LÁSZLÓ BOKOR

BANK CARBON RISK INDEX – A SIMPLE INDICATOR OF CLIMATE-RELATED TRANSITION RISKS OF LENDING ACTIVITY

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Bank Carbon Risk Index – A simple indicator of climate-related transition risks of lending activity

(Banki Karbonkockázati Index – A hitelezési tevékenység klímaváltozással összefüggő átállási kockázatainak egy egyszerű mutatója)

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*** The indicator was introduced in MNB Green Finance Report 2021 (March). This paper provides a deeper insight to the methodology.

Contents

Abstract

I propose a simple indicator of climate-related transition risks of banks' lending activity based on transaction-level loan data. The underlying idea is that the higher the greenhouse gas intensity of an economic activity (and so a debtor), the higher its transition risk. Recent Hungarian trends of this indicator alerts to significantly regrowing risks.

JEL: C43, G21, Q54
Keywords: climate change, transition risk, greenhouse gas intensity, lending activity, risk indicator

Összefoglaló

A bankok hitelezési tevékenységét érintő klimatikus átállási kockázatok egy egyszerű indikátorára teszek javaslatot. A mögöttes elv szerint minél nagyobb egy gazdasági tevékenység (és így egy hiteladós) üvegházhatásúgáz-kibocsátási intenzitása, annál nagyobb az átállási kockázata. A mutató közelmúltbeli magyar trendjei a kockázatok újbóli és jelentős emelkedésére figyelmeztetnek.

Introduction

Climate change creates the need for new tools and frameworks that can shed the light on the related threats to the financial system. Ongoing pilot stress tests of climate-related physical and transition risks in a 30-year window became the flagship of this new line of thinking. However, because of the paradigmatical novelty of these experiments and the long time-interval itself, such exercises require huge resources while involve uncomfortably enormous uncertainties. Under such circumstances, complement devices come in handy.

My motivation was to develop a metric, which is

- simple – its calculation requires basic arithmetic,
- objective – it avoids debatable „expert" assumptions as much as possible,
- flexible – it is calculable for multiple populations, e.g., whole banking system or individual banks, whole loan portfolio or loans of specific sectors,
- early warning – it is based on high frequency contemporary inputs for telegraphing trend switches.

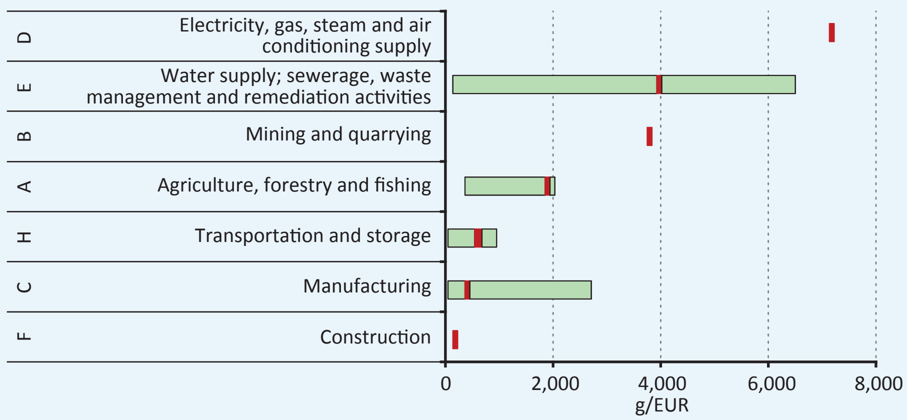
The basic idea is that specific greenhouse gas emission of an economic activity is in line with its probability of default, and thus its climate-related transition risks. Consequently, the risk of a debtor and thus that of its lending bank can be outlined as well by mapping greenhouse gas intensities to loan data.

The paper is structured as follows. Chapter 1 introduces the concept of greenhouse gas intensity. Chapter 2 presents the methodological background of the indicator. Chapter 3 compares the indicator with similar devices. Chapter 4 discusses its trends based on Hungarian data. Chapter 5 considers methodological issues and caveats. Chapter 5 concludes.

1 Greenhouse gas intensity

An important measure of the environmental burden of an economic activity is its greenhouse gas (GHG) intensity, i.e., greenhouse gas emissions per unit of value added. Given that the global warming potential per unit mass of each gas can be several orders of magnitude larger than that of carbon dioxide, the relevant statistics is CO_2-equivalent, i.e., the emitted masses are multiplied by the 100-year global warming potentials (GWP of CO_2 is 1).[1] Thus, in this paper, I use phrase *GHG intensity* and *carbon intensity* interchangeably. Intensity statistics are provided by Eurostat in annual breakdown for each country (with a lag of about 3 years), including almost all sections of the economy (NACE rev.2 level 1: A, B, …, T), and a broad but non-complete range of divisions (NACE rev.2. level 2: A01, A02, …, T98).[2] I refer to the latter level as "sector". Figure 1 shows the most carbon-intense activities of Hungary in 2017.[3]

Figure 1
Activities of highest GHG intensity in Hungary
(2017)



Notes: The bars show the scatter of sectoral values. No sectoral GHG statistics of B and F is available. In NACE classification, D covers only a single sector.
Own figure. Data source: Eurostat (retrieved: 9 June 2020).

For example, GHG intensity of mining is by order of magnitude higher than that of construction, but it is only a fraction that of electricity generation. The differences within individual sections can be similarly large. Within section A, for example, agriculture and fishing represent the two extremes in terms of carbon intensity, which is a good example of the importance of sectoral disaggregation.

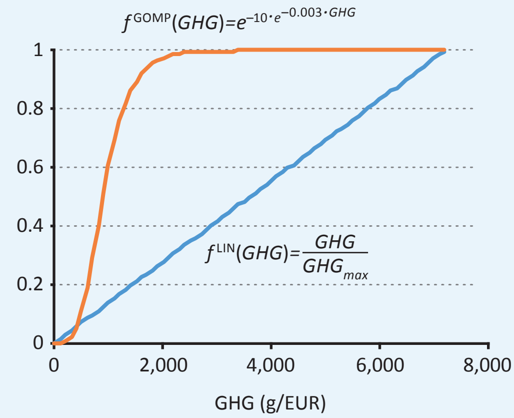
[1] There are calculations also for 20-year and 500-year windows (for details, see IPCC 2013 and 2014 – UN's Intergovernmental Panel on Climate Change).
[2] Data of national GHG inventories (guided by IPCC 2006) are broken down in line with national account concepts. In the process, some of the 98 elements of NACE level2 activities (U99 is excluded) are grouped together, and thus the resolution of GHG statistics is 64.
[3] The project described in this paper is a product of 2020. Recently, Eurostat published the data of 2018.

2 Defining the index

The basic idea is that the increasing cost of carbon emission increases the probability of default of firms, in particular, that of intensive emitters (think of future carbon tax or greening consumer preferences). Following this logic, the transition risks of financial institutions are higher if their lending leans more towards intensive emitters. The question is, however, by *how much*, i.e., what is the relationship between GHG intensity and risk. Note that backward-looking default estimates are not very useful here.

I consider two hypothetical scenarios. In the first, I assume that the price of GHG develops sector-neutral, and so the risk is directly proportional to the intensity. In the other, I assume that the anti-carbon measures basically hit the intense polluters, i.e., that the relationship is nonlinear. The latter scenario is consistent with the current situation since ETS covers only (a subset of) high polluters, which happen to be the intensive polluters in specific (unit value-added) sense as well. For this latter relationship, I assume a sigmoid (Gompertz) curve, which, with the applied parameterisation, separates intensive emitters from non-intensive emitters markedly by assigning extreme (i.e., low or high) risk weights for most of the activities.[4] Figure 2 shows these two weight functions.

Figure 2
Transition risk weights as a function of GHG intensity



Note: GHG_{max} denotes the value of the most intensive sector (D35: ~7200 g/EUR).
Own figure.

Looking at Figure 1 and 2 together, it follows that, for example, mining with linear weighting is only moderately risky, while with Gompertz weighting it bears maximum risk similarly to electricity generation.

The indicator is fed with end-of-month transaction-level (on-balance and off-balance sheet) outstanding principals of HUF and FX credits, loans, credit-type agreements, financial leases (hereafter together "loans") provided by other monetary financial institutions to non-financial companies with a Hungarian tax number.[5] These principals are multiplied by the risk

[4] Were the function, for example, $f(GHG) = \begin{cases} 1 \text{ if } GHG > t \\ 0 \text{ if } GHG \leq t \end{cases}$, it would simply select loans with intensity above threshold *t*.

[5] The origin of these data is Central Credit Information System (KHR). The debtors' sectoral classification is not available for foreign companies not having a Hungarian tax number, i.e., they are excluded from my calculations. Sectoral classification of sole traders and proprietorships are periodically incomplete, and so I also ignored them completely. In the examined time interval, on average, all these excluded items account for only the fifth of the total outstanding principals.

weights of the debtors' core activity (sectoral classification) and the result is divided by the total amount of outstanding principal, i.e.

$$BCRI = \frac{\sum_i principal_i \cdot f(GHG_i)}{\sum_i principal_i}.$$

where *i* is the index of individual credit transactions, GHG_i is the GHG intensity of the core activity of the debtor of transaction *i*, and *f* denotes the abovementioned [0,1]-normalised weight functions. By "credit transaction" I mean the relationship between a financial institution and a debtor. It implies a more granular approach than a listing by credit agreements since an agreement might cover multiple debtors. In other words, a credit agreement of multiple debtors implies multiple credit transactions here. The advantage of this approach is that the main activity (and so the riskiness) of debtors may differ, and thus more than one sectoral classification can be linked to a credit agreement. In such cases, I divide the outstanding principal between the debtors equally.

Since $0 < f^{LIN} \leq 1$, it follows that $0 < BCRI \leq 1$ in the linear case. It is $0 < BCRI < 1$ in the sigmoid case because of the asymptotic convergence of f^{GOMP}. All these imply that if all loans were provided to the most GHG-intensive sector (in the sigmoid case: sectors), the value of the indicator would be 1 (in the sigmoid case: very close to 1), while if it were provided to the least intensive, it would be close to 0. The index could be zero only if there was no lending as there is no economic activity with zero GHG intensity, i.e., with zero risk weight.

The indicator can be calculated not only for the whole banking system, but also for individual banks (banking groups) or sectors. If it is calculated, for example, regarding sector *k*, the formula is

$$BCRI_k = \frac{\sum_j principal_j \cdot f(GHG_k)}{\sum_i principal_i},$$

where *j* is the index of individual credit transactions of sector *k*. Note that the denominator is for the full sample, consequently $BCRI = \sum_k BCRI_k$, i.e., the subindexes are additive.

When calculating regarding a particular bank, both system-level and bank-level denominator has its rationale. In the first case, the indicator combines the riskiness of a bank with its weight in the banking system. That is, a small bank with brown portfolio conveys the same risk as a large bank with green portfolio. In the second case, it shows the individual riskiness of banks, that is, a particular bank can be compared to another in terms of "brownness".

The index can be rewritten in accordance with the traditional risk concept of PD-EAD-LGD (probability of default, exposure at default, loss given default). To put it simple, my base hypothesis was $PD = g(GHG)$, where function *g* is unknown except that $g' > 0$ on the whole domain. Since *g* is bijective, it has an inverse. Let $EAD_i = principal_i$ and $LGD_i = 1$, which follows that

$$BCRI = \frac{\sum_i EAD_i \cdot f\left(g^{-1}(PD_i)\right)}{\sum_i EAD_i}.$$

2.1 CONTROLLING FOR "NOISES"

The purpose of the indicator is to highlight the impact of banking decisions and not a less informative resultant of several related layers. Thus, I control for two variables: technological development (change in GHG intensity) and exchange rate. The GHG intensities markedly lowered in recent years. In Hungary, it decreased by 30 percent from 2007 to 2017 considering the whole economy. Naturally, the sectoral rates are significantly scattered, moreover, there are sectors with increasing values. These increases are mostly due to base effect, but there are some remarkable exceptions, such as manufacturing of coke and refined petroleum products (C19), paper products (C17) or printed media (C18), with 70 to 100(!) percent increase rates. When calculating the index, I fix carbon intensity values at the most recent available levels (2017).

I do similarly when converting foreign currency-denominated loans to Hungarian Forint. In my calculations, I have used the exchange rates of 31 December 2019. Note that the fixing of exchange rate is usually far less important than the fixing of intensity. In the Hungarian case, the differences in calculations with spot and fixed exchange rates are tiny.

Proposition: *BCRI is not sensitive to the treatment of exchange rates if (i) the riskiness of domestic and foreign currency denominated loans is similar, or/and (ii) the total loans in base currency (in which currency the calculation is conducted, typically the domestic currency) dominates the total loans in currencies to be converted (typically the foreign currencies).*

Proof (i): Let $a = \sum principal^{HUF} \cdot f(GHG)$, $b = \sum principal^{HUF}$, $c = \sum principal^{FX} \cdot FXrate \cdot f(GHG)$, $d = \sum principal^{FX} \cdot FXrate$, where, for the sake of perspicuity, I have omitted the indices and consider one foreign currency. The indicator is then

$$BCRI = \frac{a+c}{b+d}.$$

A *ceteris paribus* increase of exchange rate with a gross rate of *e* alters the ratio to

$$BCRI = \frac{a+ce}{b+de}.$$

The two ratios are identical if

$$\frac{a+c}{b+d} = \frac{a+ce}{b+de}$$

$$ab + ade + bc + cde = ab + bce + ad + cde$$

$$ade + bc = bce + ad$$

$$ad(e-1) = bc(e-1)$$

$$\frac{a}{b} = \frac{c}{d}. \blacksquare$$

Proof (ii): Since $\lim_{b\to\infty} a = \infty$ and $\lim_{d\to 0} c = 0$, it follows that $\lim_{\substack{b\to\infty \\ d\to 0}} \frac{a+ce}{b+de} = \lim_{b\to\infty} \frac{a}{b} = BCRI, \big(e \in \mathbb{R}: (0,\infty)\big).\blacksquare$

Easy to see that, as a result of GHG-intensity and FX-rate anchoring, if loans are provided/repaid in an unchanged activity structure, the level of the index remains unchanged.

3 Similar devices in action

The concept of utilizing greenhouse gas emission as a proxy for climate-related risks is not novel. However, as far as I know, there is no simple indicator which examines the (i) climate-related "riskiness" of loan portfolios (ii) with NACE level2 greenhouse gas intensity approach (iii) by incorporating various relationships between greenhouse gas intensity and risk.

Task Force on Climate-related Financial Disclosures (TCFD 2017a) recommended various metrics of carbon risk exposures for banks, insurance companies, asset managers, asset owners, public- and private-sector pension plans, foundations. In their headline measure, Weighted Average Carbon Intensity (WACI), the values of investments relative to the portfolio value are weighted by the related carbon emissions relative to the issuer's revenue (for details, see TCFD 2017b, p.43). In the process, Scope 1 or 2 GHG protocol (GHGP) was recommended. Scope 1 refers to the direct emission only, while Scope 2 also involves the indirect emission related to the energy consumed (Scope 3 also accounts for the indirect emissions of the whole value chain). A few central banks embraced the idea and provided WACI for their own portfolios, for example, Banque de France (2019, 2021), Bank of England (2020). They typically report the numbers divided into multiple elements, such as sovereign bonds and equity components within own funds or pension funds.

WACI differs from BCRI in several points. First, it measures a specific carbon emission (in tonnes), i.e., it is not a min-max normalized measure, and so its value can be interpreted only in comparison with other values that differ in space, time, or asset type. Second, it is based on the emissions of firms/sectors/cities/countries and not only on the emission of NACE sectors; moreover, it considers multiple asset types, not just loans. That is, in some ways it is more ambitious, and thus its data requirement is much higher. Consequently, the sample applied is certainly less in par with the ambitions[6] than by BCRI where Eurostat's national statistics are combined with a complete national dataset on bank loans. Third, its carbon intensity factor is based on the revenue, which, in sectoral or country levels, corresponds to the output. I have fundamental concerns with this approach, and I argue for using carbon intensities based on gross value added (see Chapter 5). Nevertheless, in any case, consistency should be maintained, and so I disagree with the common practice of mixing the concepts, i.e., the use of revenues by firms (output concept) and GDP by countries (value-added concept). Fourth, it is more of an "exposure" metrics rather than a "risk" metrics since it does not account for various relationships between carbon intensity and risk, which BCRI does, undoubtedly in a very simplistic way. Fifth, it is probably more exposed to greenwashing and brownwashing (about these phenomena, see Kim and Lyon 2014). Companies has incentives to overstate and understate their environmental efforts, while non-profit agents those estimate the national GHG inventories from multiple sources might be less exposed to these siren voices.

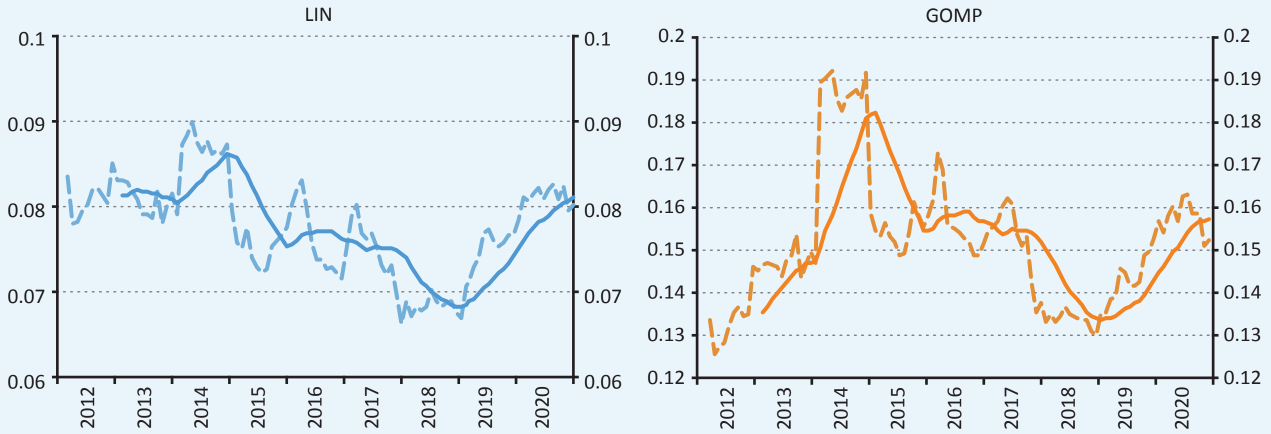
With regards to loan risks and data-poor environment, the much more complex VaR exercise of Battiston et al. (2017) should be also mentioned. Their stating point was the set of high-emitter NACE sectors B, C, D, F and H, from which a subsample was extracted and reorganized to "climate-relevant sectors" (fossil-fuel, utilities, energy-intensive, housing, transport). They account for three asset types: equity, bonds, loans. However, in case of loans, there was a crucial shortcoming due to data scarcity: In the ECB's Statistical Data Warehouse, the NACE-granularity of loan data is only one digit.

[6] See for example the strongly selective sectoral coverage of GHGP calculators.

4 Trends in Hungary

Figure 3 shows the evolution of BCRI over time. It is to be emphasized that, at least for now, because of the arbitrariness of the underlying functional forms, the *level* of the index is less relevant than its *change*. In other words, historical comparison is more robust than the evaluation of the value of a specific date.

Figure 3
Monthly values of banking system BCRI with annual backward-looking moving average
[GHG intensities: 2017. Exchange rates: 31.12.2019.]

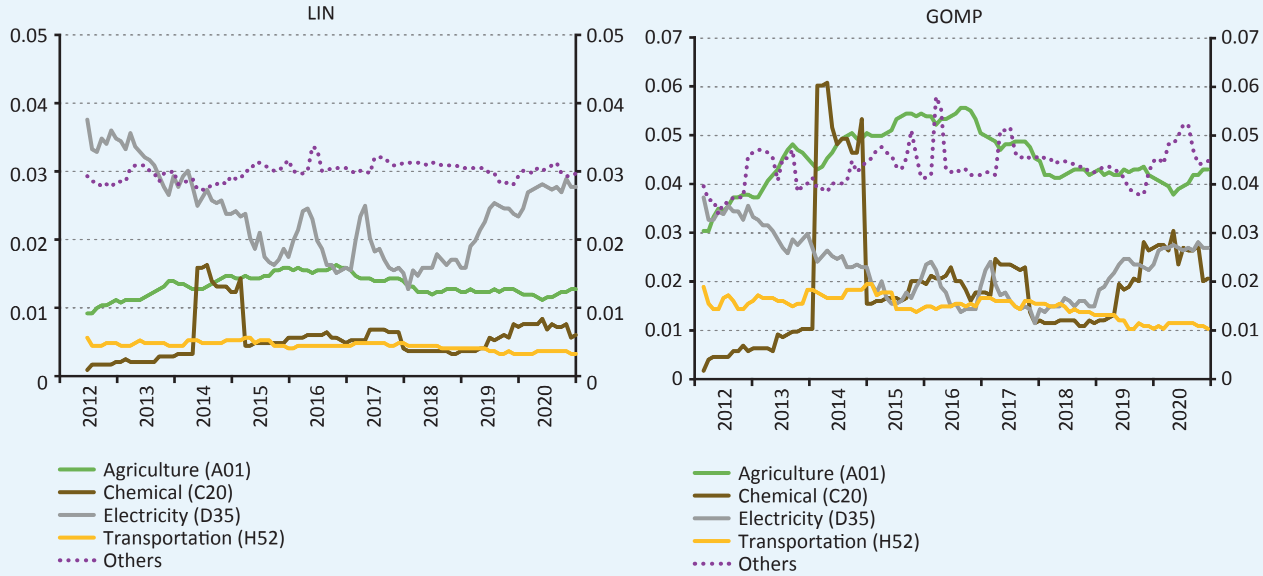


Notes: Transaction-level outstanding principal data are available as of April 2012.

Own figure. Data sources: MNB/KHR (loan data, retrieved: 20 November 2020), MNB (exchange rates), Eurostat (GHG intensities, retrieved: 9 June 2020).

It is perceptible that there was a significant drop in the risks after the mid of last decade. However, after a sideway move in 2018, the indicator skyrocketed again in 2019, thanks to which the annual moving average turned into a long-unseen growth. The reversal was basically due to loans provided to a handful of carbon-intensive companies of which some was belonging to the same corporate group. This can be clearly seen on Figure 4, which shows the evolution of the indices of most risky activities.

Figure 4
Monthly values of sectoral BCRI
[GHG intensities: 2017. Exchange rates: 31.12.2019.]



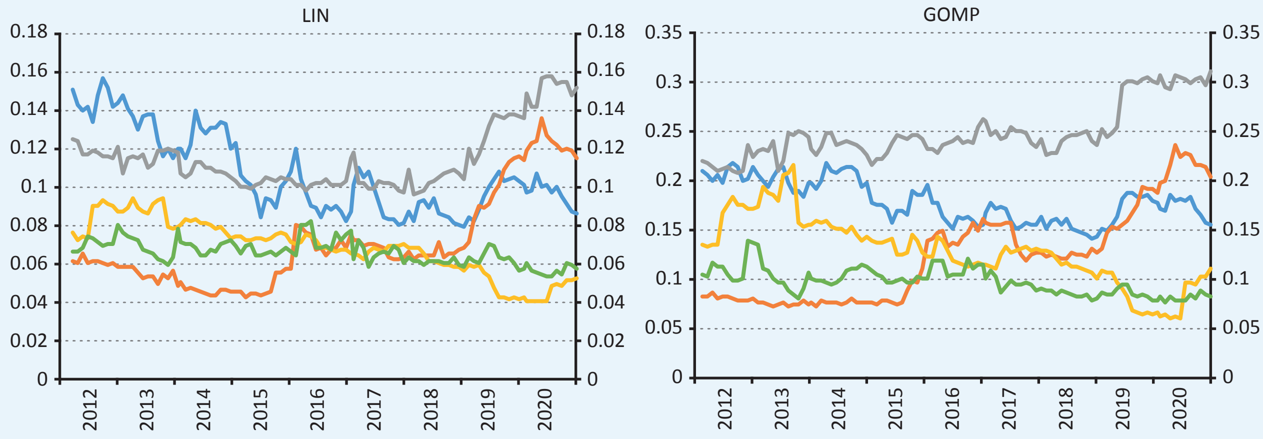
Note: Recall that the denominator covers the entire banking system, and so the sectoral indices are additive.

Own figure. Data sources: MNB/KHR (credit data, retrieved: 20 November 2020), MNB (exchange rates), Eurostat (GHG intensities, retrieved: 9 June 2020).

It can be read from the figures that the post-mid-decade decline in the main index was primarily due to shrinking agricultural exposures. Recently, risks have risen sharply mainly driven by loans financing electricity production and chemical activities, just like was the case with chemical industry in 2014, or with electric power industry in the middle of the decade. Nevertheless, upward pressure is perceivable also in other sectors. All these perfectly exemplify that the carbon risk of the Hungarian banking system is fundamentally influenced by the decision of one or few large carbon-intensive corporations. Of course, this relationship holds for any small country whose loan market is relatively small compared to the credit needs of large transnational corporations. Overall, as several factors point towards a deteriorating situation, it is a warning moment.

As far the brownness of the portfolios of individual banks, the picture is very diverse (Figure 5).

Figure 5
Brownness of some banks
[GHG intensities: 2017. Exchange rates: 31.12.2019.]



Note: The denominators here are the loan portfolios of the respective banks.

Own figure. Data sources: MNB/KHR (credit data, retrieved: 20 November 2020), MNB (exchange rates), Eurostat (GHG intensities, retrieved: 9 June 2020).

Looking at the depicted banks, we can draw interesting conclusions. First, there are consistently brown and green banks regarding their loans. Second, some institutions shift towards green financing, while others intensify their engagement in brown sectors. Third, bank portfolios may rearrange markedly in a few years.

5 Dilemmas and caveats

I consider five related issues of BCRI: complexity of the index, risk functions, data availability, intensity statistics applied, and GHG accounting methods.

The index could be made more complex, for example, by incorporating additional weighting in line with the duration of loans. Putting more emphasis on long-term loans is consistent with the idea that they are more affected by transition risks in parallel with the intensifying anti-carbon policies. Similarly, it could be amended with a weighting system which considers the concentration of debtors. As for risks, it is not indifferent whether the exposure towards a carbon-intensive company is significant compared to the provider bank's loan portfolio. By incorporating such elements, the indicator might convey a more sophisticated picture of risks. However, each additional (and simplifying) assumption brings in additional arbitrariness into the calculation, and so the interpretation of the resultant is questionable. On this basis, even though I have experimented with such calculations, I refrain from the discussion of these results.

As I have already pointed out, the assumed functional relationships between GHG intensity and risks are arbitrary at this point. Consequently, changes in the index are more interesting than the levels of the index. In time, with better understanding and incorporating the "true" relationship(s), levels will also get their full meaning.

The general problem of data availability also needs to be emphasized. Currently, risks might be misidentified because of the insufficient granularity of NACE classification system or Eurostat's GHG-intensity data. For example, in the case of electricity production (D35), NACE makes no distinction between the sources of the electricity. Consequently, in this model, the GHG intensity and so the transition risk of, e.g., coal and solar power plants are coerced to be the same. With historical and contemporary data, it is still not that big issue, but it could be in parallel with significant advances in green transition. Hopefully, data availability will catch up these needs.

Even if GHG intensities were available in full granularity, central banks might not be able to take full advantage of it. In the Hungarian case, only the core activity of the debtor is recorded in the loan database. Now consider a debtor with a quite heterogenous profile. If the loan finances its core activity, the risk weight based on carbon intensity is adequate. However, if it is not the case, for example, an oil company (sector C) builds a solar park (sector D) from the loan, it will spoil the interpretation of risks. Magyar Nemzeti Bank has a running project which will handle this challenge by flagging green loans in the database. Note, again, that not just in Hungary but globally we are still in the early stage of greening, and so this issue does not imply a significant bias in the index value at this point.

In this paper, I have used GHG emission statistics related to the unit value added of activities. However, alternatively, the base could have been also the unit output. It is easy to see that the two concepts can lead to very different conclusions. Think of economic activities with huge output but small value added. These are typically the over-maturing, low profitability companies, of which a growing portion is climate-related stranded asset like coal power plants. It was the main consideration that I have sticked to value-added approach.

Finally, national GHG inventories record the emissions by geographic place of production. It means that a country' footprint is more of less incomplete since the data lack import-related emissions. Consequently, the risks might be underestimated if the import is significant and mainly stems from carbon-intensive activities. Of course, the inventory would be incomplete with a consumption-based accounting method, too, since in that case the export-related emissions would be missing. These issues, however, goes beyond the scope of this article.

6 Conclusions

This paper provides an indicator of climate-related transition risks of banks' lending activity based on the assumption that higher greenhouse gas intensity of an economic activity results more climate-related transition risk because of increasing future carbon price, greening consumer preferences etc. This methodology can be easily applied to any countries which has a credit register with comprehensive transaction-level outstanding principal data and sectoral classification record. I showed the development of Bank Carbon Risk Index for the Hungarian banking sector from 2012 to 2020. Recent trends warn of deteriorating prospects.

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