $\tilde{\boldsymbol{x}}$, $\boldsymbol{\Sigma}_{\tilde{\mathbf{x}}}$. We define the diagonal matrix $\boldsymbol{\Lambda}_{\tilde{\mathbf{x}}} = \mathrm{diag}[\lambda_1, \dots, \lambda_8]$, where λ_j represents the j^{th} eigenvalue of $\boldsymbol{\Sigma}_{\tilde{\mathbf{x}}}$, with $\lambda_1 \geq \lambda_2 \geq \ldots \geq \lambda_8$, and the 8×8 matrix $\boldsymbol{V}$, of which columns represent the eigenvectors of $\boldsymbol{\Sigma}_{\tilde{\mathbf{x}}}$, with the j^{th} column of $\boldsymbol{V}$ being the eigenvector corresponding to the j^{th} greater eigenvalue. The first n principal components of $\tilde{\boldsymbol{x}}_t$ are computed by multiplying $\tilde{\boldsymbol{x}}_t$ by the first n columns of $\boldsymbol{V}$, denoted by $\boldsymbol{V_n}$. Letting $\widetilde{\mathbf{X}} = (\tilde{\boldsymbol{x}}_1, \ldots, \tilde{\boldsymbol{x}}_T)^{\boldsymbol{T}}$, then the matrix of the first n principal components $\mathbf{W}_n$ can be obtained as:

$$\mathbf{W}_n = \widetilde{\mathbf{X}}\boldsymbol{V_n}$$

For the purpose of this exercise, we select the first n principal components such that $\frac{\lambda_m}{\sum_{i=1}^{8}\lambda_i} \geq 0.05\ \forall\ m\ in\ \{1, \ldots, n\}$.

Step 3: Identifying $\mathrm{y}_{i,t}$ as the log returns of the fund i at time t, the mapping of $\mathbf{H}_i$ is applied to find the normalized log returns $\tilde{y}_{i,t}$ such that:

$$\tilde{y}_{i,t} = \mathbf{H}_i(\mathrm{y}_{i,t}); \qquad with\ \tilde{y}_{i,t} \sim \mathrm{N}(0,1)$$

we also define $\tilde{\mathbf{y}}_i = (\tilde{y}_{i,1}, \ldots, \tilde{y}_{i,T})^{\boldsymbol{T}}$.

Step 4: The normalized returns of fund i is regressed on the first n principal components:

$$\tilde{\mathbf{y}}_i = \mathbf{W}_n \boldsymbol{\gamma}_{\mathbf{i}} + \boldsymbol{\epsilon}_i$$

from which the estimate of $\boldsymbol{\gamma}_i$, $\hat{\boldsymbol{\gamma}}_i = (\mathbf{W}_n{}^{\boldsymbol{T}}\mathbf{W}_n)^{-1}\mathbf{W}_n{}^{\boldsymbol{T}}\tilde{\mathbf{y}}_i$ is obtained. Moreover, all the parameters of $\hat{\boldsymbol{\gamma}}_i$ which are not statistically different from 0 are set equal to 0. Finally, the estimated vector parameter $\widehat{\boldsymbol{\beta}}_{\mathbf{i}}$ is obtained, which links the normalized performance of the indices to the normalized performance of the fund i in the form of:

$$\tilde{\mathbf{y}}_i = \widetilde{\mathbf{X}}\widehat{\boldsymbol{\beta}}_{\mathbf{i}} + \boldsymbol{\varepsilon}_i$$

Step 5: Initially, the log equivalent of the losses $\boldsymbol{\delta}$ (estimated in Step 1) suffered by the indices following the introduction of a tax is obtained, using the equation: $\boldsymbol{\delta}^* = \ln(\mathbf{1}_x + \boldsymbol{\delta})$. Then mapping of $\boldsymbol{G}$ is applied to the shock vector $\boldsymbol{\delta}^*$:

$$\widetilde{\boldsymbol{\delta}^*}_t = \boldsymbol{G}(\boldsymbol{\delta}^*)$$

The estimated effect of the carbon tax on the normalized returns of the fund i is given by:

$$\widetilde{\Delta}_i = \widetilde{\boldsymbol{\delta}^*}_t^{\,T} \widehat{\boldsymbol{\beta}}_\mathbf{i}$$

The inverse of the mapping $\mathbf{H}_i$ is used to find the actual log loss that fund i would suffer due to the newly introduced carbon tax:

$$\Delta_{\boldsymbol{i}} = \mathbf{H}_i^{-\mathbf{1}}\left(\widetilde{\Delta}_i\right)$$

Since the loss $\Delta_{\boldsymbol{i}}$ is in logarithmic terms, the percentage loss suffered by fund i is equivalent to $\%P_{y,T} = \exp(\Delta_{\boldsymbol{i}}) - 1$, where $\%P_{y,T}$ is the percentage change in price of the fund i at time T (in this case 30th June 2020).

Empirical Application

Data

The two primary sources of information used within the study are financial regulatory statistical returns and Refinitiv. In particular, security-by-security assets data (SbSA) is used for licensed entities, extracted from Banking Rule 6 (BR06) statutory financial returns for banks, Solvency II Quantitative Reporting Templates (QRTs) for insurances and Central Bank of Malta statistical returns for investment funds. Moreover, the amount of CO2 emission, financial data, together with the NACE classifications, are obtained from Refinitiv, with government bonds being excluded from the assessment. The reference date used is June 2020.

The extracted SbSA data covers a total of 18 banks, 104 funds[8] and 36 insurance undertakings, providing an overall sample of more than 8,100 unique ISINs (including government bonds), split as follows: 6,200 bonds, 1,000 equities and 858 CIS. The simulation of the tax is successfully carried out on nearly 5,800 ISINs[9]. This results into a coverage of €3.3 billion in banks' assets (34% of their investment portfolio reported in SbSA), €3.2 billion in insurance undertakings' assets (53% of their transferable securities identified by ISINs reported in SbSA) and €2.8 billion in funds' assets (60% of their investment portfolio reported in SbSA).

For instances where it was not possible to retrieve information of a particular ISIN, peer-based measures split by NACE category[10] was used as an alternative. Moreover, the median of CO2 tons per million of revenue was used for those companies which do not report emissions data. Other fields populated using peer-based medians are the leverage ratio (liabilities on assets) and CO2 to asset ratio (which is needed to compute the tax effect on bond prices). The dataset of peer-based measures is extracted from Refinitiv, having over 46,000 instruments that are split by NACE classification. Not all instruments report the same level of information, having less than 10% of the sample reporting the CO2 per million of revenue. When it is not possible to estimate company specific CO2 per million of revenue, the effect of the carbon tax on equity

[8] One fund has been excluded due to biases arising on the results.
[9] The number of ISINs dropped mainly following the exclusion of government bonds.
[10] The NACE codes are aggregated at two-digit level. When the sample within a particular group is not large enough, further aggregations are implemented, based on an activity-similarity basis.

prices are approximated by computing the median effect of the tax on equities within the same NACE category. For bonds, such approximation is based on the median effect of the tax on bonds' issuers within the same NACE category and same maturity bucket.

Results

The estimated losses arising on the investment portfolio of Maltese financial entities, following the introduction of carbon tax rates (under six scenarios) are outlined within this section. The tax rates considered are: $10, $20, $50, $75, $100 and $200 per ton of CO2 emitted.

Financial Instrument Level

Table 1 presents the average expected losses suffered by the instruments held by the Maltese financial institutions following the introduction of a carbon tax rate, aggregated by asset class.[11]

Tax ($/Ton CO2)	10	20	50	75	100	200
Bond	-0.21%	-0.30%	-0.59%	-0.86%	-1.15%	-2.38%
CIS	-0.45%	-0.81%	-1.81%	-2.33%	-2.89%	-5.32%
Equity	-1.14%	-2.12%	-4.28%	-5.82%	-7.25%	-11.33%

Table 1 - Average expected losses on asset value split by instrument type under carbon tax scenarios

In all of the six scenarios, equity is the asset class which is impacted the most by the introduction of the tax, followed by CIS. These results are in line with our ex-ante expectations. In fact, CIS are generally more diversified among economic sectors as compared to equities, while bonds tend to be less affected given that a tax is expected to have a small impact on the probability of default in instruments having a short-term maturity.

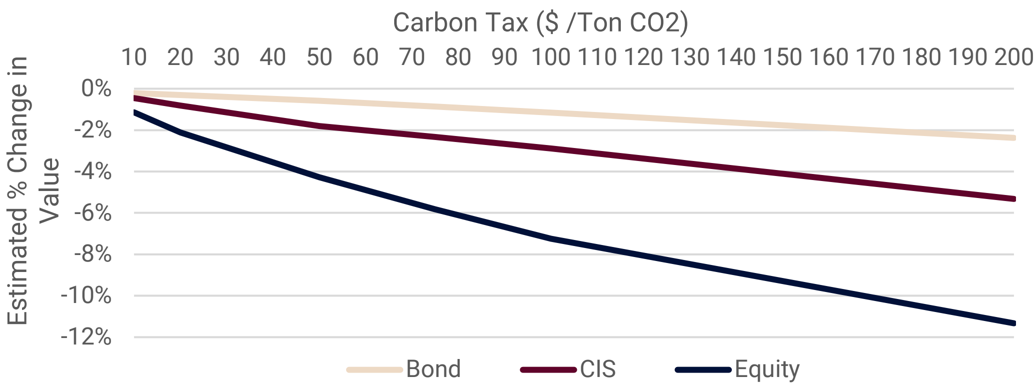

Figure 1 - Average expected losses on market value split by instrument type under carbon tax scenarios

From Figure 1, there seems to be a quasi-linear relationship between the level of the carbon tax and the average impact on the different classes of instruments. This relationship is tested using a regression where the endogenous variable is the average impact of the carbon tax, while exogenous variables are the carbon tax level and its quadratic term. The non-linearity hypothesis (i.e., coefficient of the quadratic term being statistically different from zero) is tested against the null hypothesis of linearity. The null hypothesis of linearity is not rejected only for the bond categories, suggesting that the average effect of the tax on CIS and Equity

[11] Repeated instruments are counted only once in the computation of the simple average.

is not growing linearly (in both cases the quadratic coefficient is statistically positive). The results of the bond regression go against the initial expectations, since the Merton Model used to estimate the effect of the carbon tax is non-linear. Of course, such an outcome could have been driven by the scarce number of observations.

Financial System Level

The losses generated on the financial system (i.e., aggregate of banks, insurance undertakings and investment funds) following the implementation of a carbon tax, are presented in the subsequent tables split according to economic sectors (NACE) from where the losses emanated. Tables 2 and 3 lists the eight economic sectors which were found to consistently generate large losses onto the financial system, with Appendix 1 providing the NACE descriptions to each NACE digit.

Tax rate	10 $/Ton CO2		20 $/Ton CO2		50 $/Ton CO2	
NACE sector	Losses by NACE sector (€)	% Total losses	Losses by NACE sector (€)	% Total losses	Losses by NACE sector (€)	% Total losses
23	-8,278,237	30%	-16,567,003	33%	-22,730,321	24%
CIS	-7,771,632	28%	-13,081,598	26%	-26,618,273	28%
35	-2,911,497	11%	-5,322,355	11%	-11,167,739	12%
19	-1,626,528	6%	-2,322,133	5%	-4,438,029	5%
20	-912,335	3%	-1,835,560	4%	-4,674,823	5%
10	-883,130	3%	-1,767,391	4%	-4,426,983	5%
11	-583,440	2%	-1,167,063	2%	-2,919,042	3%
31	-437,857	2%	-875,715	2%	-2,189,291	2%

Table 2 - Top 8 economic sectors in terms of expected losses on instruments' asset value and share of losses on total losses under carbon tax scenarios 10, 20, 50 $/Ton CO2

Tax rate	75 $/Ton CO2		100 $/Ton CO2		200 $/Ton CO2	
NACE sector	Losses by NACE sector (€)	% Total losses	Losses by NACE sector (€)	% Total losses	Losses by NACE sector (€)	% Total losses
23	-23,505,653	19%	-24,356,160	15%	-28,490,843	10%
CIS	-34,217,502	27%	-43,357,297	28%	-83,219,309	30%
35	-16,139,232	13%	-21,182,535	13%	-33,472,367	12%
19	- 6,234,981	5%	-8,062,532	5%	-14,070,250	5%
20	-7,124,321	6%	-9,545,276	6%	-18,502,373	7%
10	-6,651,101	5%	-8,882,238	6%	-17,873,904	7%
11	-4,380,308	3%	-5,842,756	4%	-11,704,527	4%
31	-3,283,940	3%	-4,378,591	3%	-8,757,221	3%

Table 3 - Top 8 economic sectors in terms of expected losses on instruments' asset value and share of losses on total losses under carbon tax scenarios 75, 100, 200 $/Tons CO2

For the low end of carbon tax rates (i.e. 10, 20 and 50 $/Tons of CO2), depicted by Table 2, the economic sectors which are expected to impact mostly the Maltese financial sector through a climate policy initiative are: '[23] *manufacture of other non-metallic mineral products*'; '[CIS] *investment in collective investment schemes*'; and '[35] *electricity, gas, steam, and air conditioning supply*'. For these sectors, the aggregated direct financial losses that would be incurred by the Maltese entities under the three tax scenarios range between 24-33%, 26-28% and 11-12%, respectively.

The results change slightly when the tax is calibrated at higher rates (i.e. 75, 100 and 200 $/Ton of CO2). In fact, '[CIS] *investment in collective investment schemes*' becomes the largest source of loss. This could reflect the fact that CIS is widely held by businesses operating in varied economic activities, such that a higher tax rate would give rise to an overall increase in losses. The exposure to the CIS represents between 28-30% of aggregate losses. The increase in losses in relative terms (% of total losses) of the CIS sector at higher tax rates, contrasts with the drop observed for the '[23] *manufacture of other non-metallic mineral products*' sector, whose share of losses decreases from 19% (at 75$/Ton CO2) to 10% (at 200 $/Ton CO2) of total losses.

The average losses incurred aggregated by asset type and NACE Level 1[12] sector are presented in Table 4.

Tax rate	**20 $/Ton CO2**		**50 $/Ton CO2**		**200 $/Ton CO2**	
NACE sector	**Bond**	**Equity**	**Bond**	**Equity**	**Bond**	**Equity**
A	NA	-0.66%	NA	-1.65%	NA	-8.76%
B	-0.52%	-4.73%	-1.32%	-9.45%	-7.35%	-36.86%
C	-1.38%	-2.23%	-2.58%	-4.69%	-8.91%	-13.87%
D	-1.35%	-21.00%	-3.65%	-36.40%	-18.89%	-79.45%
E	-1.37%	-10.29%	-4.08%	-25.74%	-17.23%	-63.89%
F	-0.02%	-3.88%	-0.05%	-5.28%	-0.24%	-15.06%
G	-0.17%	-1.09%	-0.44%	-2.52%	-1.94%	-9.93%
H	-0.57%	-6.71%	-1.34%	-15.31%	-5.96%	-47.99%
I	-0.33%	-1.49%	-0.56%	-3.72%	-5.45%	-16.20%
J	-0.05%	-0.32%	-0.12%	-0.78%	-0.45%	-3.13%
K	-0.03%	-0.08%	-0.03%	-0.20%	-0.04%	-0.55%
L	-0.01%	-0.41%	-0.03%	-1.03%	-0.13%	-5.55%
M	-0.02%	-0.16%	-0.04%	-0.39%	-0.19%	-1.68%
N	-0.01%	-0.17%	-0.04%	-0.43%	-0.17%	-1.70%
P	-0.01%	-0.11%	-0.02%	-0.27%	-0.09%	-1.09%
Q	-0.07%	-0.49%	-0.16%	-1.22%	-0.65%	-4.42%
R	-0.02%	-0.23%	-0.05%	-0.57%	-0.25%	-2.87%
S	-0.09%	-0.20%	-0.15%	-0.50%	-0.40%	-2.01%
U	-1.40%	NA	-1.40%	NA	-1.60%	NA

Table 4 - Average expected losses on asset value split by instrument type and NACE classification under selected carbon tax scenarios

[12] The list of the NACE Level 1 is included in Table A.1.

It emerges that overall, transition risk is expected to emanate mostly from entities operating within the 'D- *electricity, gas, steam and air conditioning supply*' and 'E - *water supply; sewerage; waste management and remediation activities*' sectors. For equity instruments, under a climate policy scenario of moderate intensity - carbon tax rate of 20 or 50 $/Tons, the equity value of companies operating in these sectors are estimated to fall by 20% to 35% and by 10% to 25% respectively. In an extreme scenario - carbon tax rate of 200 $/Tons, the estimated expected losses would range between 64% to 80%. Conversely, the losses arising on bond instruments are expected to be more contained. Under a moderate scenario, losses are expected to reach at most 4% for both sectors, whereas under an extreme adverse scenario loss could reach up to nearly 20%.

Financial Industry Level

The estimated losses based on the different carbon tax scenarios are assessed on the three financial industries considered. The estimated losses are shown in Table 5, with Table 6 showing these losses as a percentage of the investment portfolio and of the assets under analysis.

Tax ($/Ton)	10	20	50	75	100	200
Banks	-1,294	-2,011	-4,193	-6,022	-7,904	-15,778
Funds	-16,130	-30,231	-53,140	-66,076	-79,744	-129,840
Insurances	-10,128	-18,220	-39,203	-53,889	-69,577	-128,879
Total Losses for the Maltese Institutions	-27,552	-50,461	-96,536	-125,987	-157,224	-274,497

Table 5 - Expected losses on asset value split by financial industry under carbon tax scenarios ('000 of €)

Tax ($/Ton)	10	20	50	75	100	200
Banks	-0.01% (-0.04%)	-0.02% (-0.06%)	-0.04% (-0.13%)	-0.06% (-0.18%)	-0.08% (-0.24%)	-0.16% (-0.48%)
Funds	-0.35% (-0.58%)	-0.65% (-1.08%)	-1.15% (-1.90%)	-1.43% (-2.37%)	-1.72% (-2.86%)	-2.80% (-4.65%)
Insurances	-0.17% (-0.32%)	-0.30% (-0.57%)	-0.65% (-1.23%)	-0.90% (-1.69%)	-1.16% (-2.19%)	-2.15% (-4.05%)

Table 6 - Expected losses on asset value split by financial industry under carbon tax scenarios as a ratio of total assets. Between brackets as a percentage of the total value of the assets covered by the analysis.

The funds sector is expected to incur the highest amount of loses following the implementation of a carbon tax. One of the reasons is that funds invest most of their assets in transferable securities, and their exposure to government securities is limited when compared to other institutions. While Maltese funds' business model is driven mainly by the gains in their investment portfolio, Maltese banks are more conservative in this regard. This explains why the losses in banks' investment portfolio are limited to a few basis points, with losses exceeding 10 basis points only in the case of a carbon tax rate of $200 per ton of CO2. The expected losses estimated at industry level are summarised in Figure 2.

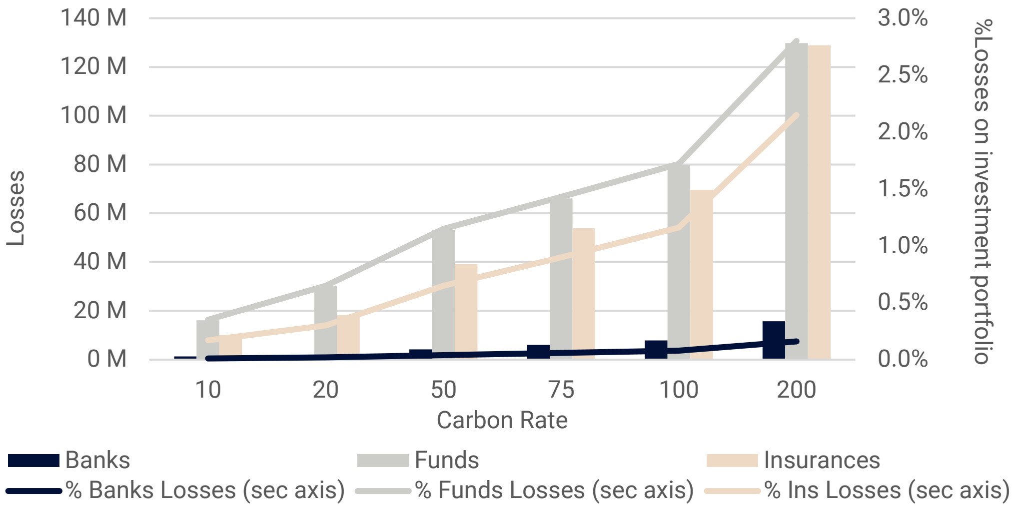

Figure 2 - Expected losses on the investment portfolio split by financial industry under carbon tax scenarios

The lower exposure of banks to climate transition risk can be observed also from Figure 3. Maltese banks are mainly exposed to instruments which would lose a maximum of 40% of their value in the extreme scenario of a carbon tax of $200 per ton of CO2. The instruments which are more vulnerable to climate transition risk are nearly totally targeted by insurances and investment funds. Specifically, nearly two third of the Maltese financial entities' exposure to financial instruments which would lose more than half of their value as consequence of a $200 per ton of CO2 carbon tax are in the investment funds' portfolios (€84 million in the investment funds' portfolio, and €46 million in the insurance companies' portfolios). However, it is important to highlight that the Maltese financial sectors (i.e., banks, insurances and funds) are mainly exposed to instruments which would lose a maximum of 10%, which thus indicates a low level of exposure to climate transition risk. In fact, this bucket represents more than 90% of the investment portfolio analysed (excluding government bonds which make up a very substantial part of the sectorial assets). Hence, based on this methodology, the results show that a few Maltese financial institutions would experience substantial losses following an abrupt and severe climate policy intervention. Overall, the Maltese financial sector appears to be generally resilient to climate transition risk.

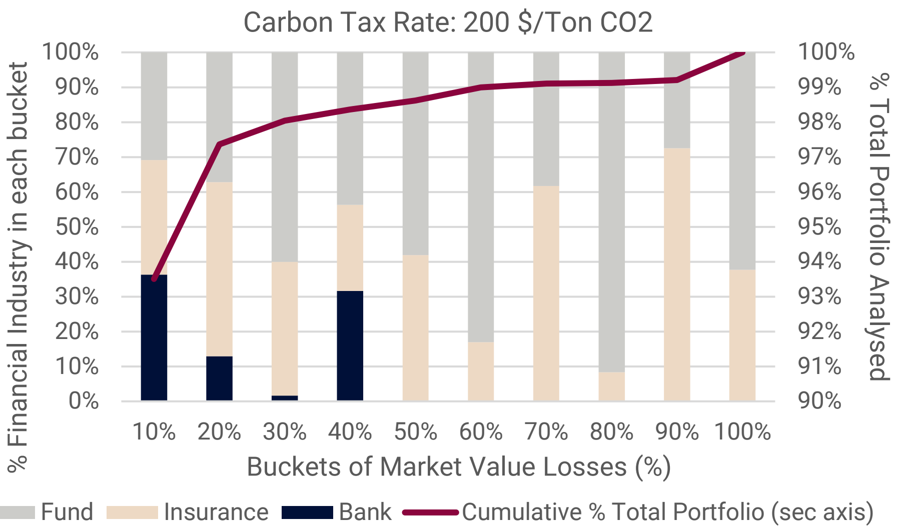

Figure 3 - Exposure of Maltese financial sectors to instruments by losses due to a carbon tax rate of $200 per ton of CO2.

Entity Level

This section delves into the losses suffered by individual licenced entities as a result of the climate policy intervention. The results are reported in the form of losses over total equity (or NAV for funds). Overall, results indicate that most entities would incur limited losses as percentage of total equity, across all tax rate scenarios. In particular, most entities would lose less than 50 basis points following the introduction of a carbon tax.

The histograms in Figure 4 portray the estimated losses at different carbon tax rates for the three financial sector industries.

In line to the initial expectations, banks are the least affected, with no bank suffering losses higher than 2% when the carbon tax rate is below \$100 per ton of CO2. Only in the case of a carbon tax of \$200 per ton of CO2, there would be a bank losing up to 6% of its equity. Moreover, core banks appear to be even less exposed to transition risk, with the largest loss being 0.33% of total equity (carbon tax of \$200 per ton of CO2). Under a moderate scenario - carbon tax of \$20 per ton of CO2, no core bank would lose more than 10 basis point within their investment portfolio. Results show that the five banks which would suffer the largest losses are banks having limited or no systemic relevance to Malta.

With respect to the insurance sector, most of the insurance companies would incur moderate losses following the introduction of a carbon tax. However, of note are two life insurance companies that were found to be susceptible of incurring material losses under the base scenario of a carbon tax of \$20 per ton of CO2. For one company, the main source of losses relates to its investments held in very large companies operating in highly polluting sectors such as production and distribution of electricity and manufacturing of carbon intensive products. For the other life insurer, losses would mainly arise from its indirect exposure to transition risk, given its investments in CISs. The losses due to a carbon tax for these two life insurance companies are estimated to hover around 7% in the case of a rate of \$20 per ton of CO2, rising above 10% with a rate of \$50 per ton of CO2. Life insurers' higher exposure to transition risk can also be linked to their greater vulnerability to market factors compared to non-life insurers, as identified in the insurance stress test recently carried out by the Financial Stability function. On a positive note, it is important to highlight that the estimated losses mainly emanate from exposures to blue chips companies and therefore should have the capacity and tools to reduce emissions by investing in green technologies in the case of the extreme scenario of a carbon tax of \$200 per ton of CO2. Apart from these two life insurances, only one additional insurance company would lose more than 1% of equity in the case of a carbon tax of \$20 per ton of CO2, with no insurance company losing more than 6% under the extreme carbon tax scenario of \$200 per ton of CO2.

Results on the funds sector shows a more pessimistic outcome than that observed from banks and insurance undertakings. Although no fund would experience extreme losses (maximum loss in the \$200 per ton of CO2 scenario stands at 25%), a broad number of funds were found to be susceptible of incurring material losses. In the case of a tax rate of \$20 per ton of CO2, only one fund was observed to lose a significant amount (around 7%) given that it holds investments in two highly polluting companies which are estimated to lose more than half of their value in the case of a carbon tax. Under the \$50 and \$75 per ton of CO2 scenarios, no additional fund would lose more than 10% of NAV, except for one fund which would incur losses above 16% under the \$75 per ton of CO2 tax rate. This is due to the substantial leverage employed by this fund, which thus magnifies the losses. Exposure to transition risk by domestic funds is relatively contained, with losses not exceeding 5% in all carbon tax scenarios, with the exception for the $200 per ton of CO2 scenario where a few domestic funds would lose up to 8% of NAV.

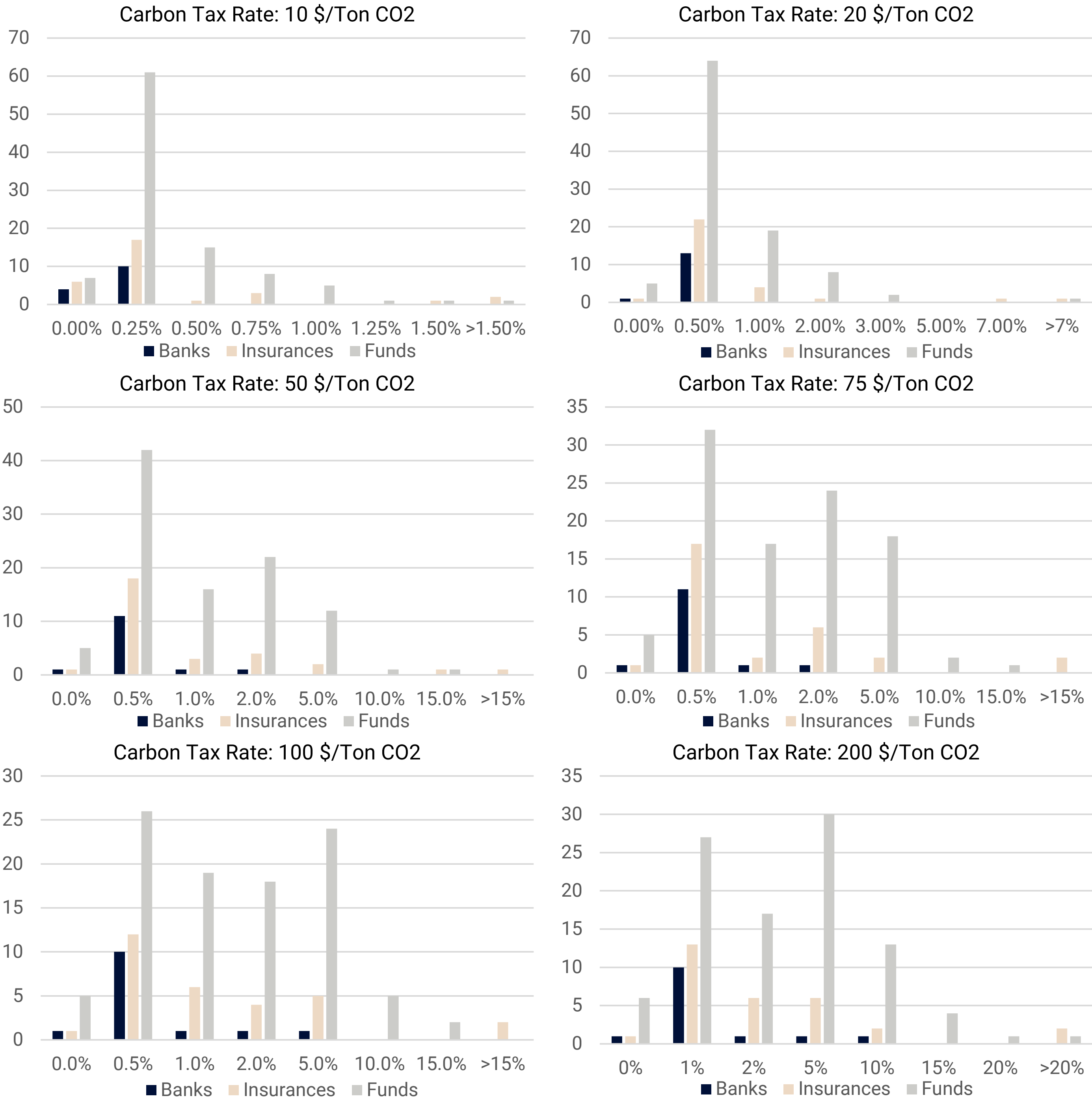

Figure 4 - Number of entities within each loss bucket under the different carbon tax scenarios. (y-axis: number of entities; x-axis: average expected losses).

A limitation within this study relates to the choice of investment assets and in particular to the fact that government bonds have not been included in the analysis despite accounting for a substantial part of entities' investment portfolios. Nevertheless, climate policies could eventually contribute to the transition towards a more sustainable economy, ultimately benefitting governments' finances. Hence, on this account transition risk emanating from this channel is expected to be less relevant.

Conclusions

This paper represents a first comprehensive and innovative attempt to estimate the losses arising on the investment portfolio of banks, insurance undertakings and investment funds following the introduction of a tax on corporate CO2 emissions. Adopting a static balance sheet assumption, six carbon tax policy scenarios were analysed. Various methodological techniques were used to estimate losses in the equities, bonds and CIS holdings, namely through ratio analysis, Merton model and sensitivity analysis, respectively.

The results indicate that equities would incur the highest losses due to the introduction of a carbon tax. This is followed by losses in CIS and subsequently bonds. The main sources of transition risk for Maltese financial entities were found to be from companies operating within the: '[C23] *manufacture of other non-metallic mineral products*', '[CIS] *investment in Collective Investment Schemes*' and '[D35] *electricity, gas, steam, and air conditioning supply*' sectors. Furthermore, the NACE aggregate sectors presenting larger average losses are '*D - Electricity, gas, steam and air conditioning supply*' and '*E - Water supply; sewerage; waste management and remediation activities*'.

The analyses of the carbon tax impact within the three financial industries reveals investment funds as being the most susceptible to losses. Although the investment fund industry, overall, appears to be resilient to a carbon tax, a few funds are expected to suffer material losses. This impact is more prevalent across the non-domestic funds. With respect to banks, across the six scenarios, the losses on their investment portfolio are expected to be limited. Moreover, the impact was found to be insignificant for the core domestic banks. Insurance undertakings also have limited exposure to climate transition risk, with only two life insurers which could be influenced by the introduction of a moderate carbon tax rate.

To conclude, although the study indicates that a small number of Maltese financial institutions could experience noteworthy losses following an abrupt and severe climate policy intervention, the overall investment portfolio held within the Maltese financial sector appears to be resilient to climate transition risk. The implementation of climate policies at a moderate level of intensity is expected to cause minor consequences on the Maltese financial system. However, this first exercise concentrates on the financial system's investment portfolio. Taking into consideration other assets held within the financial sector, such as the loan portfolio, could result in different conclusions in terms of ultimate impact from transition risk.

Looking forward, future studies will attempt to address identified gaps. Some examples include enhancing the coverage of the study to include the carbon footprint of the banks' loan portfolio, delving into the companies' trade-off between business models sustainability and absorption of any future carbon taxation policy. Furthermore, it would be beneficial to link this climate change analysis to possible contagion risk within the financial system. The MFSA will continue to analyse climate related risks with the objective of assessing their implications on the Maltese financial system.

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Appendix 1 - NACE Sectors

NACE 2-Digit	Sector Description
A	AGRICULTURE, FORESTRY AND FISHING
1	Crop and animal production, hunting and related service activities
2	Forestry and logging
3	Fishing and aquaculture
B	MINING AND QUARRYING
5	Mining of coal and lignite
6	Extraction of crude petroleum and natural gas
7	Mining of metal ores
8	Other mining and quarrying
9	Mining support service activities
C	MANUFACTURING
10	Manufacture of food products
11	Manufacture of beverages
12	Manufacture of tobacco products
13	Manufacture of textiles
14	Manufacture of wearing apparel
15	Manufacture of leather and related products
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
17	Manufacture of paper and paper products
18	Printing and reproduction of recorded media
19	Manufacture of coke and refined petroleum products
20	Manufacture of chemicals and chemical products
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
22	Manufacture of rubber and plastic products
23	Manufacture of other non-metallic mineral products
24	Manufacture of basic metals
25	Manufacture of fabricated metal products, except machinery and equipment
26	Manufacture of computer, electronic and optical products
27	Manufacture of electrical equipment

NACE 2-Digit	Sector Description
49	Land transport and transport via pipelines
50	Water transport
51	Air transport
52	Warehousing and support activities for transportation
53	Postal and courier activities
I	ACCOMODATION AND FOOD SERVICE ACTIVITIES
55	Accommodation
56	Food and beverage service activities
J	INFORMATION AND COMMUNICATION
58	Publishing activities
59	Motion picture, video and television programme production, sound recording and music publishing activities
60	Programming and broadcasting activities
61	Telecommunications
62	Computer programming, consultancy and related activities
63	Information service activities
K	FINANCIAL AND INSURANCE ACTIVITIES
64	Financial service activities, except insurance and pension funding
65	Insurance, reinsurance and pension funding, except compulsory social security
66	Activities auxiliary to financial services and insurance activities
L	REAL ESTATE ACTIVITIES
68	Real estate activities
M	PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES
69	Legal and accounting activities
70	Activities of head offices; management consultancy activities
71	Architectural and engineering activities; technical testing and analysis
72	Scientific research and development
73	Advertising and market research
74	Other professional, scientific and technical activities
75	Veterinary activities

28	Manufacture of machinery and equipment n.e.c.
29	Manufacture of motor vehicles, trailers and semi-trailers
30	Manufacture of other transport equipment
31	Manufacture of furniture
32	Other manufacturing
33	Repair and installation of machinery and equipment
D	ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY
35	Electricity, gas, steam and air conditioning supply
E	WATER SUPPLY; SEWERAGE; WASTE MANAGEMENT AND REMEDIATION ACTIVITIES
36	Water collection, treatment and supply
37	Sewerage
38	Waste collection, treatment and disposal activities; materials recovery
39	Remediation activities and other waste management services
F	CONSTRUCTION
41	Construction of buildings
42	Civil engineering
43	Specialised construction activities
G	WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES
45	Wholesale and retail trade and repair of motor vehicles and motorcycles
46	Wholesale trade, except of motor vehicles and motorcycles
47	Retail trade, except of motor vehicles and motorcycles
H	TRANSPORTING AND STORAGE

N	ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES
77	Rental and leasing activities
78	Employment activities
79	Travel agency, tour operator and other reservation service and related activities
80	Security and investigation activities
81	Services to buildings and landscape activities
82	Office administrative, office support and other business support activities
P	EDUCATION
85	Education
Q	HUMAN HEALTH AND SOCIAL WORK ACTIVITIES
86	Human health activities
87	Residential care activities
88	Social work activities without accommodation
R	ARTS, ENTERTAINMENT AND RECREATION
90	Creative, arts and entertainment activities
91	Libraries, archives, museums and other cultural activities
92	Gambling and betting activities
93	Sports activities and amusement and recreation activities
S	OTHER SERVICES ACTIVITIES
94	Activities of membership organisations
95	Repair of computers and personal and household goods
96	Other personal service activities

Table A. 1 - NACE Rev2

Appendix 2 - NACE Categories’ Median Figures

NACE 2-Digit	CO2 per Mil Rev.	Leverage	CO2 to Assets Ratio	NACE 2-Digit	CO2 per Mil Rev.	Leverage	CO2 to Assets Ratio
1	134.73	40%	0.06‰	47	21.38	58%	0.03‰
2	134.73	50%	NA	49	409.38	54%	0.13‰
3	134.73	41%	0.05‰	50	1,185.90	53%	0.53‰
5	1,447.51	45%	1.03‰	51	1,045.22	75%	0.66‰
6	594.68	41%	0.18‰	52	45.77	47%	0.02‰
7	454.46	15%	0.19‰	53	40.91	55%	0.04‰
8	459.83	25%	0.11‰	55	79.73	40%	0.04‰
9	100.28	50%	0.05‰	56	57.80	59%	0.04‰
10	86.41	48%	0.09‰	58	6.38	36%	0.00‰
11	56.08	40%	0.04‰	59	39.10	43%	0.04‰
12	56.08	42%	0.01‰	60	8.62	49%	0.00‰
13	15.95	51%	0.15‰	61	39.10	58%	0.02‰
14	15.95	44%	0.02‰	62	9.48	44%	0.01‰
15	9.44	48%	0.01‰	63	12.47	41%	0.00‰
16	136.09	50%	0.05‰	64	6.14	78%	0.00‰
17	381.59	48%	0.29‰	65	1.49	75%	0.00‰
18	381.59	39%	0.05‰	66	2.65	42%	0.00‰
19	406.56	56%	0.37‰	68	59.00	46%	0.00‰
20	310.09	41%	0.19‰	69	16.85	55%	0.00‰
21	24.64	34%	0.01‰	70	16.85	44%	0.01‰
22	144.33	45%	0.11‰	71	16.85	53%	0.01‰
23	2,022.79	44%	0.75‰	72	14.81	25%	0.01‰
24	935.87	50%	0.74‰	73	6.64	50%	0.00‰
25	71.78	45%	0.05‰	74	6.64	46%	0.00‰
26	22.92	39%	0.02‰	75	6.64	64%	NA
27	35.67	43%	0.04‰	77	10.86	63%	0.01‰
28	20.11	44%	0.02‰	78	5.04	54%	0.01‰
29	34.32	53%	0.04‰	79	5.04	55%	0.04‰
30	24.62	57%	0.02‰	80	28.79	49%	0.02‰
31	20.11	44%	0.03‰	81	28.79	64%	0.03‰
32	20.80	40%	0.02‰	82	5.04	45%	0.00‰
33	12.26	51%	0.01‰	85	8.04	48%	0.01‰
35	1,390.69	57%	0.45‰	86	26.45	47%	0.02‰
36	176.86	51%	0.03‰	87	26.45	67%	0.01‰
37	530.96	52%	0.06‰	88	26.45	59%	0.00‰
38	530.96	52%	0.42‰	90	4.98	53%	NA
39	530.96	58%	NA	91	27.14	33%	NA
41	15.24	59%	0.00‰	92	12.69	51%	0.01‰
42	45.13	59%	0.03‰	93	12.69	48%	0.01‰
43	12.26	48%	0.02‰	94	12.26	NA	NA
45	12.26	62%	0.02‰	95	12.26	63%	0.01‰
46	12.09	52%	0.02‰	96	26.45	60%	0.04‰

Table A. 2 - NACE Rev2 Peering Median Figures
Source: Refinitiv and authors' calculations

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